I,SCIENCE

THE SCIENCE MAGAZINE OF IMPERIAL COLLEGE

MONEY, POWER, & INFLUENCE

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I, SCIENCE

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I, SCIENCE

Dear reader,

Knowledge is power, time is money, and money makes the world go round. The concepts of currency and control underpin many aspects of our society—including within the world of science. That's why for our second issue of the academic year, I, Science Magazine has decided to tackle all things Money, Power & Influence.

As usual, our writers have impressed us with their creativity and insight in broaching this extensive, potentially abstract, and occasionally controversial area.

We begin with a recap of the biggest science news stories of the term, followed by an insightful exploration of gender stereotypes in children's toys. Next up, we consider the role of power dynamics in universities, focusing on students' roles as partners in higher education and independence within PhD projects. Keep reading to learn about the birth of "Insta-science" and the economic implications of climate change, before a double bill on celebrity scientists, featuring Ada Lovelace and Nikola Tesla. Next, have you ever considered the privileges (or lack thereof) afforded to you by your passport? What about how gender plays into the prestigious Nobel Prizes? Or, if pharmaceutical companies spark your interest, turn over to find our piece about the growing trend of merger and acquisition deals.

As we know, funding is a huge determinant of scientific research avenues. This issue features two articles examining issues surrounding funding, covering the economic justifications for blue-skies research and how billionaires' investment drives science. On the subsequent pages, read about the influence of flagship endangered species on wider conservation efforts, followed by a fascinating take on power and corruption. Our penultimate sub-topic concerns ideology in science, from the colonial undertones of modern research collaborations, to the communist values that powered Soviet science. Lastly, we end with a perceptive examination of the workings of the academic publishing industry.

We've really enjoyed working on this thought-provoking theme and we hope you find it both engaging and informative! ■

Until next time,

PRIYANKA AND CHARLOTTE
EDITORS-IN-CHIEF

We are always looking for new contributors for both the magazine and online. If you would like to get involved as a writer, illustrator, or photographer, please get in touch with us.

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news

Harry Jenkins covers the latest.

COVID-19: THE VIRUS DOMINATING THE HEADLINES

There couldn't be a news roundup for this term without mentioning COVID-19, the disease caused by the new coronavirus, originating from Wuhan, China, which has grown into an official international health emergency.

As of February 22nd, 2020, there have been over 76,000 cases globally (1,400 outside China) and over 2,300 deaths according to the WHO. This has vastly outnumbered those from SARS, the disease caused by a previous coronavirus, which expanded into an epidemic and also originated in China.

At the time of writing, experts say that the world is at a tipping point as health systems across the globe struggle to keep up and contain the virus. This is exacerbated by the current lack of a vaccine and the recent discovery of an individual who passed on the virus despite having no symptoms and testing negative.

The virus is a true insight into a global health emergency in the information age, displaying both the talents of modern technology as hospitals are built in 10 days, and how misinformation and racism can spread in times of crisis.

BREXIT AND BORIS JOHNSON'S 'GLOBAL TALENT' VISA

Amid global health crises, one can't ignore that as of January 31st, 2020, Britain has started the process of becoming less global as we formally leave the EU.

In a bid to assuage fears that Brexit could be detrimental to the UK science landscape, the Government announced a fast-track visa system to attract world-leading scientists.

The system began on 20 February, and there is no cap to the number of people that can come to the UK under this visa. The UK Research and Innovation Agency (UKRI) is managing applications rather than the Home Office so that their scientific credentials can be quickly assessed by those qualified to do so.

Research organisations have been lobbying the Government to put together a new system amid fears that Brexit could lead to a brain drain from Britain, however concerns remain around the UK's future role in EU research programmes.

SEPSIS: THE UNDERESTIMATED KILLER

In January, a report in The Lancet highlighted a global killer which hasn't been making the headlines, stating that the current figures for the number of people in the world dying of sepsis have been grossly underestimated. They estimate that 11 million people die per year from sepsis – double the previous estimates.

The new figure also takes sepsis above cancer in terms of numbers killed annually, with most cases occurring in low and middle income countries.

Sepsis is considered a hidden killer due to how hard it is to detect. It is the result of the immune system attacking parts of the body, and is most commonly triggered by diarrhoeal infections or lung diseases.

THE POWER OF AI IN THE FIGHT AGAINST DRUG RESISTANCE

Headlines can be depressing but that doesn't mean that they all have to be. AI has sparked new hope against the global fears of drug resistant diseases, as it is used to discover a new antibiotic.

The drug, called Halicin, has been shown to wipe out a range of antibiotic-resistant strains of bacteria, including 2 of the top 3 high-priority pathogens identified by the World Health Organisation.

Researchers at MIT used machine learning to work through a database of 107 million compounds, looking for those that look effective but are unlike current antibiotics. Eventually, this led them to Halicin, which was originally researched as a potential drug to treat diabetes.

The WHO calls antibiotic resistance one of the biggest threats to global health security and development today, so this is a major breakthrough in the fight against it.

TOYING WITH SCIENCE

Lydia Melville raises concerns about gender stereotypes in toys.

I still remember what my favourite childhood toy was; a giant cuddly pig. Some of us may still own our favourite toy, proudly on display, worn and torn with love, or at least have it safely stored in the attic. You would be amazed at how this toy may have influenced your choices in life beyond merely providing entertainment. So, what am I playing at?

In the 1996 Friends episode 'The One with the Metaphorical Tunnel', Ross makes gendered comments about toys he believes his son, Ben, should play with, favouring G.I. Joe (the original Action Man) despite Ben's preference for Barbie. Many of the female characters confront him on this. Although it does not help the gender stereotypes, the episode then discloses that Ross himself used to dress in his mum's clothes, which reveals a deeper issue in what is considered 'normal' both by the characters and viewers.

There is an overwhelming sense of ridicule associated with playing with the 'other' gender role. In many ways, Ross' views are dated as children need to learn to interact with everything around them. So why is this division between the sexes and genders still happening, especially with toys?

Child psychologists showed in 2015 that certain toys which involve building and creating, such as Lego, are too often aimed at boys. Physicist and STEM ambassador, Dame Athene Donald, emphasises how creating during playtime develops children's visuospatial and mathematical skills. Playing with dolls is also important for strengthening language, communication and empathy skills, but these toys are often only directed towards young girls. As human beings, we need both sets of skills. So without influence from both toys, children are missing out.

> "Researchers showed in 2015 that certain toys which involve building and creating, such as Lego, are **too often aimed at boys.**"

Television adverts for Lego date back to the 1960s, where all children are addressed. However, by the 1990s they showed mostly 'male' children as 'Lego maniacs' playing with the toys. Not only are they the ones playing, but the only mention of a female character is a toy princess to save from the castle. Girls were largely excluded from the toy range until the development of Lego Friends in 2012, which skewed play towards more passive roles rather than actively creating.

Gender flexibility refers to an open-minded attitude around gender roles. Gender psychologists Ruble and Martin defined it in 1998 as "the willingness to apply an attribute to both sexes, rather than just to one or the other, or the recognition of the relativity of stereotypes, which may vary across cultures".

A child's preferences for toys and playmates is often driven by gender stereotypes from the world around them. This alters through their growth but establishes itself firmly, especially in young girls, at around 7 years old, according to the study. Their results showed that at this stage, girls are more likely to base play decisions on their playmates as well as on the type of toy, whereas young boys care more about what, not who, they play with. Research in 2008 showed that young boys would be excluded more than girls for adopting a non-stereotypical gender role. Clearly, exposure in early life to all types of toys and people could help to remove these barriers and could help to prevent stereotyping, but gendered toys are still being made.

We need to see that there is far more variability within a gender than between the biological sexes. Toys exaggerate the masculine and feminine roles that prevent us from moving into a more gender fluid reality, not just in a toy world. Society then expects young children to decide on their future, influenced by culture, peer groups and adult expectations. When gendered, the way we play ultimately shapes our decisions either towards or away from a career in science.

The toy industry also largely fails to truly represent different ethnicities and disabilities in toys. The Barbie brand, launched by Mattel in 1959, expanded the skin tone and hair styles of the dolls to show the first African American Barbie doll in 1980. By 2016, in preparation for celebrating Barbie's 60th birthday, a new range of dolls with varying body shapes was released – but this does beg the question of why it took so long. A campaign called #toylikeme began to highlight this. Some of the toys are available to see at the 'Play Well' temporary exhibition at the Wellcome Trust Collection in London. Change is slow in happening. But is this enough?

The lack of representation of different individuals among toys raises concern not only of gender or ethnicity, but of the extent that class rules us. Money and income greatly influence what we can and cannot afford as we grow up. Being unable to relate to other children in social environments deeply affects children for a long time. Memories of bullying remain with us for many years afterwards. Social exclusion can have severe consequences for children, including reduced academic motivation, academic success and can cause a negative impact on general well-being. However, divisions based on socioeconomic backgrounds can be dissolved, albeit temporarily, through play. By focusing on how to break barriers in the toy industry during early childhood, we can help future generations feel happier all-round.

The toy industry in the UK is worth around £240m worldwide. The market is enormous and now expanding with online games. So, are we still using the toy industry to 'play well' in accordance with the origins of Lego's Dutch name? The way we spend money guides future generations to discover their interests and the toy industry is just another business with adverts which are made to appeal to what we know and trust.

Ensuring a positive and inclusive message is delivered to children is imperative for their happiness in years to come. Breaking the stereotypical gender roles is part of the game to ensure playtime gives children an understanding of themselves, which they can then use to delve into any career, scientific or otherwise, playing from early life onwards with every possibility. ■

STUDENTS AS PARTNERS IN HIGHER EDUCATION

Sharan Kapadia shares his takeaways from the Student-Shapers programme.

