Columbia Science Review

SLEEPY TIME
THE SCIENCE BEHIND NAPS

LACTASE PERSISTENCE
GENETIC MUTATIONS FOR THE ENJOYMENT OF Dairy

BIRTH ORDER
EFFECTS ON PERSONALITY AND INTELLIGENCE

THE LIFE AND DEATH OF STARS
THE BEAUTY OF SUPERNOVAS

Editorial Board

The Editorial Board biannually publishes the Columbia Science Review, a peer-reviewed science publication featuring articles written by Columbia students.

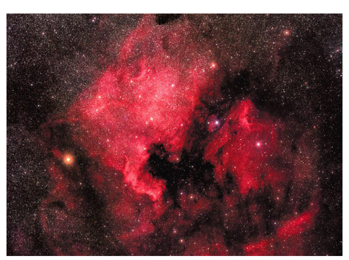
Administrative Board

The Executive Board represents the Columbia Science Review as an ABC-recognized Category B student organization at Columbia University.

The Columbia Science Review strives to increase knowledge and awareness of science and technology within the Columbia community by presenting engaging and informative articles, in forms such as:

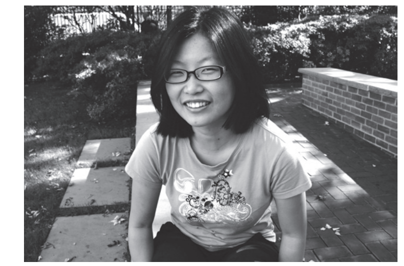
- Reviews of contemporary issues in science
- Faculty profiles and interviews
- Editorials and opinion pieces

Columbia Science Review



COVER PICTURE: An angiogram of a healthy human heart. Doctors use angiograms, also known as arteriogram x-rays, to diagnose and determine treatment for coronary artery diseases as blockages of either the left or right coronary artery could lead to a heart attack. [See Healing the Heart, pg. 10, for more information] Photograph by SPL/Photo Researchers, Inc.

Editor's Letter



In every issue of the Columbia Science Review, we aim to present engaging articles on developing areas of research and demonstrate the relevance of science and technology in our daily lives. This issue is no exception, as it covers many exciting topics in science, including the emerging field of neuroengineering and the technology behind invisibility. But how do they affect your life?

I'm going to venture out on a limb and assume that very few of you are epileptic, have had a heart attack, suffer from trigeminal neuralgia, use alternative medicine, have an implanted tracking microchip, and dream of being invisible. Not every article will be directly applicable to your life. But the scope of these articles is broad enough to engage everyone. Many of us are familiar with Harry Potter's invisibility cloak, enjoy art, and/or know someone suffering from a mental disease or heart disease. From this issue, hopefully you will learn a little more about these topics and gain a better understanding of the work and research behind them, as well as the social, political and ethical issues surrounding them. Some articles may answer questions you've had and raise even more. I hope these articles will spark your curiosity for science and all its implications.

Ying C. Li
Editor-In-Chief

President's Letter

Many historic lessons were obtained through tremendous sacrifice. Such as eating food- if something is poisonous, we all seem to know it. It is common sense. But in the past many people must have eaten this food and died so that now we know better. There I think the first person who ate crabs was admirable. If not a hero, who would dare eat such creatures? Since someone ate crabs, others must have eaten spiders as well. However, they were not tasty. So afterwards people stopped eating them. Those people also deserve our heartfelt gratitude. -Lu Xun (1881-1936)

Since 2004 the Columbia Science Review has been following the frontiers of scientific advances both within the Columbia community and throughout the world. In my last semester at Columbia, I want to give thanks to those scientists who stand at the forefront, allowing the rest of us to benefit from their dedication and insight. Some were martyrs, such as Rosalind Franklin, who died at the age of 37 to ovarian cancer from overexposure to x-rays. Others have suffered tremendous pain in order to stand firm in their own beliefs, such as renowned Galileo Galilei, the father of modern of science, who was forced under house arrest for the last years of his life on charge of heresy. There are still millions of more scientists, philosophers, and thinkers who have dedicated their entire lives to research and to better understanding the world. Finally let's not forget all the young scientists who dedicate hours of their time to the lab, running experiments, analyzing data, and writing articles-the same ones who contribute to our publication.

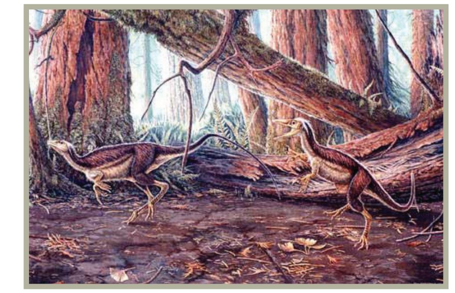
Shelly Zhu
President

Laika Simeon
Jeffrey Spear
Elizabeth Lindhardt
Lisa Weber

Cocktail Science

Andrew Whiten and Carel van Schaik define a behavioral tradition as "a distinctive behavior pattern shared by two or more individuals in a social unit, which persists over time and that new practitioners acquire in part through socially-aided learning." After controlling for environmentally and genetically determined behaviors, they identified 28 such traditions among orangutans. These include building a second nest above the primary nest during rain or bright sunshine, wiping their faces with leaves, and using leaves to pad the hands when handling spiny fruit. They also found 39 traditions among chimpanzees, including cracking open nuts with stones, holding hands while grooming, and coordinated hunting. Furthermore, different groups often perform similar behaviors differently. For example, chimps in one group might fully clasp hands while grooming, while those of a neighboring group might only touch wrists. These distinctive behavioral patterns mirror the diversity of human cultures.

A Belgian patient who has been in a vegetative state after a car accident 5 years ago has defied the expectations of doctors by showing signs of basic thought. People in vegetative states are awake but don't voluntarily respond to stimuli. Recovery from this condition after 12 months is extremely unusual. This condition is different from comas in that coma patients are not awake. Defying all odds, this patient has had his responses to simple 'yes' or 'no' questions measured by brain imaging techniques. His brain activity, when asked 'yes or 'no' questions, appears similar to that of a normal person performing the same task. This discovery, though ground breaking, is still extremely rare in patients who are diagnosed as being in a 'vegetative state'. However, this new discovery exposes the problems with how we diagnose 'vegetative state' and pushes the limits of the ethics of end of life treatment and what we consider death.



Despite numerous artists' depictions of vibrantly colored dinosaurs in the past, they have never been based on scientific fact until now. The fantasy of a world teeming with brightly striped dinosaurs of an array of colors has finally come to life with a recent study conducted by a team of British and Chinese researchers. In 1996, whisker-like structures were found on a small therapod, known as *Sinosauropteryx*, but there was doubt as to whether or not they were truly feathers. After examining numerous other theropod fossils, this 2010 study of early Cretaceous fossils from 120 to 131 million years ago has determined that these filaments are indeed feathers and they contain melanosomes, which are organelles that produce color. These scientists have identified the color pattern of the tail of the *Sinosauropteryx* to have a reddish tint with alternating white areas. The findings from this study allow for future color patterns to be identified from the analysis of dinosaur fossils and give insight into the true color of creatures before our time.

In spite of centuries of evolving to get bigger, sheep in Scotland have started shrinking. Bigger sheep are more able to survive the bitter cold of winter, so most of the big babies survive, and many of the small babies die off. However, as increasing CO_2 concentrations in the atmosphere make winters warmer, more vegetation is able to grow throughout the winter. More vegetation means plentiful food, so even the smaller, more vulnerable sheep are able to get enough to eat. Climate change is a powerful force that can affect lots of different, interconnected aspects of our world. Even a small change in temperature can change where and how well plants grow, which in turn can affect animals, land erosion, and agriculture. It can even trump evolution.

the silent killer?

Helena (Hao) Wu

Can a wireless gadget so commonplace in this electronic era cause brain tumors? While the probability of getting cancer is low, you should still be aware of the potential health hazards that cell phones may pose.

Cellular telephones emit a type of wave called radio-frequency energy (RF). Most of the RF energy is produced through its antenna, which you normally place very close to your head when you are talking on the phone. Distance is an important factor for the amount of RF absorption. With increasing distance between the antenna and the user, the amount of RF energy absorbed by a person decreases significantly. The intensity of RF also depends on the signal strength sent from the nearest base station. The farther away you are from the base station, the higher the power level needed to maintain the connection.

Cell phone companies say that the amount of RF energy generated by the antenna is too low to cause a significant increase in body temperature or localized tissue heating. The main concern is how the RF energy affects the brain. Some research has concluded that brain tumors, both malignant and benign, can arise from the close proximity of the cell phone to the body. Meningiomas, tumors of the membranes that encase and protect the brain and spinal cord, and cancers of the salivary glands may be caused by frequent mobile use.

Short-term studies have found little or no correlation between cell phone use and tumor development. However, several long-term studies in Denmark, Finland, Norway, Sweden, and the United Kingdom have shown that ten or more years of cell phone use slightly increase the risks for certain types of brain tumors. A more extensive study of over 400,000 people in Denmark tried to link cell phone use to increased cancer risks by looking at how many people with cellular telephone subscriptions were listed in the Danish Cancer Society as having brain tumors. Surprisingly, results indicate that there is no association between cell phone use and tumors such as glioma or acoustic neuroma, even among users who have subscribed for ten or more years.

