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Message from the Editor-in-Chief

Dear Readers,

Welcome back to the tenth issue of Science Focus! Our beloved planet is in dire need of saving, as evidenced by the plethora of global issues in the media revolving around climate change, environmental awareness and new technology to ease the damage to the Earth. Much of this issue of Science Focus identifies current environmental and climate change research. As the next generation of scientists and policy makers, we hope to instill in our readers a sense of responsibility and invested interest in our planet’s future.

We hope that you can take a break from all that studying by getting caught up with the latest science and technology news by reading our magazine. If you’re interested in science and writing, please don’t forget to keep sending your articles to our Science Focus Article Submission Competition, where we will select the best articles to be published in our magazine and to have a chance to win our juicy prizes!

Enjoy your Science Focus!

Yours faithfully,
Prof. Yung Hou Wong
Editor-in-Chief
Looking for something to do? Check out the following science activities and events happening in Hong Kong.

**Astronomy March at the Hong Kong Space Museum**

Take control of the cosmos at the Hong Kong Space Station in a month of astronomical observations!

<table>
<thead>
<tr>
<th>Event 活動</th>
<th>Date 日期</th>
<th>Time 時間</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy Course: Astronomical Observation 天文課程: 天文觀測</td>
<td>March 21 2017 年 3 月 21 日</td>
<td>7:00 pm – 9:00 pm</td>
</tr>
<tr>
<td>Special Lecture: Are You Ready for the Total Eclipse 2017 in the U.S.A.? 專題講座: 你為2017年美國日全食作好準備嗎？</td>
<td>March 26 2017 年 3 月 26 日</td>
<td>3:00 pm – 5:00 pm</td>
</tr>
</tbody>
</table>


**HKSciFest 2017**

HK SciFest is back again at The Hong Kong Science Museum! Starting **February 18** to **April 23**, enjoy inspiring and interesting events from learning about the world of medicine to coding robots.


**Hong Kong Green Building Week - Green Ambassador Pitch**

Get savvy about environmental issues. Students are invited to team up and come up with a plan to motivate people around them to combat climate change. You can watch your fellow peers, free of charge, on May 20, May 27 and June 7 at the Hong Kong Convention and Exhibition Centre.

Visit their website for more information: [https://www.hkgbc.org.hk/eng/gbw.aspx](https://www.hkgbc.org.hk/eng/gbw.aspx)

![HKSciFest 2017](image1)

**2017香港科學節**


**香港綠色建築週**

想深入瞭解環保問題？香港綠色建築會議邀請各位同學組隊制定計劃，鼓勵週週營造友對候時代，你可以在6月7日到香港會議展覽中心，免費入場支持你的朋友。

The Ancient Chinese had long believed that there was a special relationship evident in blood between paternity and offspring. While not in the least bit scientific, the mixing of blood was a paternally test used in many courts dynasties ago. It was not until centuries later, when scientists offered explanations to the relationship between blood type and paternity, that our understanding towards blood chemistry deepened.

ABO blood groups were first identified in 1900 by Austrian physician Karl Landsteiner. With this identification, Landsteiner discovered that blood types are hereditary, and could be used as a way to test for paternity. Studies then revealed that a single ABO gene gives rise to four variants - A, B, AB, and O - through the co-dominant expression of alleles. In more modern science, molecular biology allowed scientists to identify that these genes encode enzymes in what is known as glycosyltransferase activity. This enzyme activity plays a role in modifying oligosaccharides on glycoproteins sitting on the surfaces of red blood cells. Glycoproteins are antigens, the identifier to our immune system, as well as the markers that differentiate one blood type from another.

Glycoproteins are guarded by various antibodies, which recognise the marker that signifies “self” and “non-self”. Foreign substances, such as viruses and bacteria, are exterminated. Likewise, foreign blood types are rejected by antibodies that attack certain red blood cell antigens. For instance, people with type A blood have A antigens on their red blood cells and make antibodies that attack B antigens. Thus, blood transfusion is highly regulated and could go catastrophically wrong by causing agglutination [1].

Aside from the four blood types, the Rh blood group system, including the Rh factor, is also important in blood transfusion. Named after the rhesus monkey, the Rh factor was discovered to be similar to the antigen of this primate. The Rh factor refers to the most important antigen within this group and an individual either has or does not have this antigen on their red blood cells. This is denoted by Rh positive and Rh negative, respectively [2].

This article may be useful as supplementary reading for biology classes, based on the DSE syllabus.

The question of why humans have blood types to begin with has yet to be answered. Laure Segurel and her colleagues at the National Centre for Scientific Research in Paris surveyed ABO genes in primates. Their conclusions showed that the human ABO blood group likely stemmed from when gibbons and early hominids diverged in their evolutionary tracks [3].

In fact, by 2014 the International Society of Blood Transfusion had recognised 33 blood group systems, namely the MN, Diego, Kidd, and Kell. They are fortunately less common to us because
they trigger weaker and less frequent immune reactions. However, blood science is an ongoing study, and has been extended from identifying new blood groups in the human race to studying the correlations between blood type and risks to diseases and infections. Interestingly, these findings may conversely shine light on the reasons behind the existence of various blood types in human and closer primates in the first place.