My participation in a two-week 'Student-Shapers' programme, a student-staff collaboration for curriculum redesign at the Imperial College School of Medicine, highlighted the clear benefits of 'students as partners'. There is, however, a perception that the power dynamics inherent to such partnerships can pose a significant barrier. I was keen to explore this further and share some strategies that helped during our project.

STUDENTS AS PARTNERS

Traditionally, Higher Education (HE) has favoured a hierarchical structure, wherein students learn what teachers intend to teach. It seems this unidirectional, consumerist ideology continues to dominate even today. However, a relatively recent and refreshing approach to HE teaching and learning is the 'students as partners' model.

In 2014, Healey, Flint and Harrington summarised the benefits of these student-educator partnerships for both students (in the form of improved engagement, improved agency and increased motivation) and educators (honing teaching methods based on student perspectives).

Collaboration can also create a greater sense of community. However, a significant challenge to the successful implementation of, and outcomes from, such partnerships is the seemingly omnipresent unbalanced power dynamic between staff and student.

WHAT ARE POWER DYNAMICS?

There are many definitions! From a general standpoint, 'power' is the capacity of one entity to influence the behaviour of others. In an educational context, 'power' is inextricably linked to the knowledge possessed by an individual, and 'power dynamics' can be conceptualised as the "differential capacities to act" between teachers and learners. It is therefore unsurprising that an educator's greater subject knowledge and experience introduces a significant imbalance of power.

"Avenues for anonymous feedback is another way to prevent power dynamics from **interfering with student honesty**."

IMPACTS OF POWER DYNAMICS ON COLLABORATIVE WORKING

I believe that the student perspective is one of the richest sources of feedback in the 'students as partners' model. Hence, a significant number of the benefits afforded by student-staff collaboration are grounded in students' honesty and freedom of expression. Indeed, throughout my Student-Shapers project, I saw first-hand the cruciality of an 'open' collaboration. However, it is clear that it would require significant courage to share opinions with senior faculty. When there is an imbalance of power, students may fear being judged, being considered ignorant or arrogant, or their ideas being dismissed. This can thwart expression of a student's own ideas, and their ability to "negotiate" with staff. Furthermore, it is important to remember that several senior faculty members have roles as assessors.

It can indeed be challenging for students to see faculty simultaneously as 'partner' (implying a one-to-one relationship) and as 'assessor' (implying a hierarchical dynamic). Interestingly, the phenomenon of disrupted student expression seems to occur despite the fact that faculty are often keen to hear student opinion. It is quite probable that this is more of an intrinsic apprehension among students rather than an intentional suppression of students by faculty.

SOLUTIONS?

The productivity benefits of "disrupting" power dynamics, such as greater legitimacy and agency, has been described in a recent blog. Though it is likely that some imbalance of power is an inevitable product of student-staff collaboration, we should attempt to lessen it, or mitigate its impacts. In our project, our educators sought to create an environment of friendliness and openness. They engaged with us as colleagues, not superiors. They encouraged contribution by emphasising that no suggestion is trivial. It was evident from day one that faculty were genuinely interested in our thoughts, and we found this highly motivating; it immediately allayed any apprehension.

Changes at the level of the organisation are also paramount. For example, the Higher Education Academy should continue to endorse and promote Student Involvement Projects. At Imperial, we were informed via online announcements, which worked well. Avenues for anonymous feedback is another way to prevent power dynamics from interfering with student honesty. Finally, 'Train the Teacher' courses could work well for staff who collaborate with students.

FINAL THOUGHTS ON A MULTI-DIMENSIONAL CONCEPT

The issues surrounding power dynamics are evidently complex. Although disruption of power dynamics has benefits, power need not always be completely equally divided—I believe we should instead focus on seeking the best out of both parties for the task at hand.

Invariably, viewing barriers such as power dynamics as opportunities to improve partnerships, rather than as roadblocks, is the first step. As summarised eloquently by Healey, Flint and Harrington, committing resources and thought towards mitigating these "barriers" will transform them into "levers for change". ■

PHDS: INDEPENDENT RESEARCH PROJECT OR DIRECTED FROM ABOVE?

Samuel Page talks about the degree of freedom in PhD work.

Doctoral students choose to pursue a PhD for a wide variety of reasons. However, a common motivating factor is the chance to manage an independent research project over several years. An academic environment offers students freedom and autonomy that would be almost unheard of in industry. Doctoral students have a supervisor, but no boss; their research need not be narrowed by the requirements of a company to turn a profit or attract customers.

Despite this initial appeal, many PhD students become frustrated and feel unable to steer their projects in the directions that they wish to. What, then, are the barriers preventing students from holding control over their projects, and is it naïve of them to expect this?

"It can be **difficult for students to communicate their achievements** to their supervisor when their progress has been slowed by unexpected problems."

The principal role of PhD study is to train students as independent scientific researchers. To this effect, they require a supervisor, or supervisors, to teach and guide them. Each supervisor possesses particular interests, expertise and equipment, and they can only take on students to work on projects that they have funding for. Therefore, regardless of how little a PhD student collaborates with other group members, their project is fundamentally dependent on others.

Undoubtedly, the position of a supervisor as the expert is a positive thing. They bring an awareness of previous work in the field and a knowledge of the most promising novel approaches. Despite this, the relationship between a student and their supervisor is sometimes difficult. The project of a PhD student is their primary focus for three to four years of their life. For their supervisor, it is just part of a large portfolio of work undertaken by countless students over countless years, fundamentally differing in personal investment.

Students often feel that their supervisors are too distanced from the day-to-day realities of the science involved, with expectations of the student that are too difficult to achieve. Speaking from the perspective of a Chemistry PhD student, the number of failed experiments often far exceeds the number of successes. It can be difficult for students to communicate their achievements to their supervisor when their progress has been slowed by unexpected problems, leading to conflict and feelings of pressure, or disappointment.

This is symptomatic of a wider problem in science. Only the best results can be published in scientific journals or presented at conferences. Journals don't publish papers of failed experiments, even if they are the norm. This means that a student pursuing a difficult project can often only go so far before they must change to an easier route, so that they can collect some data for their thesis.

Beyond this, the student is fundamentally constrained by the funding and resources available to them. Of course, students can seek to borrow equipment from elsewhere, but this too is affected by the networks they find themselves in. A PhD project rapidly becomes limited to the safety of what the supervisor has done before, what will provide results, and to the environment the student is placed in.

Outside of their projects, PhD students generally feel powerless on a wider scale. Although postgraduate student numbers at a university are often equal to that of undergraduates (as is the case at Imperial College London), postgraduates often feel undervalued as an under-recognised community. Understandably, most university bodies, events and societies are focused on undergraduates. Postgraduate communities, especially those of PhD students, are far more fragmented owing to their variable working hours and the small sizes of research groups. Yet, if PhD students crave independence and self-direction, isn't this an inevitable consequence?

Perhaps the lack of power felt by PhD students can be attributed to their transitory position as not-quite-students in a student world, facing an uncertain future with no guarantee of progression into an academic career. Given all that, is the will for PhD students to have control over their projects unreasonably high? In truth, PhD projects are intrinsically collaborative, constrained and short-lived, meaning that students can only wish for full ownership.

Perhaps the true lesson of a PhD, beyond the training of students as independent scientific researchers, is that people must overcome difficulties by working together towards a common goal for the betterment of science. Simply, in my opinion, there's no such thing as an independent research project. ■

THE AGE OF INSTA-SCIENCE

Priyanka Dasgupta discusses the complications of communicating science in the social media age.

More and more, science is communicated through Facebook posts, Instagram stories and even memes. We have gone from 50 page proposals, to 20 slide presentations, to "Insta" science.

In this attention economy, content needs pretty fonts and spiffy design, while being captivating enough for a reader to consider it worth their while. But does this trimming of content pose a danger to the attention we owe these stories? Does it have the effect of making everything superficial and fleeting?

THE PROOF

A 2019 study from the Technical University of Denmark (DTU) looked at data from Twitter, Google books, movie ticket sales, Google Trends, Reddit and more. It provided extensive empirical data that showed our collective attention span is on the decline. Dr Sune Lehman from DTU explained how the allocated attention in our collective minds has a certain capacity, for which the many cultural items of the world must now compete. This means that the individual attention given to things must be narrowed down.

The results of the study leave room for interpretation. For instance, an oft-cited statistic claims that human attention span has decreased to about eight seconds—down from twelve seconds in 2000. For context, a goldfish has an attention span of about nine seconds. For many, it is evidence that the age of social media has had its dreaded effect, making for a more frivolous generation.

Others argue that this paints only half the picture. When it comes to what one can give their precious time to, there's a seemingly infinite number of options to choose from. And so, people have adapted to going through or filtering content at a quicker speed—call it an evolution of sorts of the collective attention span. It's like when you're able to go through the important information in five chapters on the night before an exam.

The views contradict. Think of it like this: you might not stick around to read a news report on your phone for 10 minutes, but can binge-watch a series on Netflix in four hours. This seems to suggest that while our collective attention span is definitely decreasing, we have started to develop ways to sieve out irrelevant information, and, if the content is engaging enough, we will give it our attention for longer and more often.

THE BIGGER PICTURE

Imagine what this means for communicating complex issues of science. This generational dive into selective condensed experiences, brings on challenges for the contenders from various sectors, who are all vying for our attention. With the inclusion of science as a big part of policy, ranging from health, energy, transport or security, there is a growing need to communicate certain multifaceted concepts quicker and well. There has, thus been an increase in investment in science communication and engagement strategies by a variety of non-scientific institutions. However, this throws us into a highly competitive playing field, where the importance of a subject hinges on the press it receives. We end up with a hack formula of sorts: Attention = promotion = numbers = mass support = funding.

What then of the scientific idea that didn't gain enough traction for investment? Such a financial dependency means that institutions often find themselves toeing a line where the anticipated positive impact of an idea depends on a successful brand campaign.