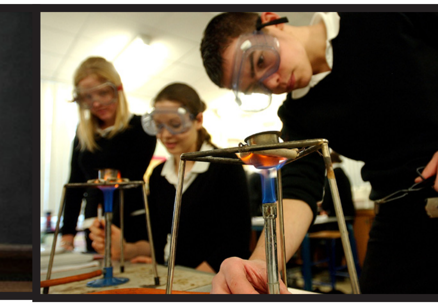
The study results are inconsistent because the time interval between exposure and onset is long. Researchers also face the challenge of finding test subjects who consistently use their cellular phones for decades. Another cause could be reporting bias because in many cases, subjects are more likely to report cell phone use after they are diagnosed with cancer.

Further research is underway to find more reliable results. Meanwhile, another interesting frontier to pursue is the effect of RF energy on children whose nervous systems are still developing. Would brain development be hindered if children started chatting on their iPhones?

Until more definitive research results are published, it might just be a good idea for you to figure out the mysterious workings of those ROLM phones.

modernizing science education

Yaniris Gomez



I recently learned that the organizers of the Intel Science Fair ask the participants to name the person who inspired their interest in research. If they go on to become semi-finalists, Intel contacts that person, usually a science teacher, to recognize them for their part in the scientific process. American students rank 19th worldwide in science literacy and roughly 39% of US citizens do not believe Darwin's theory of evolution. Considering the former, it is reassuring to learn that science educators are nevertheless appreciated in some venues.

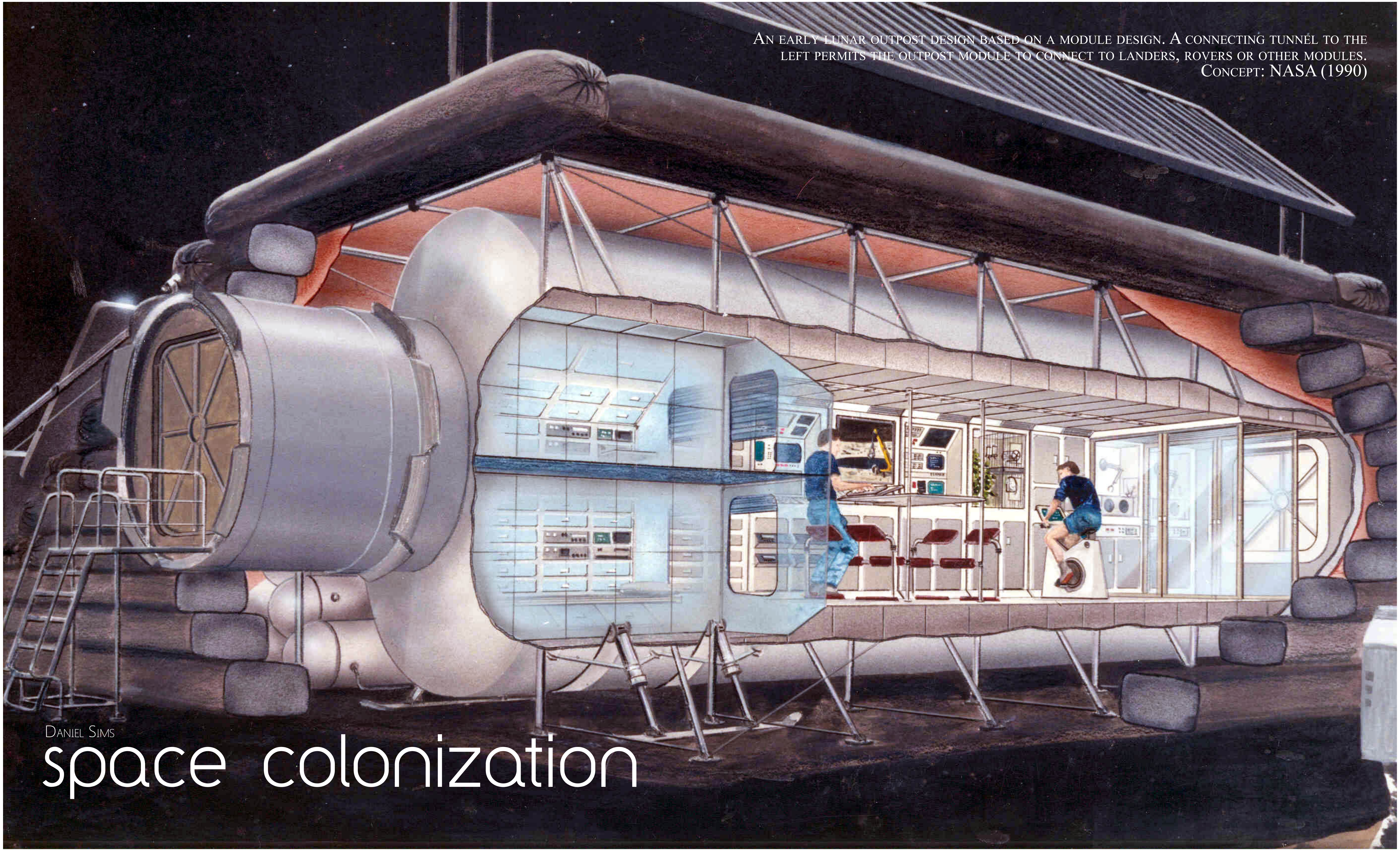
But let's go back to the figures. The United States, though arguably the world's largest political and economic power, is constantly falling behind in the education of its children. Granted, general literacy and mathematics skills are important, but the idea that science is set aside or even vilified is particularly disturbing. This is because the analytical and critical thinking skills that are a foundation of good science education are also the foundation of a prosperous modern society. It's not enough for a society to make technological, medical, and general scientific advancements; it must also have a populace that understands and supports scientific progress. The creation of such a populace starts with the proper education of children.

In general, kids are not encouraged to like science. The kids who do show an interest are labeled as nerds and certain groups (especially girls) are discouraged from getting too involved. What we need is to support education that makes science interesting and fun, especially in under-funded school systems.

A program that does this is Columbia Science Outreach, better known as Brainiacs. This afterschool program meets every Friday at the Community Health Academy of the Heights (CHAH) to teach sixth grade students about a fascinating field of science otherwise unavailable to them. They learn brain anatomy, neuron anatomy and function, applications of the latter knowledge. At the end of the year, they get to dissect a real brain (sheep, not human, as the students amusingly assume). Throughout the year they demonstrate an unmistakable enthusiasm for the subject and the next year they want to come back and learn more. Clearly the interest is there and the teachers enjoy the fact that their time is well-spent and appreciated.

Who are these teachers? They are Columbia University undergraduates who are passionate about neuroscience and feel that understanding the brain, as well as its impact on behavior and perception, is useful and relevant. Not only that, but teaching in this field is a way to reinforce the scientific education during the normal school day.

For the kids at CHAH neuroscience provides the necessary "cool" factor to engage them. For others it could be robotics, physics, or explosive chemistry experiments. There really is a science for everyone, we just need to build an education system that values this insight and implements similar programs into the K-12 curriculum. What better way to make the scientific method a take home message than to illustrate it with interactive lessons and experiments? After all, who says that learning can't be fun and games?



An early lunar outpost design based on a module design. A connecting tunnel to the left permits the outpost module to connect to landers, rovers or other modules. Concept: NASA (1990)

Daniel Sims

space colonization

The idea of space settlement, more often called space colonization, is not a new one. It was originally brought up in the book "The Brick Moon", written by Edward Everett Hale in 1869. However, the idea of space settlement did not become mainstream until the Apollo program showed that humans could set foot on other planets. During this program, men like Gerard K. O'Neill wrote books like "The High Frontier: Human Colonies in Space" which gave credibility to this seemingly impossible dream. Support for space habitation strengthened throughout the '70s and '80s. In fact, support was so strong that Congress passed the Space Settlement Act of 1988. In this bill, space settlement was declared "a long-range objective of the American space program." In addition to that, "once every two years....the National Aeronautics and Space Administration (NASA) has to submit a report to the President and to Congress which analyzes ways

"Current spaceship design would be deadly if applied to space habitation."

in which current science and technology can be applied to the establishment of space settlements...[and] identifies scientific and technological capacity for establishing space settlements including a description of what steps must be taken to develop such capacity". Yes, Congress actually passed a law saying we need to inhabit space.

Despite this active work on space habitation, I am not currently sipping some sort of blended fruit drink made from moon-fruit in a moon resort and playing moon golf. What's going on? Why is this so hard? Where on Earth is my moon colony?

Obstacle 1: Launch Costs

In his Technology, Entertainment and Design conference talk, Peter Diamandis, the founder and chairman of the X PRIZE Foundation, gave his analysis of launch costs. He found that it should only cost about $100 to send a person in a space suit into space. $100 is cheap as dirt, yet the cheapest rocket, in terms of launch cost per pound is the Ukrainian Zenit 2 at $1,404. And that is per pound. A space colony would require much more mass than the Internal Space Station ISS, which weighs nearly one million pounds, much of it coming from fuel and radiation protection. The costs of space colonoization would be astronomical.

Obstacle 2: Radiation

Current spaceship design would be deadly if applied to space habitation. When a radioactive particle hits metal or anything else it causes a reaction that is similar to a nuclear reaction. The shielding material will then eject particles of its own. This is why lead spacecrafts are not being proposed since lead has more particles to eject as it has a high number of protons and neutrons. This is why NASA is proposing plastic spaceships that will use polyethylene to cut down on the radiation. This material consists solely of carbon and hydrogen, which have very few protons and neutrons. In addition to shielding technology, there is an ongoing push for further observation of the sun. With more and more resources poured into the observation of the sun, humans living in space will have increased warning about solar storms and could seek shelter.