<table>
<thead>
<tr>
<th>Red blood cell type</th>
<th>Group A</th>
<th>Group B</th>
<th>Group AB</th>
<th>Group O</th>
</tr>
</thead>
<tbody>
<tr>
<td>紅血球細胞型態</td>
<td>A</td>
<td>B</td>
<td>AB*</td>
<td>O</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antibodies in Plasma</th>
<th>Anti-B</th>
<th>Anti-A</th>
<th>None</th>
<th>Anti-A and Anti-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>抗體存在</td>
<td>B 抗體</td>
<td>A 抗體</td>
<td>無</td>
<td>A 與 B 抗體</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antigens in Red Blood Cell</th>
<th>A antigen</th>
<th>B antigen</th>
<th>A and B antigens</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>抗原存在</td>
<td>A 抗原</td>
<td>B 抗原</td>
<td>A 與 B 抗原</td>
<td>無</td>
</tr>
</tbody>
</table>

除了這四種血型之外，另一個與輸血有重要關係的血型系統是以Rh因子為主。Rh因子與恒河猴紅血球的抗原相似，所以得名。Rh血型系統是根據紅血球表面是否帶有Rh因子，而把血型分為Rh陽性和陰性 [2]。

對於人類血型的起源暫時所知不多。巴黎國家科學研究中心的勞荷-賽格瑞和他的團隊研究靈長類ABO基因，得出的結論是人類的ABO血型，可以追溯至長臂猿和人類分開進化之前 [3]。

直至2014年，國際輸血學會已確認了33個血型系統，其中包括：MN, Diego, Kidd和Kell。這些血型系統引起的免疫反應不多也相對微弱，所以為人所知。關於血液的研究並不沒有停止，並且已從考證人類新血型，拓展至探究血型與疾病感染風險之間的相關性。有趣的是，這些研究結果或可反過來提供線索，揭示人類和接近人類的靈長類動物中，為何會出現各種血型。

参考資料


References 參考資料
Global warming has been an ongoing problem for the environment due to the emission of carbon dioxide. Global temperatures rise, as do sea levels, causing unpredictable changes to ecosystems. Researchers have recently discovered a method that efficiently converts carbon dioxide into ethanol, effectively removing it from the atmosphere, and potentially turning it into useful fuel.

Researchers from The Oak Ridge National Laboratory’s Department of Energy accidentally stumbled upon an electrochemical process that harnesses nanotechnology and catalysts to turn carbon dioxide into ethanol, which can be used as a fuel.

Their original goal was to grow a graphene based catalyst and to assist in the conversion of carbon dioxide into methanol, which also happens to be the first step in producing fuel. However, they realised that the catalyst was doing surprisingly well, so well in fact that they noted the catalyst was doing the entire reaction on its own, skipping anticipated steps [1]. The technique involves using a copper catalyst designed with copper nanoparticles on the surface of silicon, and applying electricity to carbon dioxide in water. Only 1.2 volts are needed to complete the conversion to ethanol at 63% efficiency. The reaction also works in room temperature and can be easily switched on and off without energy penalty, which indicates that the energy conversion can be used as energy storage when generating intermittent renewable energy from wind or solar.

The scientists stated that the reaction is typically difficult to achieve with one single catalyst [2].

The key to this reaction seems to lie with the manipulation and design of the catalyst. While copper itself is not an impressive catalyst, by
ORNL researchers developed a catalyst made of copper nanoparticles (seen as spheres) embedded in carbon nanospikes that can convert carbon dioxide into ethanol. (Photo credits: ORNL)

References


arranging the copper nanoparticles similar to a lightning rod formation, the surface area is maximised (and therefore creates more reactive sites for the reaction to take place). Each spike is around 50 nanometers in length and the tips of these spikes provide the most concentrated areas for the reaction. The energy breaks the dissolved carbon dioxide and reforms it as ethanol. The researchers stated that this process is synonymous to the reverse reaction of ethanol being split into carbon dioxide and other molecules in the presence of oxygen [3].

Advantages of the reaction are twofold. First, the catalyst in question – copper – is inexpensive and easy to manufacture, particularly in comparison to more commonly seen catalysts such as titanium dioxide. Due to its availability and low cost, researchers suggest that their technique to produce ethanol could be fine-tuned to be commercially viable. Second, ethanol can be used as an additive to gasoline that powers vehicles, used in power generators, or as a fuel in ethanol fuel cells.

Their technique still needs to be honed if it were to become viable on the commercial level. Production rate and efficiency need to be increased and there is still much to study in the catalyst’s behaviour. Excess atmospheric carbon dioxide has posed a perplexing problem for scientists for decades, but this technique offers a low-cost, efficient solution to reversing the release of carbon dioxide.

能耗能量，這意味着從風力或太陽產生的間歇式再生能源，可以通過這種能量轉換方式儲存。

科學家指出通常是難於以單一的催化劑來完成整個反應 [2]。

蓉反應具有兩方面優勢：首先，所討論的催化劑——銅，價格低廉而且易於生產，尤其是相對更常見的催化劑如二氧化鈦等而言，由於供應充足和成本低，這種生產乙醇的技術可以改良為商用；其次，乙醇可以作為車用汽油的添加劑，也可用於發動機或乙醇燃料電池。

不過，若要應用在商業層面上，這種技術仍需要多加改進，提高生產率和效率；此外，對這種催化劑的行為也要作更深人的研究，在過去數十年，科學家們為大氣中過剩的二氧化碳煞費苦心，這種技術為逆轉二氧化碳的釋放，提供了一種低成本、高效率的解決方案。

References 參考資料


Global positioning systems (GPS) have taken the world by storm since its development in the 1970s. Its applications have extended from purely navigational assistance to smart phone gaming, spawning popular apps such as Pokémon Go and its predecessor Ingress. In addition to the complex technology of satellite signalling, the GPS is often quoted as a device that is directly affected by Einstein’s theory of Special and General Relativity, but scientists have managed to circumvent this problem entirely.

A GPS can be divided into three segments, namely, specialised satellites, the control centre, and the user device or receiver. Around 30 satellites containing atomic clocks orbit the earth. At any given time, the GPS receiver must be able to receive radio emissions from at least four satellites to determine the location. The receiver essentially calculates the distance between each of the satellites based on the time required for the transmissions to be received. In a process called trilateration that somewhat resembles a Venn diagram, the satellites create information in the form of spheres. The intersections where these spheres overlap pinpoint the location of the GPS receiver. More satellites signals received equate to more accurate of a location.