Granted, a campaign, if it manages to gain traction, can help meet the aimed impact far sooner than it would have taken ten years ago. Think conservation projects, cancer research or autism awareness campaigns. It can also go very wrong, very fast. Seeing things in passing as on Instagram, leaves the scope to get across ideas subliminally, to define new normals or disguise statements as facts. For example, ten influencers who tweet about climate change being a hoax might convince their audience that it's true. The algorithms then push media similar to previous clicks, thus providing similar posts, which then inevitably strengthens polarised communities with staunch ideologies.

> "Institutions often find themselves **toeing a line** where the anticipated positive impact of an idea depends on a successful brand campaign."

There is no doubt about the incredible power of social media when it comes to speaking of science. Stories shared by scientists can give insightful peeks into the diversity, messiness and uncertainty of the world of science. However, the pruning of science to fit Insta stories and campaigns can give way to a fear of dilution of the actual work. While it does make science more accessible and can help break prejudices, as with everything that wields power, caution must prevail. ■

THE COST OF CLIMATE CHANGE

Daniel Mello-Jenkins examines the financial considerations of combatting climate change.

It has been estimated that across the world, over $0.5 trillion is spent annually on projects which will help tackle climate change. This may seem like an enormous amount of money, yet there are still worries that it is simply not enough. Stopping a threat as existential as climate change requires us all to implement the changes needed to keep temperature rise under the 2°C goal, set by the Paris Agreement in 2016. This will require multiple changes to the way we live, and money will play a major role in implementing them.

Climate change is a highly complex issue, but this complexity provides a range of ways to combat it. Reducing current global emissions is a well-known and highly important aspect of lessening future impacts. Currently, the most effective ways to reduce the amount of carbon dioxide released into the atmosphere include investing in green energy, creating and advancing sustainable transportation (such as electric vehicles), and developing agricultural techniques which produce lower emissions. The question is: can this problem be solved simply by throwing money at it?

Perhaps unsurprisingly, the vast majority of climate finance is driven into renewable energy resources, as these projects provide the best returns for their investors. Investment in renewable energy is necessary to reduce future emissions and is clearly an important part of the battle against climate change. However, global emissions have continued to rise, year after year, despite this heavy investment from both the private and public sector.

Not only is there an insufficient amount of money being spent on climate change at the moment, but it is also being distributed unequally. An estimated $400 billion was used to fund fossil fuel subsidies in 2018. With such a thriving market for fossil fuels still existing, it is hard to imagine vital changes occurring over the next few years. The carbon tax, discussed by economists, is a popular option but it undermines an economy that is highly supported by fossil fuels. Very little money was invested in improvements to agriculture, for instance, despite it being a major source of carbon emissions.

As well as decreasing global emissions, it is essential that we begin to reduce the amount of carbon that is already present in the atmosphere. This can be accomplished through both natural processes, like reforestation, or with the highly awaited (but currently almost non-existent) technological approach of global carbon capture. With very little of the world's climate fund going into these projects, carbon will, unforgivingly, continue to build in our atmosphere.

Even more worryingly, hard defences against natural disasters from rising water levels, such as the construction of sea walls (to reduce the impacts of coastal flooding) and inland defences (against freshwater flooding) are receiving very little investment. One of the most unfair aspects of climate change is that these consequences are expected to have the most devastating impacts on poorer nations which, ironically, contribute the least to global emissions. Lower and middle-income countries also have the least money to spend on counteracting climate change. This places them in extremely vulnerable positions, in dire need of help from us in the richer parts of the world.

During the Copenhagen Climate Change Conference in 2009, developed countries set a goal that by 2020 they would provide $100 billion a year in an effort to address this issue. Now, at the start of 2020, despite a step in the right direction, we've failed to continue moving that way. It is unclear whether the target set in 2009 will be met, as the majority of climate finance in developed countries is still being spent domestically.

Wealthier countries have been including loans and money sent in aid of natural disasters within the goal set in Copenhagen. This has led to controversy over how much money is really being invested in climate change. It has been contended that aid money should not be considered as part of the goal, as it is sent to help countries recover from disasters caused by climate change, not to defend themselves against future ones. Developing countries, such as India, have argued that because of this, the money which was promised should be formed of grants alone.

A clearer definition of the agreed terms and more financial donations to countries like India, where the risk of a natural disaster caused by climate change is higher, have been promised within the next five years. However, over the last three years both The United States of America and Australia (previously major contributors to the fund) have pulled out of the agreement, making these goals unrealistic and highly unlikely to be achieved in the set timeframe.

The cost of future damages from climate change is truly mind-blowing. It is well known that natural disasters are expected not only to become more frequent in the future, but they will also be more destructive. Even without considering the uncalculatable expense of human life, damage to infrastructure across the world is set to increase vastly. The true cost of this depends on how we act now. Harrowing estimates predict that if we were to see a rise of 3.7°C by 2100 (which with a 'business as usual' approach is not inconceivable), the world could endure damages to infrastructure of up to $551 trillion, almost a quarter of the world's potential global income.

> "Even without considering the **uncalculatable expense of human life**, damage to infrastructure across the world is set to increase vastly."

These figures are clearly still not worrying enough to those in charge of driving political change. Unless significant change starts now to boost climate funding and to reduce subsidies for fossil fuels, we will drown in the ever-increasing cost of the impacts from climate change. Without coughing up now, we will not have the necessary damage control in place, leaving consequences of our current decisions and the financial burden of them, for future generations to face alone. Without drastic changes to the way the current economy functions, it is clear that no matter how much money is thrown at the problem, the cost of climate change will become an incurable debt. ■

Extinction Rebellion Climate Protesters
by Ben Malandrinos

ADA LOVELACE: A TANGLED LIFE

Cristina Coman sheds light on the complicated legacy of Ada Lovelace.

'The Enchantress of Numbers', a nickname given by Charles Babbage to Ada King, countess of Lovelace, is remembered amongst the top scientists of all time. As a nineteenth century socialite, she moved in high intellectual circles, mixing with some of the greatest minds of the time, such as Michael Faraday, Charles Wheatstone, Augustus De Morgan, and Charles Babbage himself. Regarded as a visionary, Ada is considered one of the first computer programmers—thanks to her contributions to Babbage's Analytical Engine, the first design of the modern computer.

There are, however, a lot of controversies regarding both her personal life and work as a scientist. In her biography, 'Ada, a Life and a Legacy,' psychologist and computer programmer Dorothy Stein attempted to untangle the mysteries behind the Countess of Lovelace's short life. Most quotations throughout this article were taken from this book.

It is fair to say that Ada's life was plagued by drama, some as a consequence of her own decisions, and some circumstantial. As the daughter of two gifted parents, Ada was required to be a genius. As the only legitimate child of Lord Byron, "the mere consciousness of this connection was enough to shape her existence". It most likely did.

"It is fair to say that Ada's life was **plagued by drama**, some as a consequence of her own decisions, and some circumstantial."

Concerned about keeping up appearances after her drama-filled marriage with poet Byron, and fearful of him and his family's negative influence on Ada, Lady Byron took control of her daughter's life and learning from a very young age. Considered "more fortunate than any of her intellectual female contemporaries", Ada was encouraged and supported in her scientific pursuits, particularly mathematics.

Through the power of her family name and her great financial resources, Lady Byron provided young Ada with the very best private tutors. Eager to "make her mamma proud", Ada did her best to emulate her mother, who was reputed for her great learning and ability. Unfortunately, in spite of able tutors, a questioning spirit and abundant time at her disposal, by the time she was 28, Ada was only a "promising 'young beginner'" as she had "great difficulty getting beyond her probing 'first queries' and acquiring a firm grasp of mathematical ethical practice".

"Her overbearing mother controlled **all aspects of her life**."

Her translation of Luigi Manabrea's paper on the Analytical Engine—and the personal set of notes she added to the document—form the basis for Ada's reputation as a mathematician. However, much of this work can hardly be considered original due to the Countess's "dependence on Babbage as sole authority on his machines". It seems she was mostly a promoter of Babbage's personal work.

Important scientific figure or not, her innumerable struggles as a woman living in Victorian aristocratic society left an imprint both during and after her life. Her overbearing mother controlled all aspects of her life until Ada married Lord William King and she passed guardianship to him. King, who was soon after made the Earl of Lovelace, followed clear instructions from his mother-in-law to keep a close eye on Ada's intellectual interests while also managing her finances. Upon Ada's death, Lady Byron militated to protect her daughter's reputation from her late-life mistakes and revelations: gambling debts and a love affair.

It is difficult not to be moved by Ada's life-long struggles. She was constantly battling to find a field she could excel in, having already considered a career in music in 1836. She also suffered never-ending health issues from a young age: measles that left her legs temporarily paralysed, cholera, and eventually uterine cancer, which was to take her life aged just 36. On top of this, she started obsessively gambling "out of the resentment she felt against a mother and husband who seemed so wealthy, free and powerful at her expense". It is a pity that someone with such a promising future, endless opportunities and high aspirations achieved so little.

Celebrated as a key figure in mathematical history, portrayed as a heroine for female scientists, this image of Ada Lovelace hides a more important message of her life experience from other women. As Stein mentioned in an interview with the New-York Times in 1986, Ada's titles, connections and money did not give her the freedom she so longed for her entire life, as she remained enslaved by the "condition of being a woman in society". ■

TESLA'S DESPERATION

Kenna Castleberry writes about how financial hardship affected one of the world's most famous inventors.

Darkness fell on Nikola Tesla's lab, deserted after a long day of work. Tesla had left around midnight, working another 12 to 14-hour day. It was 1895, and he had competitors to best. Marconi, a fellow inventor, was gaining fame for developing a system to transmit radio waves. Tesla had already lost to Edison for powering light through New York. He couldn't afford to lose again.

His lab lay in silence. In the basement, an employee of a steam-appliance company, Mr. John Mahoney, was fighting sleep. He had been working overtime. He decided to take a quick walk around. As he shut the door behind him, he forgot to turn off the solitary gas stove burner, which he had been using to keep his coffee warm.