Obstacle 3: Life Support

One of the ultimate ways to gain a life support system of Earth is to terraform planets. Literally, you force another planet's environment to mimic Earth's. Many think it is possible to dump enough greenhouse gases into Mars' atmosphere to warm it. This will produce a second Earth by warming up the atmosphere to allow water to flow freely. Once this is done, chemical processes will take over, finishing the transformation. This will then allow for oxygen producing plants to be placed on Mars.

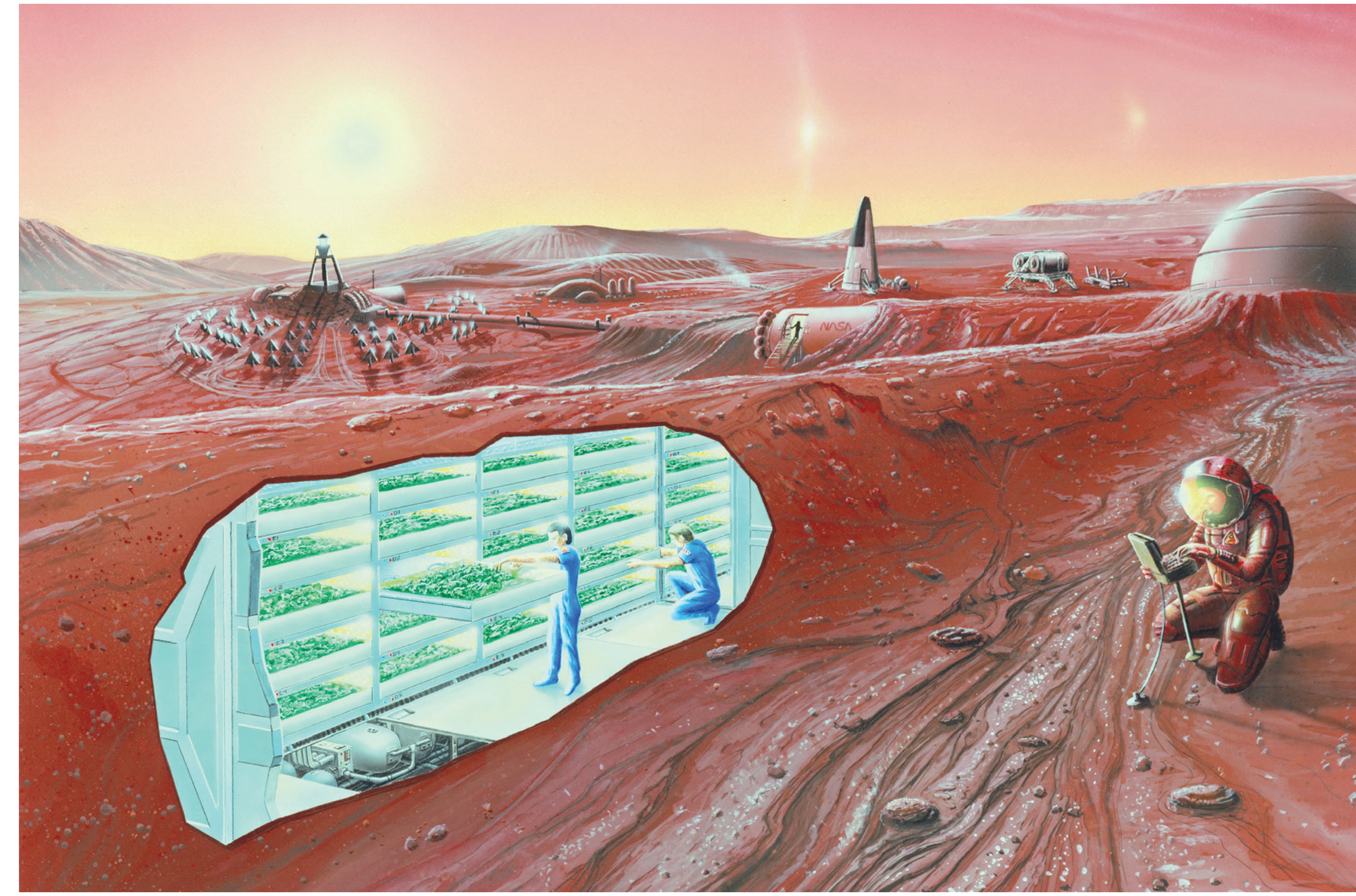
The current system for producing oxygen is recycling old air by removing the CO_2 with lithium hydroxide canisters. The chemical reaction that occurs produces oxygen which the astronauts can breathe. This is not a self-sustaining technology. Canisters have to be brought up to replace the depleted lithium hydroxide. Currently human waste is tossed overboard in unmanned vehicles that burn up in the atmosphere (that shooting star isn't a shooting star) and the mission's food is carried into space with the team.

The balancing point would not be a technological solution. It would be a natural one. Space colonies would have ample green space. This would not only produce the food the settlers need, but oxygen as well. Human waste can be effectively dealt with by reusing it as fertilizer, further increasing the life support system's efficiency.

Obstacle 4: Human Factors

Biosphere 2 was a sealed structure that simulated the Earth. This independent ecological system failed to support life and sustain itself. Some of the problems that bugged Biosphere 2 will be the same problems that affect space habitats. One issue is that humans are simply not the best decision makers under stress. However, we can learn from the Biosphere 2 experiment mistakes and improve on it.

There will also be tension between Earth and the space colony. Different cultures will emerge out of this effort and they will most likely have conflicting ideas. We already see this in the conflicts between ground control and the astronauts on current space missions. Extensive training will have to be done to avoid this problem, but ultimately, Earth will have to have a loose grip on its habitations.



Noise will also be an issue, since it generates stress. However, this wasn't a problem on Skylab, an early space station, "because of the low air pressure inside that made it necessary for astronauts to shout in close proximity to one another to be heard". Since a space colony, like Skylab, is a sealed system, we can play around with the air pressure to lower noise level.

Obstacle 5: Gravity

Alas, it is not all fun and games when the gravity goes away. The human body in space suffers greatly for the ability to do gymnastic moves with ease. A human's bones and muscles will often wear down in micro-gravity. However, we can simulate gravity in space.

If you have been to a theme park you will have come across an artificial gravity generator. On this attraction you are strapped into a drum like machine that rotates at high speeds. Soon after the machine starts up you start feeling pressure on your chest and eventually you can't even lift up your arms. This effect can be used in a space colony. A structure with a radius of about a mile can rotate at one revolution per minute and simulate Earth's gravitational pull, 1G. However, this structure would be massive, larger than anything we have ever built in space. But, you can build a colony with a radius less then 1 mile, reducing costs. This would require higher RPMs, which increases personal discomfort. However, the MIT man-vehicle lab found that people can adjust to RPMs up to 30 RPM. It has also been suggested that one could use a medieval-torture-esque device; a spinning bed called a Short-Radius Centrifuge.

Conclusion

We can achieve space habitation. There is a huge potential for a price decrease in launch costs. Better materials and better space ship designs will block radiation. Life support systems will become self-supporting and we can generate gravity. Through training, we can overcome some human limitations. Yes, there are a million reasons for one to oppose space colonization and there will be many obstacles to overcome in addition to the five listed here. However, if we achieve space settlement, society will be fundamentally changed, just like when the transistor was developed. The Space Settlement Act of 1988 puts it nicely: "The extension of human life beyond Earth's atmosphere for the purposes of advancing science, exploration, and development will enhance the general welfare on Earth."

open access:
digital publishing of science journals

Lucy Sun and Moses Nakamura

Data is becoming free to the world. The RCSB Protein Database (PDB) lets anyone with internet access view millions of x-ray crystallography plots of proteins collected by biochemical researchers worldwide. The National Institutes of Health (NIH) have a protein bank with genotypes of millions of different proteins from a myriad animals. The human genome has been free for anyone to study for years—the answer engine, Wolfram Alpha has a feature where it will try to match any sequence of A's, T's, C's, and G's with the human genome, from any computer in the world, in seconds. And there are thousands of specialized, free, and open source applications that can be used to analyze all of this data in any number of different ways. One can now make scientific breakthroughs with a laptop and use methods of analysis that scientists would have killed for even twenty years ago. However, while data is largely going free, many research journals are accessible on a subscription-only basis. What use are the most sophisticated techniques, and all of the requisite data, if one analyzes it only to find that the paper has already been published?

"That's always a fear you have," said Brian Weaver, assistant professor of Biology at Missouri State University. Researchers at universities with smaller budgets find themselves limited, "basically, by the amount of money that the school has to subscribe to journals," said Weaver. In the past twenty years, the number of research journals has exploded, and subscription prices have gone up by 500% on average. Meanwhile, science is becoming more and more interdisciplinary, and it is increasingly important for scientists to have access to journals in many different fields. According to Mark Grabois, CC '11, who interned at Cold Spring Harbor Laboratories, the lab has nearly all of the biology journals, and the biggest of the physics journals, but still could not afford access to all the journals that Grabois wanted to use for his summer research project in neuroscience.