Since the location is determined by measuring the time it takes for a signal to be received, recording time accurately is crucial. In a nutshell, Einstein’s theory of Special Relativity states that a clock moving relative to an observer will be slower than a clock that is stationary. The theory of General Relativity then states that gravity also has an effect on the way time ticks; the stronger the gravitational field, the slower the clock ticks. Satellites are in orbit around the earth at 14,000 km/hour at approximately 20,000 km above ground. By the theory of General Relativity, the clocks carried by the satellites would essentially be running at a faster time to one on Earth (the effect of general relativity due to less gravity in orbit is greater than the effect of specific relativity induced by higher movement speed), creating an error of about 38 microseconds per day. When this effect accumulates over time, the positioning detected by the GPS would be so off that it would be next to useless.

Yet, this is not the case. A commercial GPS is able to pinpoint a location to an accuracy of about 3 to 5 metres. Satellite clocks are already adjusted for general and special relativity to match the correct time on Earth, making up for the discrepancy between the user location and the satellites’. Additionally, the GPS receiver is also capable of performing calculations that are
required due to Special Relativity. Without these adjustments, the GPS would no longer work to any meaningful degree of accuracy after around 2 minutes as the time lag becomes cumulative.

A smartphone uses a technology known as “Assisted GPS”, which receives signals from both satellites and from servers such as mobile network cellular sites. Compared with a GPS, most smartphones are actually able to pinpoint location faster since it siphons help from connectivity, but where it shines in efficiency, it lacks in accuracy. It would be wise to not entirely trust a smartphone’s GPS lest you walk into a river (yes, it has happened before). Common sense goes a long way!

GPS can be divided into three parts: the satellite, the control center, and the user equipment. Without certain adjustments, the GPS would no longer work to any meaningful degree of accuracy after around 2 minutes, as the time lag becomes cumulative.

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Further Reading: [http://www.astronomy.ohio-state.edu/~pogge/Ast162/Unit5/gps.html](http://www.astronomy.ohio-state.edu/~pogge/Ast162/Unit5/gps.html)
Natural Short Sleepers

All mammals have to sleep. The necessity of sleep puts even the most powerful men and women on their backs. During this sacred time, tissues replenish and organs recalibrate. Humans spend roughly a third of their lifetime in serene slumber – except a small group of “natural short sleepers” who make up just 1 - 3% of the world’s population. These super beings are simultaneously night owls and early birds, potentially working well into the night and waking up early in the morning, feeling entirely refreshed without the assistance of power naps or caffeine.

I come to life about 11 at night, if I went to bed earlier, I’d feel like half my life was missing.  
- Linda Cohen, a short sleeper

The study of short sleepers is a largely uncharted area in sleep medicine and what is responsible for their ability to function on little sleep is widely disputed. One theory suggests that some short sleepers may have a mild form of a psychiatric disorder known as hypomania, characterised by pervasive euphoria and hyperactivity. In a study from The University of Pittsburgh Medical Centre, natural short sleepers scored significantly higher than experimental controls in test scales for hypomania [1].

There are also possible genetic factors that influence short sleeping patterns. A variation in the gene hDEC2 was discovered in natural short sleepers in 2009, by a research team led by Dr. Fu Ying-hui at The University of California, San Francisco who intended to study a circadian rhythm disorder called Familial Advanced Sleep Phase syndrome (FASP). It is a rare condition in which patients become lethargic in the evening and wake up unusually early. To their surprise, they found that the subjects naturally woke up early (around 4 am), but went to bed past midnight, contrary to what would be expected with sufferers of FASP. Genetic screening revealed that the subjects shared a single gene variation, which, once introduced to lab mice, elicited a short sleep phenotype as well [2].

Despite these discoveries, progress in identifying the genetic causes and molecular mechanisms of short sleepers remain marred by difficulties in finding true short sleepers. The data is difficult to obtain since short sleeping hours is hardly a disorder that is cause for a trip to the clinic.

Before you jump to the conclusion that you may be a short sleeper, here is something you should know. Whilst many claim to be short sleepers who regularly maintain fewer than 7 hours of sleep per night, most are chronically sleep-deprived. In fact, for every 100 people who think they do not need more than five or six hours of sleep every night, only about 5 can actually function with that little sleep, while the rest belong to a third of the
population who just do not get enough sleep for health and productivity. Dr. Christopher Jones, a neurologist at The University of Utah, oversaw the recruitment of short sleepers in the 2009 study. According to Dr. Jones, short sleepers are not only blessed with different circadian rhythms, they also feature faster metabolisms and are often more emotionally upbeat.

As splendid as gaining more hours in a day may sound, the National Institute of Health recommends sleeping at least 7 hours a day. Anything less is associated with suboptimal health and performance, particularly in memory. With the hustle and bustle of a cosmopolitan Hong Kong, the average person sleeps just 6.5 hours a day. Dr. Fu stressed that those of us who do not belong to the sleepless elite should aim to get the amount of sleep we truly need.

References


The concept of space nations has been a staple of science fiction for a long time. Coming, but an international group of scientists and entrepreneurs have begun serious proposition of the establishment of Asgardia. Named after the city of the skies ruled by Odin in Norse mythology, the Asgardia project has already recruited citizens to be part of its future. Its announcement has sparked much discussion and unanswered questions.

Asgardia is a prototype of a free and unrestricted society, a placeholder for knowledge, intelligence and science at its core while recognising the value of each human life. This ambition was announced at a press conference in Paris in October 2016. Its core aim is to launch a robotic satellite as early as the end of 2017 or 2018, followed by the establishment of a permanent space station that will act as a nation in outer space. The preliminary idea proposes a society governed by 12 ministries. The first eleven ministries are fixed, while the 12th ministry would be decided by popular vote through Asgardia’s Facebook community. Becoming a citizen of Asgardia is as simple as filling a form on their official webpage [1].

Its utopian concept, while perhaps slightly far-fetched, is at least grounded in noble motivation. The launching of a robotic satellite would potentially act as a shield for Earth, protecting it from cosmic rays, space debris and asteroids, according to a press release. Perhaps more worryingly, Earth’s natural resources will likely be depleted in the near future and building a space nation would be a nifty solution. Finally, a curiosity for the unknown and to step into the unexplored are deeply entrenched in human nature. Just as humans were driven to discover new Earthly continents centuries past, space exploration is a natural step in progression [2].