"Tesla had already lost to Edison for powering light through New York. **He couldn't afford to lose again.**"

This turned out to be one of the biggest mistakes in Tesla's and Mahoney's lives.

When Mahoney returned, he found flames running across the floor of the basement. The heat made his eyes water. He yelled for help and tried to douse the flames. The police arrived, but everyone was driven out of the building when the flames spread to the upper floors. Bystanders on the streets stared as the floors where Tesla's laboratory was burst into fireballs of heat. Light bulbs shattered with the intensity of the flames. With a rumble, the floorboards of the laboratory began to snap loudly as the fire split boards in two. Suddenly, the laboratory fell two floors down, destroying one side of the building. Firemen fought the flames for the next three hours and ordered the houses next to the building to evacuate for safety.

Tesla returned to his beloved laboratory the next morning unaware of what happened. Upon arriving on the scene, his eyes were met with burned wreckage. Ash floated above his head and filled the air with choking dust. The streets were closed around him. Tesla didn't say anything but asked the nearest policeman if he could see if there was anything worth saving from the fire. In the twisted metal and shattered glass, he could find nothing.

Six hours later, Tesla had returned home and was busy drawing designs for a new oscillator. He had lost so much in the fire, and from nothing he had to build himself up again. There was only one man who Tesla knew could finance his dreams.

That man was J.P. Morgan, one of the wealthiest men during the time. He was the head of the largest banking firm, and using his wealth, controlled many other companies such as AT&T, currently the world's largest telecommunications company. He was an imposing figure with a large moustache and staunch attitude.

Over the course of his career, Tesla wrote 500 letters to J.P. Morgan – each one a ploy for money. In each letter he would complement Morgan on his wise investments and describe to him the inventions which could build his wealth. Morgan was not fooled by Tesla's dreams of grandeur. But Tesla's desperation and dedication to continually writing to Morgan eventually won him over.

In 1901, the city of Shoreham, Long Island, became the site of Tesla's wireless transmission tower, called Wardenclyffe. It was 187 feet high, and had a large imposing metal dome. Tesla planned to use the earth's ionosphere to transmit wireless radio messages across the world. Though Morgan pledged $150,000 originally to help finance the tower, Tesla hounded him for more money, explaining how much it would cost to maintain it. By 1917, Morgan had had enough and told Tesla he would no longer finance any of his projects, and that the Wardenclyffe tower had to be taken down.

Tesla's debts were rising high at this point as he had asked other investors for money, but he continued to come up short. In 1917, the Wardenclyffe tower was taken down and sold for scrap metal to pay off Tesla's debts.

I wouldn't be surprised if J.P. Morgan had some satisfaction about Tesla's failure, hoping that he would learn to use investment money more wisely. With Wardenclyffe's ruin behind him, Tesla continued working, fighting poverty again and again, as he sacrificed his life for his inventions. When he finally passed away in 1943, he was almost penniless, but satisfied knowing that he had contributed to furthering the world. ■

PASSPORT PRIVILEGE

Sze Chung Liew reveals the biases and concerns surrounding the power of one's passport.

It is estimated that 80% of global inequality is the result of inequality between poor and rich countries. The passport that you hold, an inherent symbol of identity, determines if you can easily travel around the world, access valuable resources or be given preferential treatment from law enforcement officials.

For some citizens from the Global North, like those from European, North American or rich East Asian countries, their passport is a symbol of freedom, as visas on arrival are generally given without complications. Hence, many Britons gave little thought to the privileges attached to their passports before the announcement of the UK's divorce from the European Union. For others from poorer Asian and African countries (the Global South), it signifies oppression and a barrier to free movement, as nationals have to apply for a visitor visa to other countries months in advance. This is a constant burden, requiring much planning and emotional investment before a flight overseas can be booked.

This is especially painful for young researchers from poorer countries who are seeking to attend international conferences to build an extensive profile of potential collaborators. This is because most international conferences and prestigious research hubs are located in countries in the Global North with stringent immigration policies. As passport holders from these richer countries can usually travel without many restrictions, this further amplifies inequalities in science, rewarding and supporting those who are already privileged.

Even though idealistic science philosophers stress the universality of science, that science can be accessed by those who wish to, the harsh reality is that one's nationality can either enhance or limit their progression in science. Researchers from the Global South may choose not to attend international conferences, as they are subjected to expensive and non-refundable visa application fees which may not be reimbursed by their institutions. Visa delays, rejections or long processing times may cause too much distress to justify attendance at a short-term conference.

> "Highly discriminatory language used in visa refusal letters... can **damage relationships** between international scientists"

Moreover, an approved visa may not guarantee access into a developed country, as they may be denied entry under the discretion of custom agents. This game of chance may be too risky to pursue. A possible rejection could also hinder subsequent visa applications, as inquiry into past rejections will determine the likelihood of future success.

A 2018 report commissioned by the Wellcome Trust found that African and Asian researchers are three to four times more likely to face difficulties regarding visa applications for short-term research visits than European and North American researchers. This is partly due to a lack of visa issuing offices in Africa, thus applicants often have to travel to neighbouring countries. Furthermore, African nationals are twice as likely to be refused a UK visitor visa compared with applicants of other nationalities.

In April 2019, six Sierra Leonean Ebola researchers were unable to attend an important pandemic preparedness training programme in the UK due to visa rejections and delays, despite filling out the correct paperwork. After providing a tedious list of documentation, including his 10-year travel history, one researcher was refused entry because the Home Office did not believe his status as a scientist. Highly discriminatory language used in visa refusal letters and increased suspicion directed towards African visa applicants can damage relationships between international scientists and undermine British efforts to solve global challenges in those countries.

It is hugely ironic and counterproductive that the British government is seeking to promote global health but is systematically creating a hostile environment for those who are actively working on the ground to ameliorate disease outbreaks. Diversifying perspectives through international collaboration is important to challenge the homogenous white, male-dominated narrative that permeates across all scientific disciplines. Local people's understanding of health crises is often ignored, further justifying the need to listen to local perspectives in international conferences to derive holistic solutions.

During an investment summit aimed to strengthen global trade with African countries in January, Boris Johnson acknowledged the hardships faced by Africans in obtaining a visitor visa and pledged a fairer migration system that values "people before passports". To fast-track visa applications for scientists, an agreement between countries in the Global North could allow holders of visas from countries with stringent vetting standards to cross their border without being subjected to further visa applications.

> "We should advocate for **a science without borders**, so bridges between countries can be built for scientific innovations."

Unfortunately, immigration reforms may take years to enact. For now, international events should be held in countries with less hostile immigration policies, such as emerging research hubs in India and South Korea, so more scientists can easily attend.

Calls to improve African immigration policies to the UK exemplifies that inconvenient situations can improve as different countries' international policies and alliances shift. However, the opposite can also happen. A third of a million international students in the USA hail from China. Even though this means enormous income pouring into universities, the American administration are fearful that Chinese students and researchers are partaking in intellectual-property theft or doubling as Chinese intelligence officers. Increased funding from Chinese companies in American universities to support the Chinese Communist Party's activities, such as developing facial and voice-recognition technologies for mass surveillance, further exacerbates distrust towards Chinese scientists. Consequently, five-year visas for foreign graduate students in specific fields of science and technology, such as artificial intelligence, have been reduced to renewable one-year visas. Short-term visas for conferences that were previously issued to Chinese researchers without complications and access to research facilities are presently restricted.

This increased scrutiny towards Chinese scientists further alienates Chinese researchers, as they feel they have to constantly prove their worth to be in a country that views them as spies. In the shifting tide of geopolitics, where you come from will always hold certain prejudices in others' minds. However, we should advocate for a science without borders, so bridges between countries can be built for scientific innovations.

As the recent coronavirus disease (COVID-19) outbreak exemplifies, success in tackling the world's challenges requires global efforts. My hope is that priorities in international collaboration will outweigh any discriminatory immigration policies placed on any nationals, due to socioeconomic and political situations that are out of their hands, when applying for short-term visas. ■

NOBEL WOMEN

The Nobel Prizes have widely become regarded as the most influential award a person can achieve for lifetime accomplishments within the sciences.

Looking at the award's history, S Reid-Collins investigates the lack of diversity and what the Nobel Institute can do moving forward...

- **54 women** and **865 men** have been awarded Nobel Prizes.
- **Only 22 women** have been awarded prizes in Chemistry, Medicine and Physics.
- **6 women** have jointly won awards with their husbands in the sciences, while **only 3 women** have won individually.

There is an alarming lack of diversity within the Nobel Laureates—not just a lack of women, but also a lack of people from ethnic minorities. At the same time, we're seeing the number of women in scientific communities increasing significantly, with 28.8% of the world's researchers now comprising of women (UNESCO Institute of Statistics). This increased diversity within science is not being represented by the Nobel Laureates.

The Nobel Prizes are one of the most visible awards within the media. As the prizes shape the public perception of the scientific communities, representing women and ethnic minorities becomes essential.

The Nobel Prizes are not alone in their gender biases. The Royal Society's Hughes Medal has been awarded since 1902 to an outstanding researcher in the field of energy. It has only been awarded to two women. The first, Hertha Ayrton in 1906, wasn't able to collect her award as women weren't allowed to enter the Royal Society. Thankfully, this policy has changed. Through various programmes, The Royal Society has made great steps to campaign for diversity, including breaking down barriers for and celebrating scientists with disabilities. Despite these positive changes, only one other woman, Imperial College London's Michelle Dougherty, has won the award, in 2008.

WHAT CAN BE DONE TO INCREASE DIVERSITY?