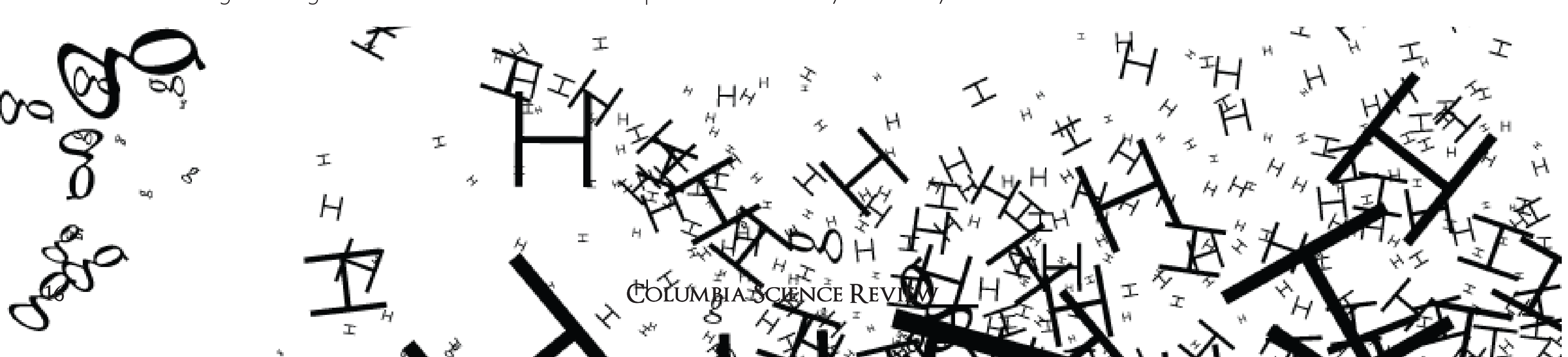
In response to scientists' needs, there has been a movement towards open access journals, which are free for anyone to read. There are now over 4,000 open access journals in existence. Even though these journals are free for the reader, "Open access does not conflict with quality in research, and it does not conflict with peer review," said Jim Neal, vice president for information services and university librarian at Columbia. In 2005, the Columbia University Senate officially endorsed open access, and according to Rebecca Kennison, director of the Center for Digital Research and Scholarship at Columbia, open access is here to stay. "The trend more and more among junior scholars and researchers is that they are convinced that this is the way things can be and should be," said Kennison.

Due to the advent of search engines, open access journals have been able to make a big impact in the scientific community, and fast. In 2003, Public Library of Science (PLoS) Biology was set up as a competitor to Nature, Cell, and Science, the big three in science publishing. Today, PLoS is the highest rated journal in the field of Biology in ISI impact factor, which is roughly a measure of how many times articles within a journal are cited. According to Kennison, in addition to garnering more citations for authors, open access journals can offer a faster publication time than print journals. "At the end of the day, people just want to get their work out," said Kennison. Although the names of open access journals may be new and unfamiliar to some scientists, "Where you publish is becoming less important than getting your work out and cited," said Kennison.

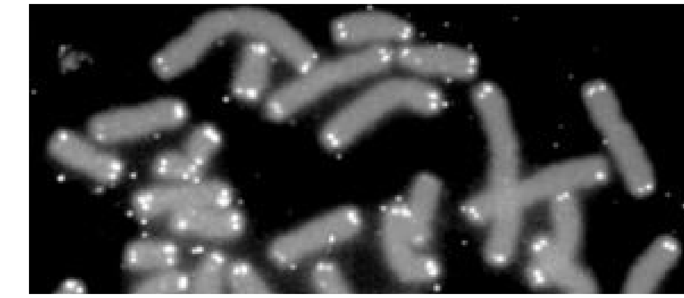
Although open access journals have been a boon to scientists, there is still the question of who pays the bills. Many journals charge processing fees, in which authors pay the costs of editing and publication. Processing fees allow an open access journal like PLoS Biology to hire a dedicated, professional editing staff. Business models for open access journals are myriad and evolving--for example, Scientific Journals International (SJI) has made its editing and peer-review processes volunteer-based but still rigorous, which allows SJI to charge processing fees on a sliding scale, according to authors' budgets. Universities are also stepping in to foot the bill-in 2010, Columbia University plans to sign on to the Harvard compact, in which Columbia would agree to pay processing fees for any Columbia University scholar who publishes in an open access journal, if the research grant does not cover the processing fees. Some research grants now do cover processing fees-most notably, all research funded by the National Institutes of Health (NIH) is mandated to be on the internet for free, as of April 2008.

What does a world look like in which all research is readily available? Kennison predicts an "increasing speed of discovery-you don't have to reduplicate peoples' work because you have that information." Neal sees a movement towards "open data," in which data is made freely available not only after the completion of a research project, but as the project is still ongoing. Kennison foresees that prestige and tenuring decisions will be determined not only by getting articles published, but by producing useful datasets. All of this will be motivated by "the needs of global science," said Neal. As collaborations among scientists become increasingly complex, spanning continents and disciplines, scientists may be ready to share like never before.

> "where you publish is becoming less important than getting your work out and cited,"





Laika Simeon

telomeres untangled

On October 5, 2009, Elizabeth H. Blackburn, Carol W. Greider, and Jack W. Szostak were awarded the 2009 Nobel Prize in Medicine and Physiology for their "discovery of how chromosomes are protected by telomeres and the enzyme telomerase."

A telomere, the portion of DNA at the end of a chromosome, was discovered by Hermann Muller and Barbara McClintock to prevent the attachment of chromosomes at certain points. Using Tetrahymena thermophila as a vehicle, Blackburn isolated the CCCCAA segment at the end of chromosomes; Szostak then injected CCCCAA to a linear DNA molecule (minichromosome) in yeast cells, leading to the discovery that the telomere protected the minichromosomes from degrading. Greider and Blackburn then discovered the enzyme telomerase - containing Blackburn's CCCCAA segment - that guides and completes the construction of telomere DNA. Greider and Szostak collectively discovered the telomere's protective role in attracting certain proteins to cover the ends of DNA strands reduces senescence (the inability of "old" diploid cells to divide further past a certain number of divisions) and damage to the chromosome.

The telomere's ability to preserve chromosomal DNA is important in its application to cancerous cells, which can divide without disturbing the original length of the telomeres and thus extending their lifespan. Solid tumors, especially those of acute and chronic leukemia, have been found to contain irregularly high levels of telomerase activity; clinical trials are currently in place to test vaccines that disrupt telomerase activity by targeting RNA transcribed from telomeric DNA. We must remember, however, that telomerase is not perfect; it can make inaccurate additions to breaks in DNA. The enzyme is supervised by the DNA damage signaling mechanism in occurrences of double breaks in DNA through Pif1 phosphorylation.

In contrast, truly defective telomeres which lead to too few cell divisions in bone marrow stem cells have been found to cause certain forms of congenital aplastic anemia, in which not enough blood cells are produced. As a result, patients with congenital aplastic anemia are often tired, weak, and short of breath. In addition, dyskerin - a protein associated with the production of telomerase - can malfunction and produce a significantly lower level of cell divisions than usual. This mutation thus leads to Dyskeratosis congenita (DKC), which can include symptoms of severe lesions on the skin, bone marrow failure, and scarring of the lungs. Diabetes, also, can contribute to a severe shortening of telomeres; telomerase influences the regeneration of beta-cells that helps prevent the onset of overt diabetes.

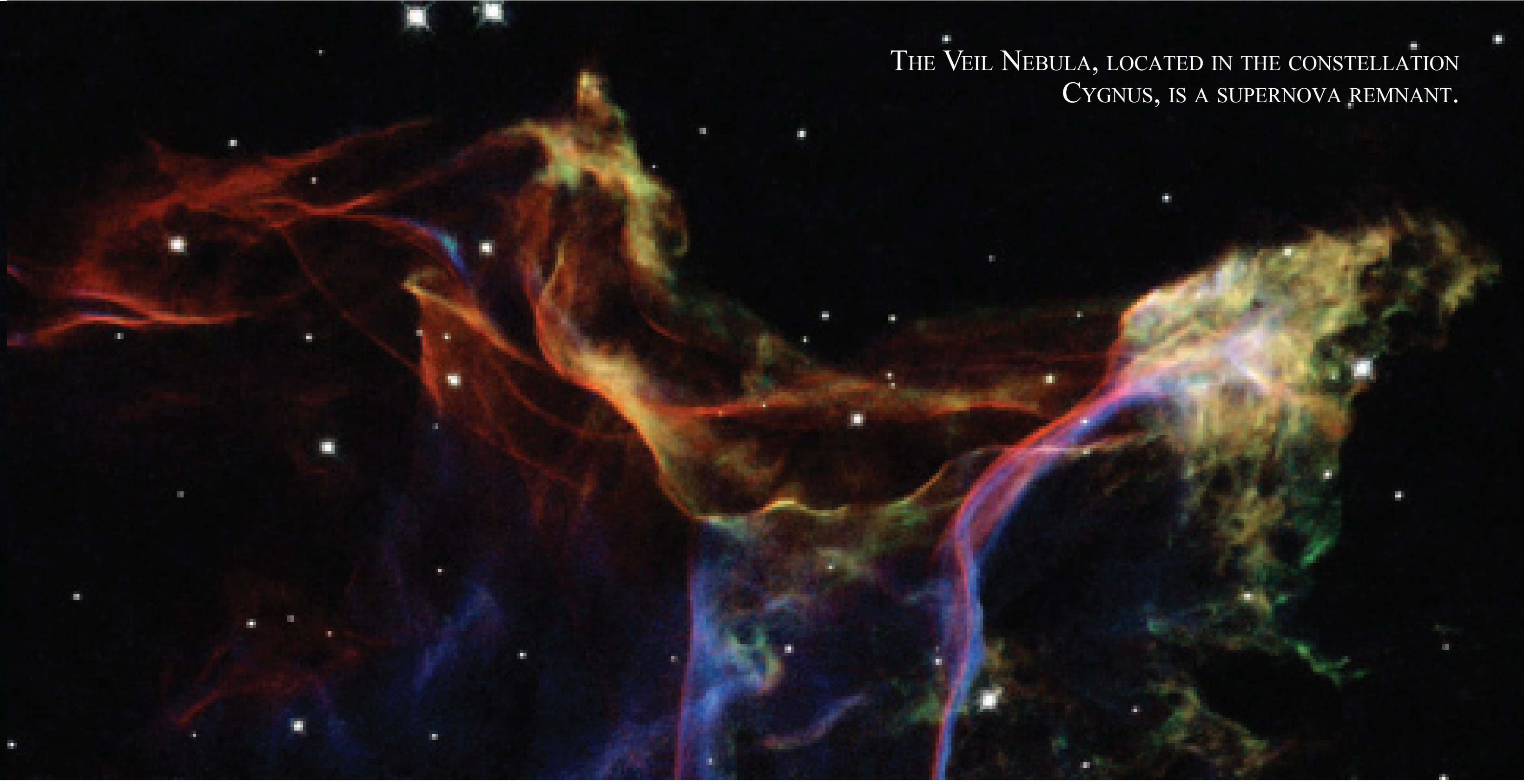
The research of Blackburn, Greider, and Szostak not only introduced the scientific community to another dimension of how DNA is transmitted, but also set the stage for development of treatments aimed at the process of DNA replication. As Blackburn mentions in an interview, it is indeed amazing that "the cell actually devotes all sorts of machinery to make sure that never goes wrong, or goes wrong as little as possible."