While there has been much debate about Asgardia’s feasibility as a recognised and legal nation, its scientific achievability is just as ambitious. Scientists have proposed that Asgardia’s role in defending Earth against asteroids, for instance, would involve firing powerful lasers to alter the trajectory of the asteroid away from Earth. To minimise rays of charged particles from the sun that damage satellites, scientists propose giant magnetic fields that deflect these harmful particles. Not only would these projects require large sums of investments to get started, they are also scientifically challenging.

For now, the proposers of Asgardia have remained relatively vague. Its initiation has undoubtedly sparked discussion on space regulations, which are currently lacking. Unlike the International Space Station, which is a joint venture between nations, Asgardia aims to be one entity. For now, the initiators hope that the project would be crowdfunded. Signing up to
become a citizen is apparently open to anyone (although it has been stated that precedence will be
given to those who develop or invest in space technology). For the less ambitious and the commitment-
phobes, the cheapest rides around space currently costs around USD$60 million on a Falcon 9 rocket.

References
asgardia.space/concept
group-claims-have-created-nation-space
An age-old status symbol of luxury and wealth, the crystal of carbon better known as diamond is a must-have jewel to adorn a ring finger. Its entrancing sparkle (measured as brilliance or lustre), characteristic properties such as its hardness, and longstanding role in western marriages have ensured that a diamond does not come cheaply. Yet, its high value is not derived from its rarity — rather, diamonds are counter-intuitively the most common gem, surpassing the more affordable rubies, sapphires, and emeralds in abundance.

Diamonds were brought to unparalleled demand in the 1930s when De Beers Diamond Company (holding 90% of the world’s entire diamond supply) launched the world’s most successful advertising campaign, convincing the public that “diamonds are forever”. Simultaneously, De Beers permanently slashed worldwide production, artificially raising the price of diamonds. In an effort to combat the stranglehold of De Beers and other cartels on the diamond supply, scientists have been attempting to perfect the synthesis of lab-made diamonds from raw carbon. The quality of these synthetic diamonds is rapidly reaching that of natural diamonds, turning a scientific endeavour into a high-stakes gambit.

Diamonds have been mined in India since at least 3000 years ago, but it was not until the 18th century that they were shown to be composed of carbon. Lavoisier used a lens to concentrate sunlight onto the surface of a diamond in a vessel filled with oxygen. The diamond combusted spectacularly and the vessel’s air was precipitated in limewater, producing a milky solution. Through this experiment, Lavoisier was able to show that diamond reacts with oxygen to produce carbon dioxide. Lavoisier deduced that since diamonds and charcoal both produced CO₂, they must be made of the same substance: carbon [1]. Tennant later proved that since the combustion of diamond and graphite both produce the same volume of CO₂, they must be equivalent forms of carbon.

Natural diamond formation requires the conditions of high pressure (4.5 – 6 GPa) and high temperature (900 – 1300 °C). Within the Earth’s mantle, there is sufficient pressure exerted by the weight of the rock above and sufficient thermal energy provided by the Earth’s core. These areas of the Earth are hardly accessible, but deep and violent volcanic eruptions around 47 million years ago brought these diamonds to the surface. Diamonds form in the mantle within the volcanoes’ ejecta. Rapid cooling of the ejecta lock the carbon atoms in place (otherwise, graphite would form). Most naturally formed diamonds are mined from rocks called Kimberlites. Diamonds are also sometimes formed from the impact of diamond-laden meteorites. The collision generates sufficient pressure and temperature for diamond formation to occur.
This article may be useful as supplementary reading for chemistry classes, based on the DSE syllabus.

References
Beyond creating jewels, diamonds have wide applications due to extraordinarily high hardness and chemical stability. For example, industrial diamonds are able to cut through most substances. Diamond windows are extremely impact and abrasion resistant, so they are suitable for spacecraft or laboratory equipment. These applications have prompted scientists to synthesise diamonds in the laboratory by recreating the conditions of natural diamond formation.

A popular method for diamond synthesis is “chemical vapour deposition” (CVD). A sliver of diamond is first placed into a high temperature, low-pressure chamber. Then, a methane-hydrogen gas mixture in a 1:99 ratio (methane contains carbon; hydrogen strips off non-diamond carbon) is pumped in. The gases are ionised into plasma via a laser. Over time, free carbon radicals adhere to the diamond seed to grow larger [2]. CVD allows notably fine control over the impurity level and gem size of the final diamond. It is the impurity level that dictates the final color of the diamond as boron impurities yields blue diamonds, nitrogen makes yellow diamonds, and radiation makes green diamonds [3].

Experts find it increasingly difficult to distinguish a natural diamond from an artificial one; their structures are chemically identical. Since artificial diamonds form differently to natural diamonds, the processes leave distinct growth patterns such as growth striations and discontinuous growth blocks [4].

For instance, IIb type diamonds are inherently blue and emit blue light for a moment (phosphorescence). The reflectance and phosphorescence spectrum differ between natural and artificial diamonds. To leverage this phenomenon, one may shine UV light upon a IIb diamond and observe the subsequent orange-red phosphorescence at a wavelength of 660 nm (sometimes the orange-red is overpowered by blue-green phosphorescence). Other diamonds simply fluoresce under UV light. Upon testing several blue boron-doped synthetic diamonds, it was discovered that they lacked the characteristic 660 nm phosphorescence [5]. Note that this method only works when comparing blue synthetics to type IIb diamonds, one of the rarest types.

Spotting a synthetic diamond remains an inexact science [2]. As synthesis methods improve, it will become even more difficult to identify a synthetic diamond.

At the moment, the demand for synthetic diamonds is dwarfed by that for natural diamonds. However, as prices decrease due to further improvements to the technology, consumers may change their minds. Perhaps natural diamonds truly have an inherent value that does not exist in synthetics.