There are many ways that the Nobel committee can improve diversity, which other organisations already recognise. The American Geophysical Union is a scientific non-profit organisation of Earth and space sciences that understands the importance of diversity in science: "Having more diverse voices at the table leads to new perspectives and unique ways of thinking which in turn leads to better science and novel solutions." One of the many ways they are working to increase diversity within science is through a global team that creates nomination packages for people from underrepresented groups.

Another way in which diversity of prize winners can be increased is through diversity within the awarding panels. When panels lack this, a bias (unconscious or otherwise) is built, as people are more likely to give awards to those who look and think like them.

Jess Wade is a postdoctoral research associate in the Faculty of Natural Sciences at Imperial College, whose public engagement work has championed women and ethnic minorities in STEM. She spoke of the importance of visible diversity in awarding bodies: "If you've published a list of who's on the shortlisting committee, it can really change who thinks to apply and also change the outcome."

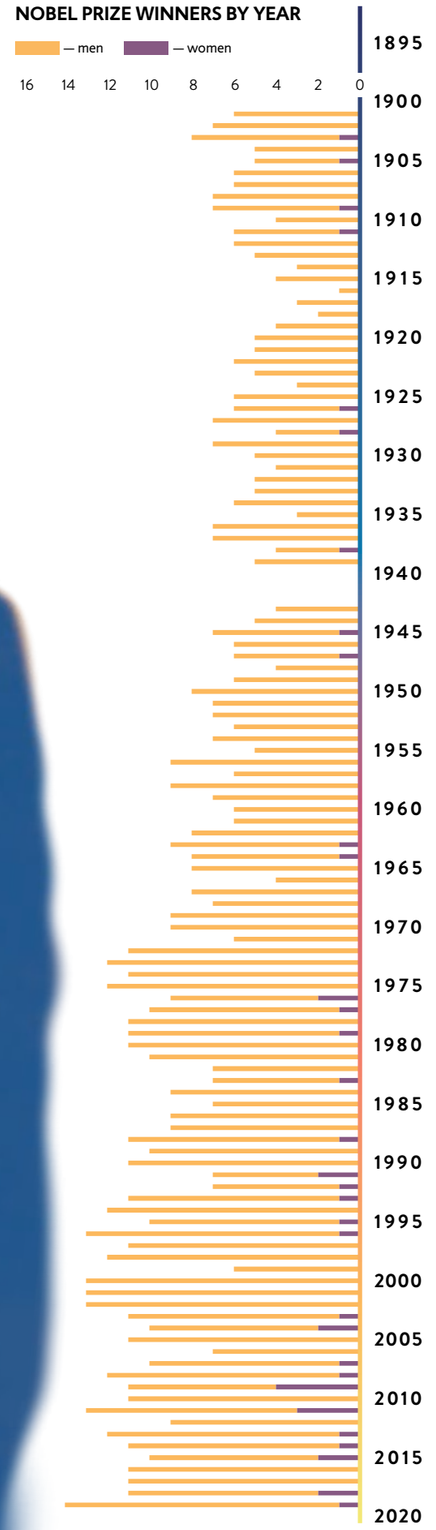
The way in which science happens has also evolved. Large international teams collaborate, and this should be celebrated. In 2017 the Nobel Prize in Physics was awarded to three LIGO (Laser Interferometer Gravitational-Wave Observatory) researchers for capturing gravitational waves. This was made possible through the collaboration of over 1000 scientists working in 15 different countries. Many of those researchers have been awarded medals for their contribution, including 16 scientists in Scotland who received the President's Medal from the Royal Academy of Edinburgh.

> "If you've published a list of who's on the shortlisting committee, it **can really change who thinks to apply** and also change the outcome."

Science has changed, and perhaps it is time for the Nobel Prizes to change to reflect that.

"Science isn't just done by one guy sitting in front of a blackboard with chalk. It's done by huge extensive teams of people around the world. Giving your prize to three old men really doesn't reflect that," says Wade. ■

A NOBEL HISTORY?



1896
Alfred Nobel dies and leaves the majority of his estate to a fund that would award "prizes to those who, during the preceding year, have conferred the greatest benefit to humankind".

1901
First Nobel Prizes awarded in Stockholm on December 10.

1903
Marie Curie becomes the first woman to win an award. Together with her husband, Pierre, she wins the Nobel Prize for Physics for their study into spontaneous radiation discovered by Becquerel (who was awarded the other half of the Prize). She is awarded a quarter of the prize share.

1905
Baroness Bertha von Suttner is awarded the Nobel Peace Prize.

1911
Marie Curie is awarded the Nobel Prize for Chemistry for her work on radiation. She remains the only Laureate to be awarded prizes in two separate science disciplines.

1935
Marie Curie's daughter, Irène Joliot-Curie, is awarded the Prize in Chemistry, shared with her husband.

1947
Gerty Cori is awarded Nobel Prize in Physics with her husband Carl Cori.

1962
Francis Crick, James Watson and Maurice Williams are awarded the Nobel Prize in Physiology or Medicine for their discovery of the structure of DNA. Rosalind Franklin had studied, learned different x-ray techniques, and used this to produce an image of DNA. Shared with Crick and Watson without her knowledge, this was essential to their work. She died four years prior, but her omission has caused great controversy, despite the fact that Nobel Prizes are never awarded posthumously.

1964
Dorothy Crowfoot Hodgkin is awarded the Nobel Prize in Chemistry. She is the first woman to win a Nobel Prize in science without a husband as a Nobel Laureate.

1969
First prize in Economic Science is awarded. To date, only two women have won.

1974
Antony Hewish is awarded the Nobel Prize in Physics for discovering pulsars (rotating neutron stars that emit high levels of radiation and have potential applications across many fields of physics). These were co-discovered by Jocelyn Bell Burnell, who was working towards her PhD at the time. Controversially she was never awarded the Nobel Prize, despite her significant contribution. She has remained vocally gracious about this.

1983
Barbara McClintock is the last woman to date to win 100% share of an award in science.

2009
Across the six awards, five women are awarded Nobel Prizes, the highest number of women in a single year. These are shared with eight men.

2014
Aged 17, Malala Yousafzai becomes the youngest Nobel Laureate.

2018
Donna Strickland is awarded the Nobel Prize in Physics for her PhD work leading to the creation of chirped laser pulses, utilised in laser eye surgery.

2019
Thirteen men are awarded Nobel Prizes. One woman, Esther Duflo, is awarded the Prize for Economics, alongside her husband, Abhijit Banerjee.

HAPPY TOGETHER?

Nelli Morgulchik discusses the impact of merger & acquisition deals in the pharmaceutical industry.

Any business wants to grow; whether it is by growing their profits internally or looking for external opportunities. These 'external opportunities' often refer to companies merging together to create a new company, or one company buying out the other. This phenomenon has a name: it's called a merger & acquisition (M&A). These deals, interestingly, appear to be more prevalent within the pharmaceutical industry than any other industry in the world.

In the last 20 years or so, 60 pharmaceutical companies in the U.S. merged into 10 giant enterprises. In comparison, it takes around 10-12 years for a newly discovered medicine to get to market due to extensive clinical trials. Just putting these figures together, you may already see that M&A deals in the pharmaceutical industry would have a huge impact on the market. As a result, the top five pharmaceutical companies in the world now take up more than half of the industry market share altogether. To put it simply, this means that they sell more than half of all existing drugs in the world.

The "merger spree" is yet to slow down, with the recent multi-billion acquisitions of Celgene by Bristol-Myers Squibb and Allergan by AbbVie hitting the headlines of almost all the financial newspapers.

When a pharmaceutical company discovers a new drug, they rush to patent it to make sure that only they are allowed to manufacture and sell this medicine for a set period of time—usually around 20 years. When the patent expires, anyone else can copy the drug design and make their own drug. This creates a lot of competition for the company that pioneered the therapeutic and can drag their profits down. To this end, pharmaceutical companies are racing against the ticking clock of patent expirations, which explains why they tend to "get together or buy out".

> "Pharmaceutical companies are **racing** against the ticking clock of patent expirations."

It takes years to push a drug through pre-clinical and clinical trials, and as many as 90% fail at one stage or another. Also, keep in mind that the cost of developing a single drug is comparable to the launch of up to ten space shuttles. After that, most companies only have around 10 years to pay off the spending on a new drug. This is because drug development time overlaps with the patent protection. This enormous pressure means pharmaceutical companies are constantly looking out for new products to refresh their portfolio—and this is where M&A deals step in.

In many cases, the M&A move works perfectly. A few decades back, merger mania gave birth to the patriarchs of the pharmaceutical industry: Bristol Myers Squibb and Glaxo Smith Kline. The mergers turned out to be extremely successful; these companies outperformed their past selves and their competitors in their drug pipeline productivity, improving the ratio of successful to failed drugs.

M&A activity also appears to boost innovation in the industry. Large pharmaceutical companies have doubled their revenue share from innovation in the last 15 years. Many pharmaceutical companies fight dirty to extend intellectual property rights for their "wonder drugs", such as AbbVie's Humira, which generates more than 60% of the company's revenue. However, patent battles stifle pharmaceutical innovation. The acquisition of Allergan might in the long term soften AbbVie's aggressive strategy and lead to more drugs in the pipelines worldwide.

On the other hand, M&A deals have their downsides. The pharmaceutical company Bayer might be regretting their decision to take over the agrochemical company Monsanto. The company has had to deal with the many legal cases against Monsanto's herbicides, which have been accused of being carcinogenic. On top of all the time and money spent on the original deal, Bayer's share price fell by a whopping 40% after the acquisition was made public.

> "As a result of M&A transactions, pharmaceutical companies are free to charge **exuberantly high drug prices** with fewer competitors in play."

Yet, as a result of M&A transactions, pharmaceutical companies are free to charge exuberantly high drug prices with fewer competitors in play. The companies don't pick the prices just to cover the research and development costs - they thrive off their profits, earning more than even the largest software companies. When few drugs are available for a specific disease, the public therefore has no choice but to pay. A few might even take out a mortgage on their house to afford the life-saving treatments.