the life and death of stars

Keri Lofftus

When we think of our universe, one of the first things we picture are stars. It is our own star, the Sun, which allows Earth and its life to exist. The millions of stars we can see in the night sky have inspired wonder in humans for innumerable generations, leading to the development of astrology, and later, scientific investigations though astronomy.


The Cat's Eye Nebula (NGC 6543), a planetary nebula in the constellation Draco.


The Veil Nebula, located in the constellation Cygnus, is a supernova remnant.

The sky is filled with thousands of stars which seem to appear the same night after night. This is because the life of a star is measured in millions or even billions of years, whereas our lifetimes are just a few decades. Humans have not existed long enough to watch a single star go from birth to death. Despite their seemingly static nature, stars have complex lifecycles.

The formation of a star begins when a cloud of cold gas begins to contract. Over thousands of years, the center of this cloud becomes denser and hotter as it becomes more compact. Eventually, this core of gas (mostly hydrogen, with some helium) reaches a density and temperature so that nuclear fusion (the conversion of hydrogen into helium) becomes possible. This releases vast amounts of energy, and once the outward force of the fusion and the inward force of gravity balance each other out, a star is formed.

After birth, stars are called main-sequence stars and will spend about 85-90% of their lives like this. Our Sun is one such star. The time a star remains on the main-sequence depends on its mass. The more massive a star, the shorter amount of time it will spend on the main-sequence, with the most massive stars burning out in only millions of years, instead of billions. The Sun will spend a total of about 10 billion years like this, so at 4.5 billion years old, it is already about halfway though this phase of its life. A star's mass is also important in determining the later stages of its life.

Main-sequence stars whose mass is less than that of the sun are called dwarfs, with the most numerous type being red-dwarfs. They have masses from 0.075 to 0.5 the mass of the sun. These stars are the most common in the universe because their small masses mean that they are the easiest to form and that they live the longest. Their small size allows red-dwarfs to be convective, instead of radiative, so helium does not build up inside the its core. Because of this, a red-dwarf just becomes dimmer as its life progresses, eventually cooling into a black-dwarf. However, since this process takes longer than the current age of our universe, black dwarfs do not yet exist.

If a main-sequence star is similar in mass to our Sun (from about 0.5 to 6 times the Sun's mass), it undergoes a more exciting transformation. Once the hydrogen fuel runs out, helium to carbon fusion begins, the outer layers of the star begin to expand, and the star turns red, giving these stars the name red-giants. Most red-giants do not have sufficient mass to fuse carbon into heavier elements, so once the helium runs out, fusion ceases. As the outer layers of these stars are blown off, beautiful planetary nebulae are created. With fusion halted, gravity again begins to compress the star, just as it did at birth. After this process is completed, all that is left of the star is a hot and dense core, made mostly of carbon and oxygen, called a white-dwarf. Most white-dwarfs are about the size of Earth. Like red-dwarfs, white-dwarfs will slowly cool off into black-dwarfs.

Main-sequence stars with masses 10 to 70 times greater than the sun will become giants. The difference between red-giants and these stars is that these have enough mass to fuse carbon into iron (through a complicated process involving other elements) once they run out of helium. This fusion will further increase their volume, creating either a red or blue supergiant. These stars' large masses make them extremely unstable and their "deaths" cause some of the most exciting phenomena in the universe.

Once these giants run out of carbon to fuse, the end is imminent. This is because the laws of physics do not allow energy to be released by the fusion of iron. The star then has no way to counteract the force of gravity, and begins collapsing again. Eventually, the core of the star is so dense that subatomic particles are pushed almost to the point of touching, and the core becomes a solid mass of neutrons. The outer layers of the star, as they also continue to collapse, hit the now solid core and bounce off, producing a supernova explosion. The energy of a supernova explosion is so great that all elements heavier than iron are created here. The luminosity of a supernova explosion can temporarily be brighter than the luminosity of the galaxy where it is located.

The next stage of the star's life is also mass dependent. For stars with masses 20 times that of our Sun or less, the core remains a dense ball of neutrons, called a neutron star. These stars are extremely small, with a diameter of only about 20 kilometers. Certain neutron stars can have interesting properties. One type of neutron star, called pulsars, emit thin beams of radiation from the top and bottom of their axis of rotation. If Earth happens to lie in the line of sight of one of these beams, we will see the radiation from the star pulse.

However, when a giant star with a mass more than 20 times the mass of our Sun collapses, not even subatomic particles can get in the way. Instead of just remaining a dense ball of neutrons, the stars core continues collapsing Eventually, the core becomes so dense that it severely warps the very fabric of space-time, forming a black hole. This means that all the mass of the star has been compressed into a point of almost infinite density. This creates a gravitational field so strong that even light, with the fastest speed in the universe, cannot escape its grasp.

Their humble beginnings as clouds hide the importance stars have in our universe. They are a source of light and life. Being the right distance from our Sun allows the Earth to harbor many different life-forms. Although we have not yet discovered life on other worlds, there are hundreds of billions of stars in the Milky Way galaxy alone, and at least one-hundred billion galaxies in our observable universe. Hopefully a few of those stars support Earth-like planets, inhabited with intelligent creatures who also look up at the sky and ask questions about the stars.

lactase persistence

Jeffrey Spear

About one in every ten people in the United States is lactose intolerant. Lactose intolerance is a genetic condition in which adults do not produce the lactase enzyme used to break down lactose, a type of sugar found in milk. Although lactose intolerance is perceived in our modern society as a genetic disorder and a minority occurrence, scientifically it is probably more accurate to describe lactose intolerance as a lack of a genetic condition, since lactose intolerance is the standard condition for the vast majority of mammals.

Infant mammals produce large amounts of lactase, but lactase production generally declines after weaning since most mammals do not consume milk in adulthood. This decline in production is regulated by the lactase gene (LCT), which is responsible for altering the amount of lactase proteins produced in cells in the digestive tract. Lactose tolerance, known as lactase persistence, arises when a mutation in LCT causes the gene to fail to decrease lactase production after weaning.

Most modern human populations contain small numbers of lactase persistence adults. For the majority of human populations, as for the majority of all mammalian populations generally, lactase persistence individuals are a minority. Lactase persistence is common in northwest Europe, particularly Sweden and Denmark, and declines in frequency in southern and Eastern Europe. It is also common in northern India, as well as among pastoralists of Arabia and Africa, although there is evidence to suggest that different mutations are responsible for lactase persistence among different groups.

Point Mutations Cause Lactase Persistence

The most well studied mutation causing lactase persistence is the one responsible for lactase persistence among most European, West Asian, and North African populations, which involves a single base in LCT. This mutation is known as C/T -13910. C/T refers to a change from the base cytosine to the base thymine, and -13910 refers to the location on the gene on which the change took place. Studies have found that the C/T -13910 mutation correlates perfectly with lactase persistence among a sample of native residents of Finland, and probably among other northern European populations as well.

Evolutionary Origins of Lactase Persistence

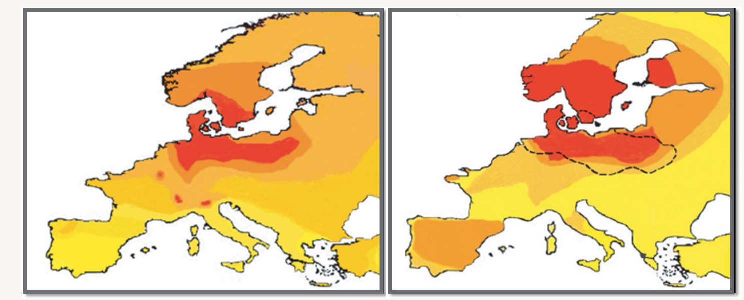
Many attempts have been made to identify the origin of lactase persistence among humans. The lactase persistence trait has undergone exceptionally fast evolution in the past 10,000 years, suggesting that strong selection pressures are acting on LCT. Although 10,000 years may at first seem like a long period of time, it is a mere 5% of the time modern humans have existed and only 0.2% of the time the human lineage generally has existed. Indeed, LCT shows one of the strongest signals of recent positive selection in the human genome. The selection coefficient for lactase persistence, or the measure of evolutionary advantage of the lactase persistence phenotype over non-persistent phenotypes, has been identified by various researchers as somewhere between 2% and 19%, the most common numbers being in the vicinity of 5%.