Regardless, the greatest demand for diamonds lies in the semiconductor industry. As transistors become thinner, silicon struggles to whisk away unwanted heat. With adequate doping, however, diamonds can prove to be the saviour of the semiconductor industry. Their naturally high thermal conductivity is conducive to withstanding higher temperatures without breaking down. In extension, diamond-based semiconductors cool faster, are more environmentally friendly, and switch voltage more readily than a silicon semiconductor. The primary obstacle to widespread adoption of diamonds in the semiconductor industry is their cost. With the advent of synthetic diamonds (specifically boron diamonds because only boron diamonds are semiconductors), a new age of semiconductors may emerge [6].
合成鑽石通常是用「化學氣相沉積」或 CVD 生產，先將一小塊作為種子的鑽石放入高溫低壓室中，然後泵入比例為 1:99 的甲烷—氨氣混合物（甲烷提供碳元素，氨氣移除多餘的碳原子），再用鋸射將氣體變成等離子體，其中的遊離碳自由基附著在種子上，讓鑽石逐漸變大 [2]。 CVD 可以精準控制生成鑽石的雜質和大小，鑽石成品的顏色取決於雜質：含硼的是藍鑽、含氮的是黃鑽，接觸到輻射的就成為綠鑽 [3]。

專家們也認為，越來越難分辨天然和人造鑽石，它們的化學結構完全不同，不過形成過程不同，留下了不同的生長紋，不連續的生長結構等特徵 [4]。

舉個例子：IIb 型鑽石本身是藍色的，也會發出短暫的藍色磷光，天然和人造鑽石有著不同的反射率和磷光光譜，可以利用這來分辨兩者。IIb 鑽石經紫外線照射後，會放出 660 nm 波長的橙紅色磷光（有時橙紅色會被藍綠色的磷光蓋過），其他鑽石在紫外光下只會發出螢光。測試過幾顆掺雜硼的合成鑽藍鑽後，發現它們都不能放出那種特殊的 660 nm 磷光 [5]，不過這方法只適用於比對合成藍鑽和 IIb 鑽石（最罕見的鑽石種類之一）。

鑑別人造鑽石仍說不上是一門精確的科學 [2]。隨著合成方法的改進，要識別合成鑽石將會變得更加困難。

目前，對合成鑽石的需求跟天然鑽石相比是微不足道，不過，當技術進一步改進以致價格下降後，消費者可能會改變主意；除非天然鑽石確實具有在合成鑽石中找不到的內在價值。

無論如何，對鑽石需求最殷的還是半導體工業，電晶體變得越來越薄，材料已難於應付所產生的變形、擴入足夠雜質的鑽石可以讓半導體工業解開這個困局。鑽石有很高的熱導率，可以承受高溫而不會損毀，相對於砂半導體，鑽石半導體更快冷卻，更環保，也更易切換電壓。目前尚未能在半導體工業中廣泛採用鑽石，主要的障礙是成本。隨著合成鑽石的出現（特別是硼鑽，因為只有這類鑽石能作半導體），可能會出現半導體的新時代 [6]。

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What comes to your mind when you hear the word dominance? You may think of a group of confident athletes and cheerleaders, or that one person in your class who frequently answers questions in class. The phenomenon of social dominance is not only seen in humans, but also exists in the animal kingdom—especially in our closest living relatives, the chimpanzee.

Chimpanzees are one of two extant great apes living in the forest of Central Africa (the other being gorillas). They travel in small groups of up to ten individuals to forage or hunt. The memberships of these small groups are often dynamic, where chimps regularly split with current groups and merge with new groups. Sometimes, these small groups join together in a large gathering when food is abundant or to increase chances of mating.

But similar to human groups, a lack of a clear shot-caller or leader could potentially signify chaos. Social hierarchy exists in chimpanzee communities, dictating the quality of life, such as who gets to eat the most fruits or to mate with the highest-ranking females [1].

Within this community, studies have shown that male chimpanzees are dominant to all females, with one male reigning at the top. This dominant male is called the alpha—and he is usually the fittest and the most aggressive in a group. Other than brute force, the ranking system also appears to follow the age of the chimps; ranking increases with age and peaks at around 20 years old, before seeing a decline as the chimp ages [1].

The social system of chimpanzees is studied by scrutinising their behaviour during their interaction with one another. To determine the social ranking of each chimp, scientists observed their communication through a signal called the “pant-grunt”—performed by one chimp to another in a display of submission. The researchers then noted who submits to whom, and eventually plotted a hierarchy in the community of chimps [2].

Though, living in this seemingly orderly community is not as harmonious as it appears. Male chimps fight each other constantly for the highly coveted alpha status to gain access to more food and better chances to sire an offspring. Even though females also exhibit similar hierarchical status within the community, their rankings were less prominent as they have fewer interactions between them in comparison to male chimps [2]. Studies show that rather than fighting, female chimps prefer to “wait in queue” until one dies or leaves the group [3].

Such seemingly “passive aggressive” behaviour could be beneficial to the females. Compared to males, female chimpanzees seem to have adopted a long-term strategy for survival. If a male wants to sire an offspring, he can mate with multiple females in a short period of time. For a female however, she can only raise one young chimpanzee at a time—thus her reproductive success depends heavily on how long she can survive [3]. For female chimps, good things come to those that wait. As they avoid challenging each other in a series of potentially-tumultuous fights, they also avoid dangerous situations and threats to their survival.