In the US, this situation is particularly desperate because no regulations are in place like in the UK and the EU. High prices and resulting poor access to medicines calls for a change in the way the pharmaceutical industry is funded, for instance, by providing conditional public grants to companies that ensure that products are made affordable when brought to market.

All in all, while merged pharmaceutical companies indeed seem to be happier together and, so far, M&A deals have boosted the industry, only time will tell whether this model will be sustainable in the future. ■

Molly
by Liang Xiao

BLUE SKY'S THE LIMIT

Kate Quillin reflects on the unexpected virtues of blue-skies research.

In 1953, James Watson and Francis Crick revealed the structure of DNA in a paper published in Nature. In 2012, CERN announced that the Large Hadron Collider had enabled researchers to observe the Higgs Boson particle. Last year, scientists at NASA captured the first image of a black hole.

All of these are examples of 'blue-skies' research, which explores ideas which don't yet have any obvious useful application. This type of science is exploratory, pursued to satiate a curiosity about the unknown; it's what we often associate with fields like particle physics, or space research. Blue-skies research is distinct from applied research, which uses pre-existing knowledge to develop specific technologies or practical applications.

What's the point in pursuing knowledge for knowledge's sake? A fair question. But blue-skies research and applied research are not entirely separate. In countless cases, the new knowledge provided by ideas in blue-skies research has formed the foundation of applied research, and led to the development of new technologies. Since the discovery of the structure of DNA, we've developed DNA fingerprinting to solve crimes, uncovered the basis of genetic diseases and identified cancer-causing mutations.

And the story of DNA is only one example. Lasers were invented in 1958, and we've since pioneered laser eye surgery, DVD players and printers. One paper published in Science estimates that 62% of medical discoveries would not have been made if it were not for blue-skies projects that preceded them. Blue-skies research can even stimulate pro-environmental movements; policies to ban plastic straws originated through exploring the amount of plastic in the oceans.

"This type of science is exploratory, pursued to satiate a **curiosity about the unknown**."

Clearly, sailing into the unchartered waters that is blue-skies research presents us with countless new opportunities, and may eventually solve problems we don't yet know exist. However, we also need the ability to solve problems allowed by applied research. With more and more challenges that threaten the world—global pandemics, climate change, food and water insecurity—it is more important than ever to work on developing solutions to these problems.

But how do we strike that balance? Money doesn't grow on trees. As we have seen, blue-skies research can be high-reward, but is also, by its very nature, high-risk. How do we know the new opportunities blue-skies might offer will present themselves? This uncertainty presents a challenge when it comes to allocating research funding.

"**Researchers must justify why**, and on what, they are spending public money."

Many sources of funding contribute towards UK research and development – be it applied or blue-skies. For individual research projects, public funding is generally allocated based on a competitive application process, usually requiring a detailed assessment of the impact proposed research would have, on the economy, and on society. With curiosity-driven blue-skies research, this case may be harder to make.

Symptomatic of these more impact-based funding schemes is a need for accountability. Researchers must justify why, and on what, they are spending public money. Blue-skies research can be expensive—although funded by internationally pooled resources, the Large Hadron Collider cost a massive £3.74 billion to build—and good value for public money is, naturally, an important consideration.

Since the 1970s, there has been a gradual shift away from the traditional view that scientists should be allowed total freedom, to a keener focus on specific objectives in line with the expectations of society, or the economy; it is important that neither extreme has total control. However, critics of the current system suggest that impact-driven research directs us towards 'known unknowns', solving only the problems we already know about.

But things may be changing. The government recently announced plans to invest £800 million in a new agency which would focus on identifying and investing in high-risk, blue skies research. Even if that happens, decisions still need to be made on the allocation of that funding: which risks to take, and where to play it safe.

All of this asks the question: who should then have the final say? Who decides what research is useful, and what is not? Complex questions indeed, with answers just as uncertain. But if the stories of DNA or lasers teach us anything, we should perhaps remember the long-term benefits of taking risks, and make sure that blue-skies research doesn't get lost in the noise. ■

SCIENCE'S BILLIONAIRE BENEFACTORS

Daisy Veysey evaluates the role of private investment in funding science.

Among the several men jostling for the position of the world's richest person, Bill Gates is a well-known name. Love or hate him, the technology giant is no longer at the top spot since giving away around $40bn of his wealth. This was achieved through the Bill and Melinda Gates Foundation, which was set up with the goal of improving global health and alleviating poverty, primarily through funding research into technological solutions. In fact, Forbes places the three trustees of this foundation, Bill and Melinda Gates and Warren Buffett, as the most charitable people in the world.

A person's wealth can be a tricky thing to measure and when faced with the fact that a billionaire, such as Bill Gates, earns an estimated $10m a day, the average person would probably baulk. It isn't unreasonable to wonder what a person could possibly do with that much money. Nevertheless, the system we live in enables such drastic accumulation of wealth into such few hands. Thus, many people believe it is the billionaire's duty to give some of their excessive wealth charitably.

"Investors are much less likely to chance a donation to a lesser-known organisation."

Bill Gates, like many of the 'mega rich', did decide to funnel money into scientific research. It is a field that can yield true innovations, exciting technologies, and life-changing medical advances with almost endless scope for discovery. Not to mention, science is 'hot' right now. The rich and powerful are clamouring to attach their name to the next disease cure or add to the long list of donors to prestigious institutes such as Harvard.

The pull of investors towards science is so strong that scientists themselves are seeking training to learn how to appeal to these bountiful donors. Many new scientific start-ups rely on private donations, for example, from private angel investors or venture capitalists. But are billionaire benefactors actually good for science?

"The rich and powerful are clamouring to **attach their name** to the next disease cure."

In many ways, they aren't. One of the most important issues to point out right now in the world of science is that, in much of the West, private investment into research has begun to outpace government funding. Only around 30% of research in the UK is government funded. This is bad for science in the same way privatisation can be a concern in any industry: when private entities control the funding, decisions may no longer reflect the interests of the people.

Even though much of the private funding comes from within corporations and not from billionaires directly, the flaws of private investment still raise concern. Strong investment biases have arisen as more money is placed into 'trendy' research topics such as infectious diseases, helping global projects like the eradication of polio but leaving physics (despite all the recent interest for black holes and space) to languish. In addition, funding disproportionately favours diseases that affect wealthier Westerners, including cystic fibrosis, and neglects those affecting populations in low or middle-income countries, or ethnic minorities, such as sickle cell anaemia.

Another dilemma with private benefactors is that funding biases do not only exist between different fields, but across research institutions. Science's private investors are much less likely to chance a donation to a lesser-known organisation without the clout or publication record attributed to somewhere like Princeton. Surprisingly, the technology sector might be a field in which, despite its appeal, investors might not get so much bang for their buck. Reports suggest that many technology innovations might not be quite so innovative when much of the work revolves around improving existing technology rather than providing ground-breaking inventions.

There is no denying the importance of the generous contributions of private investors to the world of science. Private investors can push forward start-up companies and have the propensity to target a cause to fund until the goal is met. Moreover, since they are not beholden to the taxpayer, they are likely to fund more risky ventures which the government could not touch.

When it comes to science's current funding imbalances between private and government sources, it seems unfair to only blame the private investors who are, after all, investing. Instead, perhaps we should expect government funding to begin closing the gap rather than relying on private pockets to decide on which ventures are *'hot'* enough to invest in. ■

FLYING THE FLAG FOR ENDANGERED SPECIES

Effective strategy or waste of money? Charlotte Hartley examines the use of flagship species in conservation biology.

With 27% of all species assessed by the International Union for the Conservation of Nature (IUCN) threatened with extinction, the biodiversity crisis is in full swing. Protecting at-risk species relies on securing funding from governments, corporations and the public. One of the best ways to do this is with a popular, charismatic species to draw people in, known as a flagship species.

The idea is that flagship species are appealing to their target audience, so their plight can be used to rally support and awareness of wider conservation initiatives. "[This] is a very efficient approach to sensitise people to the struggles of a declining species," says Cristina Banks-Leite, a senior lecturer in Life Sciences at Imperial College London, "Pictures of slim polar bears are much more impacting than statistics on receding ice sheets."

> "Pictures of slim polar bears are much **more impacting** than statistics on receding ice sheets."

Flagship species help conservation organisations create a brand image, often by incorporating a threatened species into their logo. A famous example is the symbol of the World Wildlife Fund (WWF), the giant panda. Willingness-to-pay studies, which investigate how much members of the public would pay to protect a particular species or landscape, have shown that people are willing to pay more money to conserve likeable species. Emblematising a beloved species can therefore encourage donations from members of the public, which is a valuable way of increasing precious funding for wildlife conservation. It also provides potential donors with a tangible recipient of their support.

A lot of thought goes into selecting the face of a conservation campaign. They tend to be large, memorable animals, with a distinctive appearance. Flagship species are often described as having "charisma", but what exactly does that mean in a non-human animal? A 2006 study defined it as a blend of the species' detectability, usefulness and aesthetics. Together, these characteristics evoke an emotional reaction in humans. For example, the golden lion tamarin makes a good flagship for the conservation of Brazil's Atlantic Forests because of its striking golden coat, social behaviour and, put simply, cuteness.

Charisma, however, is context dependent. Different groups might have different emotional responses to the same species, so it is important for conservation initiatives to have a clear target audience. For instance, hen harriers might appear charismatic to birdwatchers, but their tendency to feed on red grouse makes them a pest to grouse shooters. Likewise, African wild dogs are enormously popular with wildlife tourists, but come into conflict with local farmers wanting to protect their livestock.

Conservationists also need to consider how different flagship species might interact. Indian wild dogs, or dhole, suffered a huge decline during the British occupation of India due to British hunters. Today, they remain under threat from local farmers. Banteng, a species of wild cattle from Southeast Asia, are also threatened by hunting, as well as habitat loss and hybridisation with domestic cattle. Both are endangered and were selected as flagship species on the island of Java. Only one problem: dhole predate heavily on banteng, making it very difficult to prioritise the survival of both species.