Strong selection pressures for lactase persistence suggests that there are significant benefits to this phenotype. It allows an individual to take advantage of the ingestion of milk products without negative side effects of lactose intolerance including growth retardation, diarrhea, bloating, and decreased appetite. Milk is rich in calories, calcium, and magnesium. Lactose also has a lower cariogenicity than most other sugars such as sucrose, fructose, glucose, and maltose. This means that lactose ferments less easily, causing less tooth decay than other sugars. Lactose can also act as a dietary fiber and enhance absorption of minerals, particularly magnesium and calcium. The combination of substantial benefits of dairy consumption for lactase persistent individuals, and the problems that consumption causes for non-persistent individuals, creates the incredibly strong selection pressures for lactase persistence if adults have access to dairy products.

Lactase Persistence and Dairying

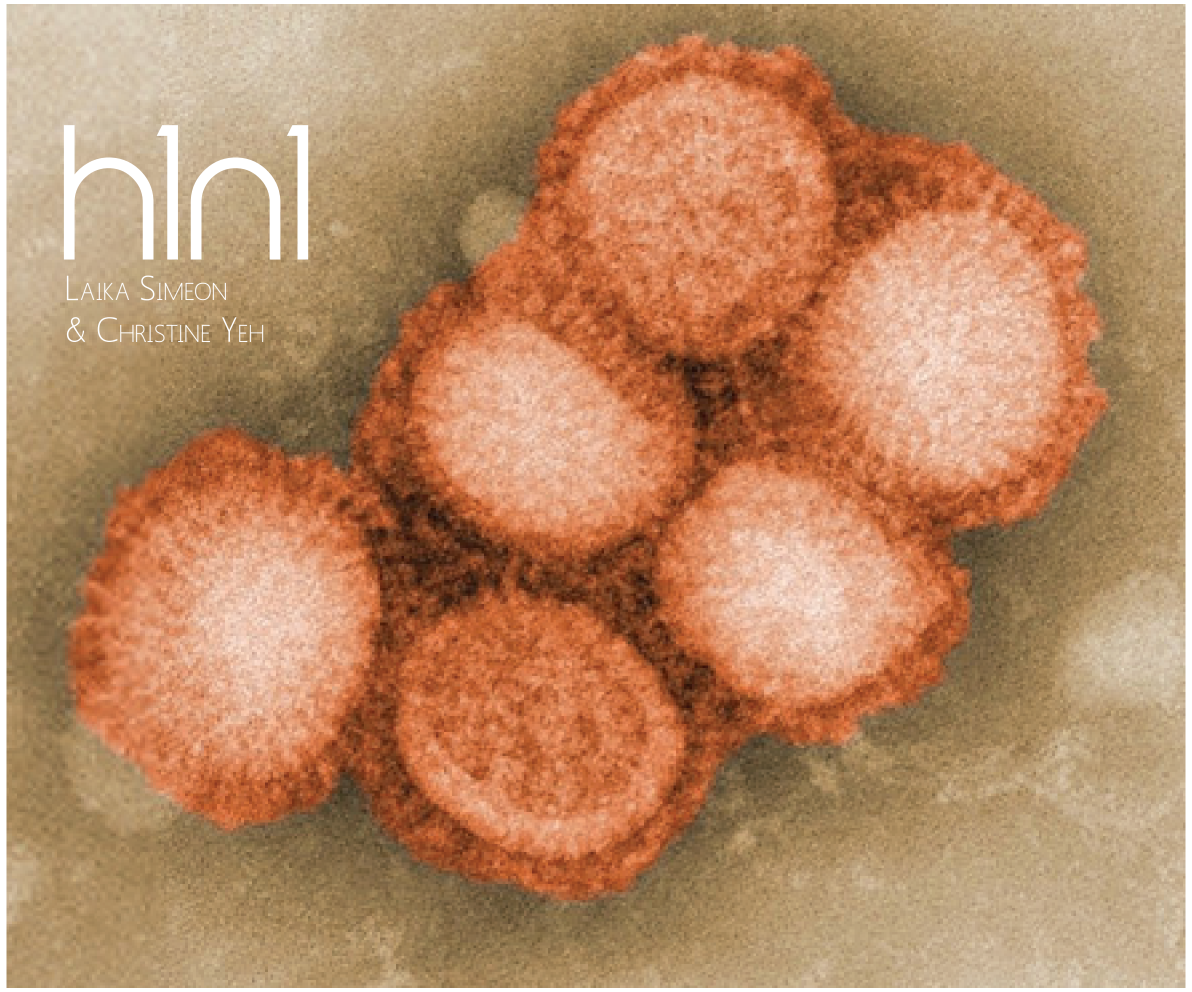
Of course, the advantages of dairy would have no bearing on natural selection if human adults did not have access to milk products. The earliest evidence for the use of dairy products by humans comes from milk fat residues found on pottery in Anatolia and the Levant dating to about eight or nine thousand years ago. The development of dairy farming created novel selection pressures on humans who lived in these new dairying societies. This phenomenon by which organisms define and create new selection pressures for themselves and for other organisms is called niche construction. A classic example of this is a beaver dam, which turns a stream into a pond, thus altering the local ecosystem and allowing different species to live in the area. It is this altered environment, not the original environment, in which the selection pressures under which the organisms live are created. Dairying is an excellent example of human niche construction. People living in an environment in which dairy farming has become prevalent will be subject to different selection pressures than those in an environment in which it has not.

The prevailing position on the origin of lactase persistence is that dairying created the selection environment in which lactase persistence was favored and eventually evolved. Some studies suggest that the most ancient of the C/T -13910 mutation corresponds with the origin of dairy farming. Direct evidence for the lack of lactase persistence among pre-dairying communities in Europe also comes from an analysis of DNA from Mesolithic and Neolithic human skeletons, which suggests that prior to the advent of dairying lactase persistence was rare, if not absent, from northern European populations. There is an alternative hypothesis that lactase persistence reached high frequencies in specific regions due to random genetic drift, and that dairying arose in those regions with a significant number of individuals already possessing the C/T -13910 mutation. Indeed, some analyses suggest that most of the diversity at LCT originated relatively early, possibly even before the advent of farming. The archaeological evidence, however, contradicts this hypothesis. Perhaps one of the most interesting studies on lactase persistence's origins is by Beja-Pereira and colleagues that compares the diversity of milk protein genes in domestic cattle in Europe, a proxy for the genetic history of dairy cows, with the frequency of lactase persistence in Europeans . The correlation is striking, although perhaps not surprising. Both maps show a heavy concentration in north-central Europe and southern Scandinavia, which declines to the south and east, suggesting that lactase persistence and cattle farming share a tightly linked common history probably originating in northern Europe. It is a remarkable example of two species evolving in tandem to cope with a constructed niche.



These maps of Europe, adapted from Beja-Pereira et al, show the relationship between the genetic diversity in domestic dairy cattle (left), and the frequency of lactase persistence (right). Red represents greater variability/higher frequency, while yellow represents lower variability/lower frequency. Genetic diversity can be used a proxy for either population size, with greater diversity suggesting larger populations, or population antiquity, with greater diversity typically representing an older population or an older origin of a particular gene. The geographic correlation between human LCT and genes in domestic cattle suggests that the evolution of humans and cattle may be linked through the constructed niche of dairying.

Lactase persistence is not as beneficial for survival in modern western society as it was in early dairying societies, because the great diversity of foods that are available to us. Lactase supplements also make it easy to live healthy lives even without this valuable food source. Being lactose intolerant is little more than an inconvenience, in contrast to earlier dairying societies in which the consequences of lactose intolerance were probably much more severe. Those of us who cannot process dairy are generally just as likely to survive and to reproduce as those who can. Thus lactase persistence is currently subject to random, rather than directional, evolution. But if you are one of the lucky mutants that has held onto your ability to produce lactase, then remember, next time you open the fridge for a glass of milk or go out with friends for ice cream, that you are part of a millennia-old tradition of milk drinkers, gifted with a lucky mutation inherited from an early cattle-rearing ancestor.



h1n1

Laika Simeon
& Christine Yeh

David H. Newman M.D. is an emergency room physician and Director of Clinical Research Medicine in the Department of Emergency Medicine at St. Lukes-Roosevelt Hospital. He served as a major in the army reserve in Iraq, where he received an Army Commendation Medal. He also teaches a class at Columbia University for those interested in clinical research called, Introduction to Clinical Research in Emergency Medicine and runs the Academic Associates research assistant program. During college, Dr. Newman studied philosophy but stumbled into medicine when he worked with EMS to pay for his education. He decided to take an EMT class after feeling angry with himself for being unable to help someone in a medical emergency and Although he says he 'wasn't picky about his philosophy' he focused on anthropology and linguistics. Newman says that a background in philosophy "helps anyone do anything." He feels that learning how to think and reason is especially important, when considering the present communication between science and society. Newman participated in a lot of different activities during school, including varsity baseball. He said he balanced all of his activities poorly but said, "I think I fit everything because I loved doing it and I would find a way." He continued his studies in philosophy during graduate school but decided to follow a career in medicine since he 'dug' working as a paramedic. After completing the required science classes, he went to medical school in Albany and completed a residency at University of Pittsburg. Dr. Newman also completed a fellowship in clinical research and emergency and resuscitation research at University of Pittsburg. As a physician he has worked extremely hard, having taken 1 sick day in 9 years.

Influenza makes those affected feel exceptionally tired. Individuals develop a severe cough, body aches, chills, and a high fever. Influenza is a common respiratory illness caused by RNA viruses and can be fatal if untreated. Typically referred to as just "the flu," influenza affects birds and mammals and targets the respiratory tract, composed of the nose, throat, and lungs. In children influenza symptoms may also include nausea, vomiting, and diarrhea. Those symptoms are less common in adults.