By Rinaldi Gotama 李嘉德

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聽到「優勢」一詞，你或會想到那些總是在運動場上耀武揚威的運動員和啦啦隊，或者那位老是搶著答問題的同學。其實，「社會優勢」現象不單是見於人類社群，也曾普遍存在于動物界，特別是在人類的近親黑猩猩族群中尤其明顯。

黑猩猩是現存中非森林中的兩類大猿之一（另外一類是大猩猩），牠們結伴覓食和打獵，每群不超過十隻。群落成員經常換換，拆夥之後又融入新群落。有時，不同的群落還會在食物豐足的日子，或是交配季節聚集起來。

跟人類社會一樣，若沒有發號司令的領導者，就有可能出亂子。黑猩猩的社群也有等級之分，主宰黑猩猩的生活質素，決定哪位成員可以享用最多的水果，或跟地位最高的雌性交配 [1]。

研究顯示，在這些群體中，雄性黑猩猩支配所有雌性（女生們對不起啦~），而且只有一隻雄猩猩會擔當領導者。屹立於社會階梯的頂層，被稱為阿爾法雄性，通常是族群裡最健壯和最好鬥的一隻；但除了蠻力以外，年紀似乎也會影響社會地位：黑猩猩的地位隨年齡而攀升，在二十歲左右達到巔峰，之後隨著年華老去而下降 [1]。

你可能會問，子非猩，安知猩之位？其實是通過細察牠們的互動行為，來探索黑猩猩的社會系統，為了判斷每隻黑猩猩的社會地位，研究人員分析牠們的溝通信號，特別是在表示服從時發出的個別的伴著喘氣的咕嚕聲。研究人員根據這些聲音記下每隻黑猩猩服從的對象，以此分析出族群裡的等級高低 [2]。

不過，在這看似循規蹈矩的社群裡生活，並非如想像般和諧。親密關係的雄性黑猩猩經常互相打鬥，以爭取高位所帶來的飽食和更多繁衍後代的機會。另外，雄性之間的互動不及雌性頻繁 [2]。研究顯示，雌性黑猩猩不會以武力爭取，寧願安分守己，等待上位者過世或者離群 [3]。

雖然如此，雌性黑猩猩的「被動攻擊」行為好處甚多。跟雄性相比，雌性黑猩猩似乎傾向採取長遠策略求存。雄性可以在短時間內跟多名雌性交配，完成傳宗接代的目的。雌性卻只能在同一時間撫養一隻幼猩，因此生殖成功率在很大程度上要取決於能活多久。既然進化適應性與壽命掛鉤，就意味著打鬥的代價太高，不值得為了爭奪高位而冒險 [3]。

對於雌性黑猩猩來說，耐心等待自然會帶來好處，牠們不會互相挑戰，捲入連番的惡鬥，也就可以避開險境，降低了對生存的威脅。

等待，值得嗎？
According to the U.S. Department of Agriculture (USDA), produce grown without the use of artificial fertilisers, pesticides and dyes and not processed using industrial solvents can be categorised as organic. Animals that turn into meat cannot be fed growth hormones or regular use of antibiotics. Furthermore, both produce and meat cannot have undergone genetic modification. These stringent rules typically translate to higher prices in the organic alternatives, but organic products are generally viewed as the healthier option.

However, according to a recent comprehensive literature review conducted by scientists at Stanford University Medical Center, organic food may not necessarily contain higher nutritional value or offer fewer health risks than non-organic food. Taking account of 17 studies that documented subjects who had normal diets versus organic diets, and 223 studies which examined nutrient levels in organic food and conventional produce, they did not find substantial evidence that supported significant health benefits in organic foods. Aside from phosphorous, vitamin content was similar in both types of food as well.

The study did reveal that organic produce in particular had less risk of pesticide contamination and that while they still contained pesticides, the levels were all under safety limits [1]. However, Christie Wilcox, postdoctoral researcher and scientific communicator at Scientific American, explains that conventionally grown produce is also strictly monitored for pesticide residue [2], and “from a practical standpoint, the marginal benefits of reducing human exposure to pesticides in the diet ... appears to be insignificant” [3].

That being said, the advantages of organic farming for the environment and for ethical reasons are far-reaching, even if the health benefits seem to fall flat. In a paper published by Nature, scientists David Crowder and colleagues reported that organic farming not only alleviates ecological damage brought about by human activity, but also restored balance between predator and pathogen biological control agents, which extended to natural pest control [4]. For instance, organic weed management enhances suppression, instead of elimination by synthetic herbicides used in conventional farming.

There is also evidence to show that organic farming may be more energy efficient than conventional methods. In a three decade study conducted by the Rodale Institute, they grew conventional and organic corn under controlled conditions and recorded the energy usage in both. The results were astounding. One hectare of corn grown conventionally required 71% more energy than that of the organic corn. They attributed this large discrepancy in energy requirement to the use of nitrogen-based fertilisers. Conventionally grown corn used synthetic nitrogen fertilisers, which requires a large amount of oil to manufacture [5]. While the organic crop also required nitrogen, they were able to use sources from compost, nitrogen-fixing crops (legumes) and natural fertilisers that contained the element. It seems, that organic farming may reduce our carbon footprint significantly.

Organic foods are indisputably more expensive than conventionally grown crops and the average consumer must make a decision as to whether it is worth the extra investment. The premiums attached to organic foods come from a typically lower yield – more time to produce and smaller farms. While there appears to be mounting evidence...
for insignificant health and nutritional benefits from the consumption of organic produce, the advantages of organic farming for the environment are extensive. Besides, organic food generally does taste better than their conventional counterparts.

References


In the past century, the Earth’s temperature has risen around 0.5 °C per year, which has translated to about a 2.6 inch rise in global sea levels between 1993 and 2014 due to melting ice caps. At this rate, experts believe it will take five thousand years to melt all five million cubic miles of ice on Earth. The precious coastlines and landscape we take for granted will soon be at the demise by our own hands. Thus, the effort in slowing down rising sea levels is extremely important.

What Would Happen if All of Earth’s Ice Melted?

Much of Earth’s land mass is comprised of ice caps in the Arctic and Antarctica. The latter alone consists of an average ice thickness of 2133 m. If all of Earth’s ice caps defrosted, the total rise in sea level will likely reach 70 m [1]. This means that entire cities will be submerged. In addition, continents and shorelines will be changed. New York, Tokyo, Shanghai, Jakarta and Hong Kong are all coastal cities that will be wiped out. In fact, a mere rise of 10 m in current sea levels will displace more than 600 million people (nearly 10% of the world’s population). The entire state of Florida will be drowned, as well as many areas in Asia and a new inland sea will be created in Australia. Half of the population in the world who live near coasts will be homeless.