A common argument against using flagships is that they skew limited funding away from species that may be in greater peril, but lack that je ne sais quoi. The lack of proportional representation becomes clear when we consider that the vast majority of flagships are birds and large mammals. Yet, the ICUN estimates that a higher proportion of conifers, a decidedly less charismatic group, are threatened with extinction than mammals or birds.

By focusing efforts on flagship species, we should in theory be able to help save other, less exciting species that live in the same habitat, or are threatened by the same causes of extinction. However, according to Banks-Leite, it is uncommon for the requirements of one species to encompass those of all other species in a community. "Saving the polar bear, panda, [or] tiger may or may not save other species and may or may not have an impact on all facets of ecosystem functioning," she says.

Ecosystem functioning constitutes processes such as pollination, decomposition or predation, which rely on many different species by definition. "If the main goal is to preserve ecosystem functions, then we really need to take an ecosystem approach," she says, explaining that by focusing conservation at a landscape level (as opposed to the level of individual species), we can improve habitat quality for multiple species with the same intervention.

Unfortunately, landscape approaches might fail to protect the most sensitive and endangered species, which are usually threatened by persecution or hunting, rather than reduced habitat quality. A recent study led by Banks-Leite showed that the number of these highly sensitive species varies widely between areas. Researchers can use this knowledge to plan the most appropriate conservation strategy. Areas with many sensitive species would benefit from a landscape-based approach, to support the needs of many species. Meanwhile, in areas with just a few sensitive species, tailoring conservation strategies to individual endangered species is more likely to save them.

One group of endangered species that might benefit from a species-based approach are Evolutionarily Distinct and Globally Endangered (EDGE) species. These are species with very few close relatives, meaning they represent a distinct evolutionary history. If an EDGE species goes extinct, a disproportionate amount of biodiversity will be lost, and their unique history is gone forever.

The Zoological Society of London's 'EDGE of Existence' programme borrows tactics from flagship initiatives to raise awareness of lesser-known EDGE species. In doing so, the programme aims to provoke conservation action in order to prevent their extinction.

> "A higher proportion of conifers are **threatened with extinction** than mammals or birds."

One way in which 'EDGE of Existence' draws attention to evolutionarily distinct species is through art. Back in 2018, street artist Louis Masai painted six murals at London Zoo. Each one depicted a different EDGE species in his iconic patchwork style. By focusing on underrepresented species like the gharial (a species of crocodile found in India and Nepal) or Olm salamander (Europe's only cave-dwelling vertebrate), Masai puts them on the map. More crucially, he creates something beautiful out of them, which evokes that all-important emotional reaction.

By learning the lessons of the flagship approach, researchers can apply them to less traditionally charismatic or familiar species. In sparking a positive association, be it through building relationships with local people or through street art, conservationists can garner the attention, support and funding needed to conserve the irreplaceable biodiversity of our planet. ■

ABSOLUTE POWER CORRUPTS ABSOLUTELY

Josie Clarkson discusses why power affects different people in different ways.

"Absolute power corrupts absolutely"—most people are familiar with this 19th century saying from the English historian, John Dalberg-Acton. But they may be unaware that there is more to the quotation. The full quotation is "Power tends to corrupt, and absolute power corrupts absolutely".

The word "tends" gives the statement subjectivity, hinting that power may affect people differently. Just as in The Lord of the Rings, Frodo can carry the ring for most of the story without it corrupting him much, but Gollum is completely overcome by it. Additionally, the distinction between power and absolute power implies that the more power someone has, the more power it has to corrupt.

Do more corrupt people actively seek out power? Or does power make corruption irresistible to even the most altruistic of people?

POWER CORRUPTS

A famous example of the ability of power to corrupt is the Stanford Prison experiment, a landmark psychology study conducted by Philip Zimbardo in 1971. In the experiment, Zimbardo randomly assigned psychologically healthy students to be either prisoners or guards in a mock prison setup, then observed how the power dynamics affected their behaviour. The experiment had to be stopped after just six days, as some guards became increasingly aggressive and sadistic towards the prisoners, who experienced severe emotional responses as a result.

The crucial element to note is that thorough psychological testing conducted prior to the experiment had concluded that the guards were psychologically fine. When interviewed after the experiment, most of them were shocked and appalled by how badly they had treated the prisoners. However, one guard said "Acting authoritatively can be fun. Power can be a great pleasure"—perhaps the allocation of power had revealed the subjects' latent underlying qualities.

Not all guards behaved cruelly towards their inmates, and those who did, did so to different extents. So, what caused this difference in behaviour?

INDIVIDUAL CHARACTERISTICS

An experiment led by Samuel Bendahan showed people are predisposed to varying degrees of corruption. He found people with higher baseline testosterone levels were corrupted more by power. Interestingly, the hormone testosterone inhibits the stress response, so people with more testosterone tend to remain calmer under pressure. Perhaps testosterone-fuelled individuals are more likely to rise to power because they can withstand the stress that comes with positions of authority?

Other experiments have shown that people with more testosterone are rated as less empathetic by their work colleagues. They were also poorer at identifying other peoples' emotions, demonstrating the 'us versus them' mentality created by authority. One study found individuals who exercised their power more avoided social interaction with their workers in order to create emotional distance from them. This lack of empathy and emotional connection explains how powerful people can take actions which benefit themselves to the detriment of others.

While the link between testosterone and power is convincing, it isn't the only variable at play. People who are more prone to dishonesty were shown at first to be more corrupt than honest people. However, honest people were not immune to the corruptive effects of power and became more corrupt when given more power. Fascinatingly, these traits mirror some of those attributed to psychopathy: dishonesty, lack of empathy and immunity to stress.

CUMULATIVE EFFECT OF POWER

Bendahan also found that the most corruption occurred when people were given the most power, supporting Acton's statement about absolute power. It suggests that, while higher testosterone and dishonesty may mean a person is more corrupt to begin with, giving those people more power will corrupt them further.

Several experiments giving people varying degrees of power have shown that power gives people greater self-esteem. This means they attribute overall success to themselves and devalue their workers' contribution, as they feel they influenced their productivity. This leads to more controlling behaviour by the leaders, creating a vicious cycle. Further investigations have demonstrated that people will use whatever power is available to them. Therefore, giving people "absolute power" will enable them to exercise more control, exacerbating the feedback loop of self-esteem.

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So, individual predisposition and the corruptive effect of power operate in conjunction to produce corruption. That is, power does have a corruptive influence, and some people are more susceptible to it than others. ■

SCIENCE COLLABORATIONS OR SCIENCE COLONIALISM?

Matthew Dale digs into the colonial roots of modern collaborations.

Have you ever wondered why our university is called Imperial College? Probably not. The literal name isn't the most important factor in choosing universities. But doesn't it carry some unsavoury connotations? The name unsubtly indicates that the science of this institution was supposed to serve the Empire. In 1920, Imperial's Rector (President) Alfred Keogh wrote that "Imperial College has been developed with a special view to meeting Empire requirements" in a letter to the Colonial Secretary.

Scientific and colonial institutes have always unconsciously enjoyed a symbiotic relationship. A country's colonies granted valuable access to scientific resources. Scientists were able to bring in many specimens of plants, animals and 'exotic humans' to study. In return, inventions such as wireless radio were fuelled by their utility for the colonial effort.

Sometimes, the scientific project played direct roles in colonial projects. Napoleon's invasion of Egypt included a battalion of 160 academics, many of whom were scientists collecting new flora, fauna, and minerals. All of this was motivated by a wider project in Enlightenment France to extract cultural and scientific artefacts for study by the only scholars who could appreciate them: Enlightenment Frenchmen (editorial note: that was sarcasm).

Whilst it may seem safe to assume that's a relic of the past, it isn't easy to recover from such a history. The inequalities created by imperialism have made some scholars concerned about the modern relationships between former colonisers and colonies. While such ties aren't inherently bad, some worry about the potential for continued imbalances in all parts of these relationships, including scientific collaborations.

These relationships are sometimes called neo-colonial. The unequal dynamics create an unhealthy dependency of former colonies on their former masters, hampering the development of their scientific institutions. Though more subtle, the signs are still there.

A 2009 study looking at Central African research demonstrated most countries primarily collaborated with their former coloniser. Cameroonian scientists found that they predominantly did fieldwork and data collection. Many non-Cameroonian collaborators believed Cameroon scientists only contributed with data collection and interpretation, suggesting local researchers were very reliant on their collaborators to do many further stages of the project.

> "Grievances were inconsistent standards adopted within collaborations and how **the collaborator's opinions always won out** in a disagreement"

A case study in an East African university explored these issues further by interviewing local scientists. Many bench scientists voiced complaints about collaborations they argued were unequal. Among their grievances were inconsistent standards adopted within collaborations and how the collaborator's opinions always won out in a disagreement. A former scientist was told they "only hired us" during a dispute with collaborators. Is it any surprise that one scientist questioned whether they could even be called collaborations?

These patterns are also exhibited in biodiversity research. Europe and North America dominates it by controlling the experimental design and analysis/interpretation of results, yet most of the studied biodiversity-rich regions are in Asia, Africa, or South America. This domination manifests through authorship.

One study showed 86% of all first authors, and 95% of senior authors, were from Europe or North America, despite 76% of their sample being co-authored with scientists in developing countries. Scientists from the Global South were also restricted to collecting data and hosting collaborators. As publishing output is important for career progression, European and American scientists have every incentive to put their names first for promotions and future funding. Whilst unintentional, it comes at the expense of the Global South who become reliant on collaborators to do the bulk of scientific work.