Even though he sees patients complaining of flu-like symptoms frequently, Dr. Newman did not enter emergency medicine for the cold and the flu patients. Like many who enter the emergency field from EMS, he was attracted to the resuscitation aspect. He did feel that the minor illnesses such as 'flu like illness' became more significant to him as he advanced in his career. He said, "Talking to humans is different from resuscitating them. Talking to humans is what you come to love when you've been doing resuscitations long enough." Dr. Newman finds human interactions valuable in that they are both intellectually and personally challenging.

Newman notes that everyone is afraid that they have swine flu. He believes that this is an understandable reaction given that the press leads everyone to believe that anyone with moderate symptoms has swine flu will probably die and should rush a medical professional. The media does this because "all the news stations have to make a profit first." Their revenue comes from advertisers who pay to run ads on their news program. Advertisers will only sponsor a program if there's good viewership, which depends on "whether or not you can scare people into watching". For example, if a news teaser says something like "strollers that kill at 11. You say to yourself, 'oh geez I gotta watch. If I don't watch than my child is going to die and I must not love my child if I don't watch." According to Dr. Newman 70-80% of a population will get some form of the 'sneezes and coughs' every year, while less than 5% of the population will get true influenza. When a patient asks him (and they usually do) if he or she has swine flu, Newman response, "gee that would be really great. I hope you have swine flu because that's the good one. That's the one you want.' This is because swine flu has killed a little bit less than 1,000 people in America, while the seasonal flu kills between 30,000 and 50,000 people every year for the past 30 or 40 years, although sad in cases where people do die of influenza. According to Newman, there is some reason behind the fear. The swine flu is a pandemic and some kinds of influenzas can be extremely deadly. It's not wrong to be a little worried and to get the public excited, but it is wrong to imply that swine flu is more lethal than it is. This sort of reasoning, Newman says is "terrible for our emergency departments, for health care providers, and for society."

Despite the fear and mystery that overblown media coverage can cause, the science behind influenza is relatively straightforward. The influenza viruses A, B, and C compose three of the five genera of the Orthomyxoviridae RNA virus family. Viruses A and B are responsible for causing seasonal flu epidemics, whereas the presence of virus C, in contrast, is much less common. Divided into two subtypes, which are differentiated by either the hemagglutinin (H) or the neuraminidase (N) glycoprotein on the virus' surface, Virus A can also be classified into two different strains: H1N1, responsible for regular seasonal influenza, and H3N2. A new strain of the H1N1 appeared in the spring of 2009 and is responsible for the swine flu pandemic.

Behind all of this fear and paranoia, the drug companies are making an extremely large profit. The two anti-flu medications that are available, Tamiflu and Rellenza, have to be taken within the first few days. This sends a message to the public that they should come in to see the doctor the instant they feel anything, according to Newman. The CDC, on the other hand, recommends that they stay home unless they are in dire need of a medical professional, in the case of extreme illness. The drug companies advertise Tamiflu and Rellenza as being capable of saving the lives of those who take it, contrary to the evidence. According to Newman, of the studies that have been done on Tamiflu there was no difference found between the amount of people who died in the Tamiflu group and the placebo group. Based on this information, Newman believes, that it's wrong to lead patients on with the idea that a pill will prevent them from dying or getting critically ill from the flu.

In response to President Obama making H1N1 a national emergency, Newman says, "public health messages are designed to have an effect on citizens. They're not always designed to inform citizens of what is truthful and honest." The White House wants the public to get vaccinated just in case this flu outbreak turns out to be enormously deadly and catastrophic. Their agenda is to prevent a possible disaster, not to inform the public of the truth.

Seasonal flu, H1N1 (swine) flu, and avian flu are all members of the influenza A genus. However, despite shared common symptoms, differences among the three influenza A subtypes exist in their genetic makeup as well as behavior. Whereas human flu viruses are characterized by the amino acid lysine at position 627 of their amino acid sequence, avian flu viruses differ at that position with the amino acid glutamine. With regard to behavior, avian influenza spreads by cell-to-cell contact, avoiding cell receptors, instead of the typical cell-entry mechanism. Whereas human flu viruses are generally not fatal, the H5N1 subtype of the avian flu is much more lethal, killing over fifty percent of those infected. The novel H1N1 strain responsible for the 2009 pandemic elicits similar symptoms and is transmitted in much the same way as the H1N1 strain that causes seasonal flu. Despite the media hype lavished on the H1N1 pandemic, the novel strain can be thought of as just a variant of the regular flu strain, with the term "pandemic" attached to signify not the virus' lethality but rather the virus' spread.

According to Newman, populations with chronic illness are probably more risk for morbidity and mortality. For example, a recent CDC report Newman read, of the 36 children who died of H1N1 in May and August, 22 of them suffered from chronic illness. However, many of the CDC at risk recommendations, such as the elderly, are "not based on data." He has personally seen cases of swine flu at St. Luke's and Roosevelt, but it's less prevalent than severe pneumonia. "The scale that we have made ourselves scared of this is a little bit silly when you compare it to the general illnesses that we see on a daily basis and have proclivity to do real harm," Newman comments.

A casual handshake, rubbing of the eye, or simply being in the presence of someone infected with influenza are some ways of contracting the illness. Once inside the body, the virus initiates its attack by first binding its surface glycoproteins to receptor proteins on its host cells, typically those of the throat, nose, and lungs, entering the cell, and replicating its genetic information before departing the host cell. Symptoms are manifest, on average, one to days after transmission of the virus.

Newman's recommendations for college students, include washing hands. Since there's not a lot of evidence that the H1N1 vaccine at this time will save lives, getting the vaccine should be an individual decision. Stay home, if you get sick unless you begin to have severe symptoms such as difficulty breathing. People should stay away from hospitals unless absolutely necessary because 'there's more H1N1 inside a hospital than outside,' you have the potential to make the sick people in the hospital even sicker, and more sick people die due to reduced resources. According to Newman, "one thing that we've proven in the world of emergency medicine is that when we crowd emergency departments people die." This is because the hospital spends time and resources treating minor illnesses that can be treated elsewhere while the patients with major illnesses don't get the attention they need.

the science behind naps

Helena (Hao) Wu

With schoolwork, jobs, activities, and noisy roommates keeping you from a "normal" eight-hour sleep schedule, many college students take naps during the day to keep up. Before getting some shut-eye during lectures or snoozing for a few minutes in Butler, consider learning the science behind sleep to optimize your nap efficiency.

Do you wonder why some naps leave you refreshed and energized, and others leave you even more exhausted than before? Everyone believes in a different napping method and mastering the art of napping first requires an understanding of the sleep cycle.

College students lead busy lives that leave little time for sleep. A well-timed nap can not only refresh you, but also strengthen your memory. A recent study shows that naps contribute to memory enhancement and improved performance during the day. Some employers believe naps to be so effective in increasing productivity that they have even built nap facilities so that workers can catch a quick snooze during the workday. A corporate firm in Dallas, Kaye/Bassman, even installed a relaxation room, complete with massage chairs, headphones, and light dimmers, for their employees. By manipulating the sleep cycle, people can rejuvenate their minds during short periods of sleep.

The sleep cycle consists of two components: the Non Rapid Eye Movement cycle (NREM) and the Rapid Eye Movement cycle (REM). NREM cycle is the period of time when the brain is in a deactivated state. During NREM, sleep-talking and sleepwalking may be observed in some people. On the other hand, the REM cycle is an active state characterized by the incidence of dreams, increased neuron activity, and periodic movements such as twitching.

> "The time of day in which the nap takes place also affects the efficiency of the nap."

The body is in a deeper resting state during the REM cycle. The NREM-REM cycles alternate throughout the night, with the REM portion lengthening and the NREM portion decreasing in time as morning approaches.

The average person takes around an hour and ten minutes to transition from NREM sleep to REM sleep. However, after physical exercise or sleep deprivation, the transition to REM sleep is quicker and the amount of REM sleep increases. A major difference between the two cycles is that NREM sleep rejuvenates the body, while REM sleep repairs the brain, increasing cerebral protein synthesis and reprogramming the brain so that information learned throughout the day can be better consolidated and recalled later on.

Because the body alternates between the two cycles, the timing of naps is crucial to achieving the maximum alertness upon waking up. Waking up before entering the deep REM sleep is recommended because once the body enters the REM cycle, getting up during the cycle could result in grogginess and fatigue. Although the length of NREM sleep preceding REM sleep varies from person to person, the nap length guideline is around thirty to fifty minutes.

The time of the day in which the nap takes place also affects the efficiency of the nap. Sleeping too late can interfere with the circadian rhythm, your natural 24-hour cycle dictated by light and darkness. A region of the brain known as the hypothalamus and receptors in the retina of the eye regulate the circadian cycle and establish sleep patterns. By napping at unusual hours, you are, in a sense, toying with your biological clock. That's why it is wise to avoid naps after three in the afternoon.

The more we learn about how the sleep cycle works, the more people try to find ways to use it to their advantage. For example, professions such as military piloting and long distance boat racing demand numerous hours of alertness, with few hours of sleep. NASA researchers have found that a 26-minute nap increased pilots' performance by 34 percent. Thus, these professionals often adopt a "polyphastic sleep" schedule, sleeping multiple times during the day for short durations in order to stay mentally alert. One such sleep schedule is called the "Uberman". The Uberman schedule consists of six twenty-minute naps: a total of only two hours of sleep each day. These short naps allow the body to immediately enter REM, resting the mind. The strict Uberman sleep schedule requires discipline and several weeks of adjusting to the intense sleep deprivation.