In addition to humans, the habitats of polar bears, seals, walruses and penguins will undoubtedly disappear as these organisms rely on ice caps to survive. According to the United Nations Global Biodiversity Outlook, the loss of ice in the Arctic threatens biodiversity across an entire biome and most species will be unable to adapt to a habitat without ice caps.

That being said, the temperature in Antarctica rarely ever fluctuates above freezing point, which protects the ice caps from melting. At present, what is most concerning to rising sea levels is actually the Arctic, where ice floats atop the Ocean and is more prone to melting. In addition, melting ice caps in Greenland contribute to rising sea levels significantly as it is geographically...
located farther toward the equator with higher temperatures.

Climate scientists at Climate Central, Ben Strauss and his group, attempted to correlate the burning of fossil fuels and carbon emissions with the rise of sea levels. By analysing massive amounts of data accumulated over the years, they plotted sea levels against carbon emissions and temperature, and were able to determine ratios between the factors. They concluded that “burning [just] one gallon of gasoline translates to adding 400 gallons of water volume to the ocean” [2]. Consider extrapolating that into global consumption - The United States alone burns a daily average of around 385 million gallons of gasoline.

Reducing carbon emissions is perhaps the most intuitive way to decrease the rate of sea level rising. However, according to a study from the National Center on Atmospheric Research, this might already be too little too late. While certain forecasts are more optimistic than others, the general consensus appears to agree that the rise of sea levels is inevitable. What seems to be a more useful solution is to embrace the ability of humanity to adapt to the changing environment and to impede melting ice caps to allow time for this adaptation to occur.

References 參考資料
Genetic disorders are abnormalities that exist at birth or from new mutations in the genome. Until recent decades, genetic disorders were not well understood, but gene therapy, which aims to restore the normal sequence of DNA after a mutation, has helped significantly. Prof. Adrian Bird, 2016 Shaw Laureate in Life Science and Medicine, shared the Shaw Prize with Prof. Huda Y. Zoghbi, in making substantial advances in treating a particular genetic disorder known as Rett syndrome, which affects the grey matter in the brain. They discovered the encoded proteins that recognise a chemical modification of the DNA which influences gene control as the basis of the developmental disorder.

Rett syndrome is brought about by mutations in the gene MeCP2 on the X chromosome and can cause developmental problems in babies such as small hands and feet as well as microcephaly in some cases (slowed rate of head growth). Prof. Bird found that mice with MeCP2 mutations also displayed similar clinical features of Rett syndrome. In both humans and mice, the syndrome causes neurons to be smaller and less active. Prof. Bird attempted to correct the mutation by replacing the missing MeCP2 protein in mice, yielding positive results after gene restoration. The experiment established that Rett syndrome is, at least in principle, a treatable condition.

While ground-breaking and undoubtedly exciting, gene therapy has historically encountered numerous setbacks. Prof. Bird said:

“Perseverance, imaginative and patience are some of the prerequisites for being a scientist.”

He discovered the MeCP2 protein back in 1992 but many of its functions are still shrouded in mystery to be unraveled. He believes that the best way of conducting research is to test hypotheses rather than to continuously collect biological data as a means to gain real knowledge. Thus, he insists on bold experiments and is not afraid of destroying hypotheses that he holds dear.

“My dream is that I am still doing science when this distressing disorder is finally cured.”

Prof. Bird’s laboratory remains interested in genome organization and, in particular, in how epigenetic markers are laid down to assist and manage gene activity. Part of his group works on CpG islands and DNA methylation. Their research on Rett syndrome is ongoing and they have plans to test new hypotheses about MeCP2 and its correlation to Rett syndrome. The ultimate goal is aimed at making Rett syndrome gene therapy a reality.
基因治療與
阿德里安 • 伯德教授
Prof. Adrian Bird
By Teresa Ming Shan Fan 樊銘珊

遺傳性疾病是指在出生時已出現或由於基因組的
新突變而造成的異常，直至近幾十年，對遺傳疾病的認識還
是不多，但因為有基因治療，情況大為改善，基因治療的目
的是將經過突變的脫氧核醣核酸 (DNA) 恢復到正常序列
艾德里安 • 伯德和胡達 • 佐格比兩位教授共享2016年度邵逸
夫生命科學與醫學獎殊榮，他們發現了雷特氏症疾病的治
療取得實質性進展。雷特氏症是一種影響大腦灰質的遺傳病，他
們發現一類蛋白能夠識別一種影響基因調控的DNA化學修
飾，並確立編碼這類蛋白的基因發生突變，就會導致發育障
礙疾病雷特氏症。

雷特氏症是由X染色體上的MeCP2基因突變引起，可以
在嬰兒期引發多種發育問題，例如 ; 骨骼發育障礙、有些案例
出小頭症(也就是頭部生長速度減慢)。伯德教授發現帶有
MeCP2突變的小鼠，出現類似性徵，在雷特氏症患者和小
鼠實驗模型中，神經細胞數量減少而且活性不足。伯德教授
嘗試修正突變，補充小鼠模型中缺失的MeCP2蛋白質，在修
復基因後得到良好的結果，這實驗說明了雷特氏症在原則上
是可以治癒的。

預期在不久將來，這漂亮的方案就可以用於治療雷特氏
症。伯德教授最近和美國科學家合作，試圖用小鼠為模型設
計基因治療，他們使用病毒載體遞送MeCP2基因。理論上這
方法亦可以用於人類，接受這些療法的小鼠，症狀有明顯改善。
不過在進入人類臨床試驗之前，還有漫漫長路要走。

這項突破鼓舞人心，但過往基因治療曾遇過許多
挫折，伯德教授說 :

「科學家必須要有毅力、想像力和耐心。」

其實，他早在1992年已發現了MeCP2蛋白質，但其許多功
能還有待破解。他認為研究的最佳途徑是驗證假設，而非
只靠不停收集生物數據來求取真知，因此，他主張大膽作實
驗，不怕推翻那些他看重的假設。