These countries labour in a feedback loop from relying on collaborators to design experiments and analyse/interpret results. This means they get the credit for the work, enhancing their reputations and keeping their institutions in the places of power. The Global North attracts funding for scientists and equipment in place of the Global South. Rather than both countries working together as equals, the North has the equipment and manpower to dominate in a neo-colonial structure.

This isn't just a barrier towards establishing healthy and independent scientific institutions, but also creates problems in biodiversity research and conservation. It can hamper attempts to engage local communities with conserving local environments. Unsurprisingly, they will be more trusting of local scientists that speak the language and better understand the culture.

Whilst names like Imperial College may seem like an outdated relic, the history it embodies still manifests in our current world. It's a sobering reminder that the past isn't dead. It's not even past. ■

CAN WE CUT THE TETHER OF IDEOLOGY FROM SCIENCE?

Billy Irving questions whether scientific knowledge can ever be free from ideological values.

Science is a methodical approach to constructing knowledge. It is a process predicated in objectivity. It should be passionless. A scientist should tie no ideological tether to their work, nor hold any stake in the outcomes of experimentation. Science is apolitical, disinterested, cultureless, and universal.

Except, historically, that hasn't been the case. The tether of ideology is not so easily severed. As noted by Sandra Harding in 2009, even the very value of scientific neutrality is founded on European enlightenment ideals. While the truths constructed via the scientific process may provide real benefits, a scientist's original motivation to explore that truth is built on cultural and political contexts.

In this article, we'll look at a historical case study that illustrates how ideology can impact science.

Trofim Denisovich Lysenko was a Soviet agronomist who sought to improve agriculture in harsh climates. In his studies, Lysenko developed a process he called яровизация (yarovizatsiya) or vernalisation. Winter wheat, if grown in the spring, will not typically be harvestable. Lysenko, however, found that by soaking winter wheat seeds in water and freezing them, he could transform the plant into its warm weather variant. This transformation was passed down to descendant generations.

> "Through collectivisation, Soviets sought to **change the human spirit and biology**."

Though scientists have previously observed processes similar to vernalisation, Lysenko was the first to achieve a high rate of success. He concluded that an organism can change its biology due to altered external conditions and pass those changes on to its offspring. This was at odds with the predominant views held by genetic biologists at the time.

More recent studies of vernalisation show that it might be an example of an epigenetic phenomenon, whereby environmental conditions affect one's genes. Lysenko would probably disagree, as he believed in neither genes nor DNA.

> "Our **desire to 'perfect' humankind** might derive from our capitalistic ideology."

Lysenko went on to become a prominent agronomist in the Soviet Union because of his claims of measurably improved agricultural practices. He denounced genetic biologists and even Darwin of proliferating reactionary sentiments. In 1948, the Lysenkoist view of evolution became Soviet canon and scientists who refused to adopt it faced legal retribution.

The source of this Soviet affinity for Lysenko's work is rooted in the issue of ideology that I promised to discuss.

For Lysenko, vernalisation proved that an individual organism is connected to its external conditions. This thinking led him to a preoccupation with an "interconnectedness" of all life. In Lysenko's 1948 speech to the All-Union Lenin Academy of Agricultural Science, he presented a view that organisms are generally mutually assistive rather than competitive, even when they are from separate species.

For a Soviet government that was in the process of collectivising agriculture, a biological imperative for communalism is a no-brainer. The philosophical foundations for the Soviet state rested upon the ability of the human mind to adapt to a new economic paradigm. In this sense, Soviet ideology sought to build a new 'Soviet Man' who could adapt to communal-living and a non-market economy. Through collectivisation, Soviets sought to change the human spirit and biology.

Obviously, this is an extreme example. A critical reader will argue that Lysenko's story is not consistent with their view of science, that Lysenko was hardly a scientist at all. To such a reader, I would point out how ideology also impacted European and American science during the same period. From the turn of the century, several U.S. states passed compulsory sterilisation laws for people in prisons and mental institutions, lasting until 1963. Likewise, the 1933 German Law for the Prevention of Genetically Diseased Progeny mandated compulsory sterilisation for those deemed genetically inferior.

With CRISPR-Cas9 editing, the issue of eugenics persists today. Our desire to "perfect" humankind might derive from our capitalistic ideology, which deems some people to be a drain on resources if they cannot contribute to economic production. Lysenkoism, in a way, is a response to social Darwinism, viewing the human being as a malleable thing capable of change.

If it's possible for ideology to impact science at all, and we choose to accept that possibility, we are left with a choice. We can either abandon any hope of achieving empiricism, or we can constantly question our science, discern the motivations behind it, and edge forever asymptotically towards the Truth. ■

THE BACKWARDS WORLD OF ACADEMIC PUBLISHING

Grace Browne dissects the complexities of academic publishing and the open access movement.

At first blush, the academic publishing system may seem a little confusing to understand. Academics write papers for free. These papers then go through a process called peer review, where the paper is scrutinised, the authors are given suggestions for its improvement, and a decision is made for or against its publication. Peer review, a lengthy and labour-intensive process, is done by fellow academics, also for free, on a volunteer-basis. If published, the research is then sold back to academic institutions and university libraries by journals, to be read by academics, who—in a large sense—created the product in the first place and paid for it to be published.

An estimated two-thirds of the world's research is hidden behind a paywall. People wanting to read an academic article must typically cough up a fee of about $30 in order to gain access. The majority of research is publicly funded, meaning it is supported by the taxpayer's money. Therefore, should a person who is not a member of an institution that subscribes to these journals want to read a research article, they are, effectively, charged twice—once to fund the research in the first place, and then again to read about it.

Academic publishing is an incredibly lucrative business. The largest companies, including Taylor & Francis, Wiley, and Springer, have eye-wateringly high turnovers. The academic publisher Elsevier is the largest of them all, and has also been the one to garner the most criticism. The publishing behemoth made $2.5 billion last year, and regularly has profit margins of 35-40%—that's more than Google, Apple or Amazon.

> "An open access world would mean making journal articles **free to read for everyone**, the world over."

The perceived inequity of the system has driven academics to fight back against it. It was through this pushback that a new movement was born, called the open access movement. The open access community is made up of a crusade of academics who are calling for the journal giants to do away with these financial barriers, once and for all. An open access world would mean making journal articles free to read for everyone, the world over.

Aaron Swartz was a computer programmer, tech-wiz and activist that championed the movement. He viewed open access as a form of political liberation, a means of making the Internet a fairer and better place. However, Swartz's rebellion against what he saw as an unfair system did not escape the attention of the authorities; in 2011, he was indicted on multiple felony counts for downloading several million academic articles from a subscription database called JSTOR. The prospect of imprisonment for up to 50 years pushed Swartz to take his own life in 2013. He was 26 years old.

To carry on Swartz's legacy, Alexandra Elbakyan steps in. Elbakyan is a young Kazakhstani computer programmer and founder of Sci-Hub, an illicit website that hosts a free collection of over 78 million scientific journal articles that would normally be locked behind a paywall. Dubbed by the internet as 'Science's Pirate Queen' and the 'Robin Hood of Science', she is forced to stay in hiding, owing to charges of hacking and copyright infringement by the US Department of Justice. Elsevier also successfully took Sci-Hub to court in 2017, winning $15 million.

But Sci-Hub remains adored by academics and the general public alike, receiving hundreds of thousands of visitors every single day.

The ramifications of a closed-off publishing ecosystem are graver than mere irritation. Only the wealthiest of universities can afford to foot the bill of pricey academic journal subscription fees, which rise dramatically with every passing year. But even the likes of Harvard University have admitted that the subscriptions fees are becoming untenable for them. In 2019, in a stunning move, the University of California system announced it would be ending its subscription to Elsevier, following the trend set by universities in countries including Germany, Sweden, Norway and Hungary.

In poorer countries, the cost of these subscriptions falls beyond the budget of many institutions, meaning much of the research they need access to is unobtainable. It has been argued that the worst of the Ebola pandemic, that resulted in the deaths of more than 11,000 people, could have been largely avoided if the necessary research hadn't been locked behind paywalls. It transpired that a host of studies, buried behind paywalls, had warned of the risk of the virus as far back as the year 1982. When the crisis came, medical professionals caught in the middle of it were not aware of the research, and it took months for Ebola to be uncovered as the culprit at play, with many lives potentially lost as a result.

But who should foot the cost of publishing instead? This is the issue that proponents of open access haven't managed to solve: if readers or the institutes they work for are no longer paying to access papers, a profit must be made somehow. Most typically, this is achieved by charging the authors themselves a fee for the cost of publication. To publish in an open access journal, one must cover the cost of article processing charges, and these can soar as high as $5,000 for some journals, a prohibitive fee for many researchers who are often badly paid. So, the model is not perfect.

> "The worst of **the Ebola pandemic could have been largely avoided** if the necessary research hadn't been locked behind paywalls."

An alternative and increasingly popular choice amongst academics is to publish research on preprint repositories, such as Arxiv and BioRxiv. In doing so, they have the chance to show off their findings before they are published in a journal—free for anyone to view. However, the research has yet to go through the rigor of peer-review, so must be heeded with a healthy dash of caution.

In 2018, a group of eleven research funders in Europe put forward Plan S, a radical proposal that declared that researchers undertaking work financed by taxpayer money would be obliged to make it available to read online for free at the point of publication. The initiative has now been backed by over 20 public funding bodies across 13 different countries, including the Wellcome Trust in the UK and the Bill & Melinda Gates Foundation in the US.

And so, the tides seem to be turning, and all for the better. The traditional for-profit publishing model's stranglehold on science hampers the impact and transparency in research, it hinders the opportunity for collaboration between academics across the globe, and scientific advances may be needlessly stalled as a result. A more open and democratic academic organism would undoubtedly lead to better science.

Until the system changes, the majority of the world's most cutting-edge and innovative research will stay locked away, with only a select few in possession of the key. It is time for the bubble of scholarly publishing to pop. ■

I, SCIENCE