「我的夢想是，當這種讓人受苦
的疾病終於能夠被治癒時，
我依然在从事科學。」

伯德教授實驗室仍然致力研究基因組的組織，特別
是關於表觀遺傳學標記，如何佈置以協助和管理基因活
動，部分成員的研究集中在CpG島和DNA甲基化。與雷
特氏症相關的研究還在進行中，並有計劃測試關於MeCP2
的假設及與雷特氏症的關係；最終目標是要實現雷特氏
症的基因治療。
For more than two decades, Prof. Randy Schekman had been a Howard Hughes Medical Institute Investigator at the University of California, Berkeley. He and his collaborators made pioneering breakthroughs and discoveries of targeted vesicular transport in eukaryotic cells, and found that malfunctions in yeast cells arose due to genetic defects. In 2013, Prof. Schekman shared a Nobel Prize in Physiology or Medicine with Prof. Thomas Südhof, whom we interviewed back in the first issue of Science Focus.

Prof. Schekman’s passion for science began early. Stemming from a toy microscope that he received as a gift, he would examine the water retrieved from a nearby creek to find a world of creatures swimming under the lens. His passion for being a scientist was magnified when he saved up enough money to purchase his first professional microscope, a treasure held dear to him until he left for university. Those findings would be reported in a yearly independent science fair project. A career path of research seemed natural.

For the past 20 years, Prof. Schekman has been working on cell communication in the form of an extracellular vesicle, or exosome, which contains membrane proteins and a set of RNAs that convey information to control signalling and gene expression in a target cell. He found that exosomes capture selected microRNAs that form on the surface of an endosome inside a donor cell. Thus, Prof. Schekman’s lab has devised a biochemical approach to study the mechanism of RNA sorting into exosomes, but the role of the extracellular RNA contained within exosomes that delivers such information remains uncertain.

Their research has helped the biotechnology industry make significant advances. The knowledge of transport and communication of cells reveal ways in which drug delivery can be made more streamlined and efficient. Insulin and human growth hormone, for instance, can be released by yeast. Additionally, their mapping identified how nerve cells release neurotransmitters. The research has far-reaching future implications as well, particularly in the application of treating metastatic cancer, or the development of progressive neurological disorders such as Alzheimer’s disease and Parkinson’s disease. According to Prof. Schekman, it is hopeful that exosomes could be engineered to deliver small molecules or RNAs that control pathological processes in targeted cells.

Prof. Schekman’s philosophy for facing the inevitable setbacks and difficulties in research is to maintain a patient attitude and to always meticulously plan in case one approach fails.

“It is easy to become frustrated with the usual failure of experiments, but one must remain motivated by the main goals and approaches, and be willing to re-examine an approach to find a new way forward.”

Not surprisingly, Prof. Schekman has received generous and continuous support for his research from the U.S. National Science Foundation, the U.S. National Institutes of Health and the Howard Hughes Medical Institute. It is likely that he will continue to work on membrane assembly, vesicular transport and secretory pathways until he chooses to retire.

“My keeest interest is in establishing the molecular basis of miRNA sorting into exosomes and to seek evidence for or against a role for the small RNAs within exosomes in delivering information from a donor to a target cell.”

蘭迪•謝克曼博士是加州大學柏克萊分校教授，同時任職霍華德•休斯醫學研究所超過20年。他與合作者在真核細胞的靶向囊泡運輸研究方面，作出了開拓性的貢獻，並且發現遺傳缺陷造成酵母細胞的功能障礙。謝克曼教授與
Cellular Transportation with Prof. Randy W. Schekman

2013 Nobel Laureate in Physiology or Medicine

托馬斯•聶德霍夫教授於2013年共同獲得諾貝爾生理學或醫學獎，我們有幸訪問聶德霍夫教授，刊於「科言」第一期。

謝克曼教授從小就熱愛科學。他在童年時收到了一份禮物，是一台玩具顯微鏡。他拿著鏡片，他看見從附近小溪採集的水樣包羅眾生。他築夠了錢，買了第一台專業顯微鏡時，他就更醉心於科學探索。每年都有成果在科學展覽展出。這台顯微鏡一直是他的寶貝，直到他離家上大學。對他來說，踏上科研路是自然不過的。

在過去20年，謝克曼教授一直研究通過胞外囊泡或外泌體進行的細胞通訊。這些外泌體含有膜蛋白和載著資訊的RNA，可以在靶細胞調控信號轉導和基因表達。他發現外泌體可以從母細胞內的細胞外液采集指定的微RNA。謝克曼教授試室試地設計了一套生物化學方法研究分選RNA到外泌體的機制。至於外泌體中的胞外RNA的機制仍然是不明確的。

他們的研究讓生物技術業取得了重大的進展。有了細胞運輸和通訊方面的知識，就可以研發更精確有效的藥物傳輸方法。例如，胰島素和人類生長激素可以通過酶釋放。他們的工作也證明了神經細胞如何釋放神經遞質。這項研究對未來還有深远的影響。特別是應用在治療轉移性癌症，或進行性發展的神經系統疾病如阿爾茨海默氏病和帕金森病。謝克曼教授認為外泌體纔改進後，有可能用於遞送小分子或RNA到靶細胞，控制病理過程。

研究中免不了會遇到挫折和困難，謝克曼教授的哲學是要保持耐性，失敗之後要細心籌謀。

“這會經常會失敗，很容易會因此而氣餒，但必須要繼續往目標前進，並且願意重新檢討以求找到新出路。”

讓人慶幸的是，謝克曼教授一直得到美國國家科學基金會、美國國立衛生研究院和霍華德•休斯醫療研究所的慷慨支持，應該可以繼續研究膜組裝、囊泡運輸和分泌途徑直到他退休為止。

“我最大的興趣是要建立微RNA分選到外泌體機制的分子基礎；及要尋找證據說明外泌體中的小RNA在細胞之間的信息傳遞是否起作用。”
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