Recently, bloggers have shared their experiences of incorporating the Uberman sleep schedule into their daily lives. They report that it is difficult to transition to Uberman sleep and even harder to maintain the schedule in the long-term. After all, can the extra several hours awake outweigh chronic sleep depriva-

birth order

Helena (Hao) Wu

Upon birth, we each bring certain information to the table; whether it is blemished with genetic mutations, or ostensibly flawless, this information in the form of genes influences our personalities, psychological development, and overall growth. Genes use the human body as a vehicle to transport and carry themselves from generation to generation, and as a vector within which to evolve. While genes provide the basic layout for the brain, our psychological development is then refined by experience and societal expectations.

When individuals enter the world, their personality, intelligence, and ultimately what is expected of them could be affected by where they are in the birth order line. Since the late 19th century, scientists have debated whether or not birth order influences intelligence and psychological development. They argue that birth order effects are either natural consequences of favoring firstborns because they are most biologically apt to continue the species, or are natural consequences of cultural expectations shaping the brain. In actuality, these debates reveal that birth order is neither strictly a cultural nor biological phenomenon, but rather a mixture of both.

From a biological standpoint, birth order effects can be reduced to the genetic influence on psychological development and the Darwinian theory that parents subconsciously assess the "reproductive value" of their offspring. Darwin suggests that parents favor the offspring most capable of reproducing (older ones, firstborns) because they can further the species and quickly pass on genetic information.[7] Although parents may not know whether or not their firstborn possesses a "good" representation of their genome, it seems that they instinctually feel the necessity to assure that their genes continue through the human species.

While genes shape the brain and may influence humans to favor one offspring over another, each cell within the human body does not necessarily abide only by the ubiquitous genetic code.[4] Like a stem cell, the human being as a whole is pluripotent, engendered with some predisposed characteristics, yet impressionable to surrounding influences and expectations. "Genes influence your intelligence and willingness to take risks," while "social dynamics unconsciously shape your choices."[1] The most prevalent argument regarding birth order and intelligence is that firstborns tend to be more intelligent because resources are disproportionately devoted to them. Firstborns have the opportunity to relish their parent's undivided attention and adoration before other siblings arrive (if they even do). They have adult influences early in life and without other children close in age in their family, they must adapt intelligent and sophisticated ways to interact with their parents and other adults.[5] Like a stem cell differentiates in order to fit in with its environment either among heart cells, skin cells, or brain cells etc., a child must adapt to fit in its environment.

Scientists use standardized test scores to show that a disparity in "intelligence levels" amongst siblings is indeed a birth order effect. In a Norwegian study on 241,310 men who took IQ tests before being drafted into the army during the mid 1960s and 1970s, firstborns had an average 3 IQ point lead over the next eldest child.[8] These 3 points may seem minor, but even a 2.3 IQ point advantage can equate to a 15 point advantage in SAT scores. Such a lead could "make an even bigger difference when you're an Ivy League applicant with a 690 verbal score going head to head against someone with a 705."[3]

Since World War I, researchers have been seduced by the standardized test, marveling at its simplistic design and the concept that one's level of intelligence could simply be assigned a number. However, standardized test scores could rather reflect what type of learner you are. For instance, a "sequential" or analytic learner who tends to learn at a rate determined by the clock and follow linear reasoning procedures, may do better on a standardized exam than the contrary "global" learner. Global learners often have difficulty understanding the most rudimentary parts of a problem and tend to make intuitive jumps, failing to comprehend the progress toward a solution. Therefore, they tend to do more poorly on standardized tests where a systematic approach is often more useful.[2] Perhaps firstborns tend to do better on standardized tests because their learning styles are different and more compatible with the standardized test format and questions.

This emphasis on using standardized tests to classify individuals according to intelligence reflects our standardized society, where most colleges and graduate schools require entrance exams to stratify applicants. Because society and the government have favored a potentially specious representation of intelligence, it seems that they have favored one type of learner over the other, and by extension, one child in the birth order over the rest. Since firstborns tend to score higher on standardized exams and are supposed to be "smarter," the erroneous societal expectations explained above enforce the idea that culture affects birth. Society seems to render the firstborn more "intelligent" by expectation, and later-borns less intelligent.

While personality is in part genetically defined, it also appears to be influenced by cultural expectations along the birth order line. Frank Sulloway, a birth-order analyst, reveals the effects of birth-order by using the "Big Five Personality Dimensions" to classify siblings according to Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Firstborns tend to score higher on Extraversion than later-borns, since they display dominance or assertiveness as leader of the brood. They also tend to score higher on conscientiousness because they have conformed to their parents' values and respect authority more, given their closeness with their parents.[3] Perhaps because firstborns are culturally expected to be the "leader of the brood," they might feel that need to conform and fill this role.

Contrarily, later-borns will score higher on Openness, or honesty, be cause they cannot identify as much with their parents. Openness is also associated with rebellion and recklessness because unlike firstborns, later-borns can take needless risks, seeing as they are not favored for survival and reproduction.7 Later-borns are also both outgoing and antagonistic, tending to counter authority. Richard Zweigenhaft, a Guilford College psychology professor, conducted a study of picketers at labor rights meetings. When the events got out of hand, he interviewed the people rounded up by the police, and found that more and more of them were later

> "Current spaceship design would be deadly if applied to space habitation."

or last-borns.3 Could this antagonism and rebellion result from the constant need to steal the spotlight and step out of the inescapable shadow of the oldest sib? Maybe so, or it could result from the later-borns giving in to cultural influence to defy the firstborn, and fulfill the disobedient expectation of the later-born.

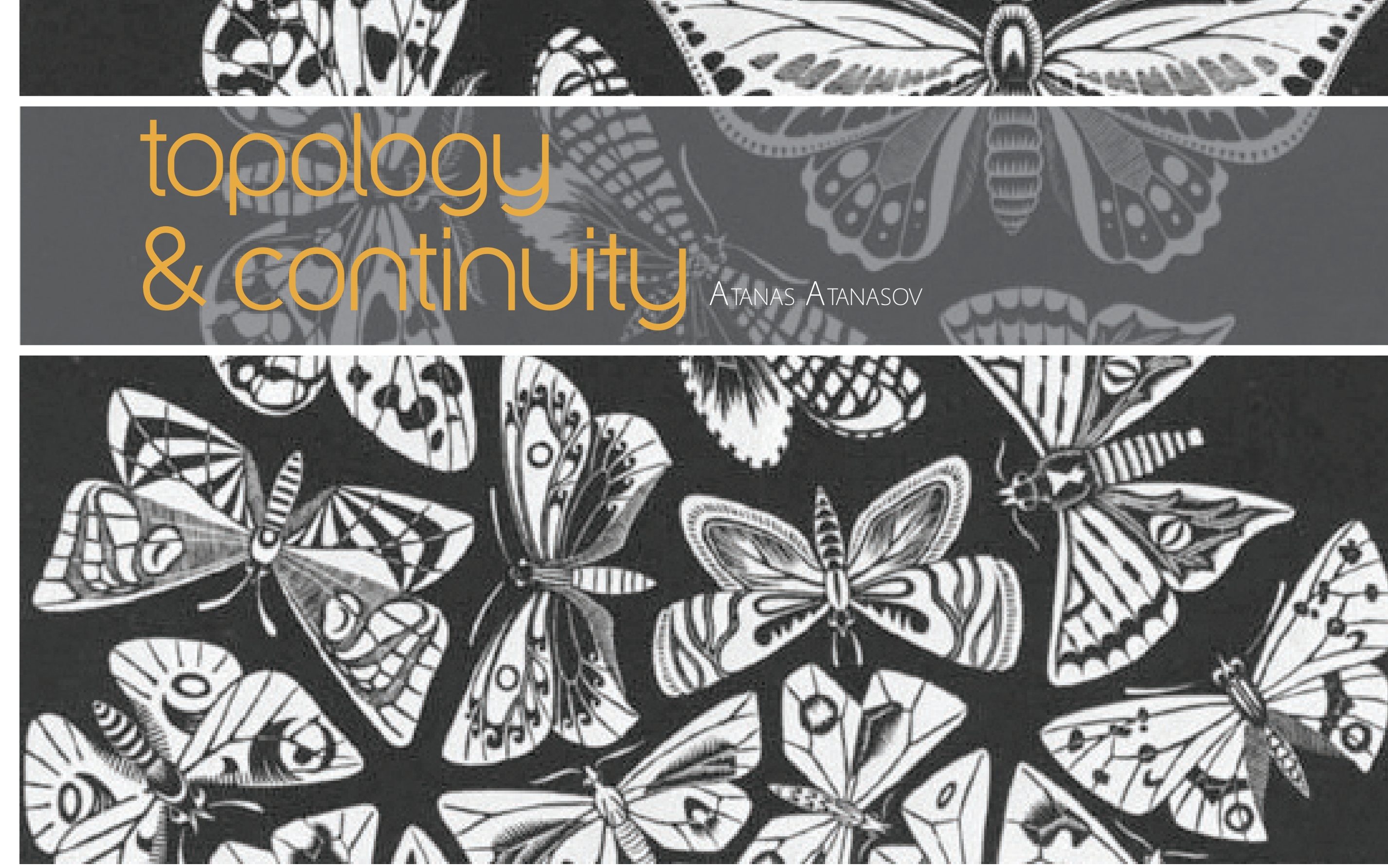
These personality differences also appear to affect what jobs firstborns and later-borns generally have. For example, in a survey of a group of CEOs, 43% were firstborns, 33% were middle-borns, and 23% were last-borns. Firstborns are disproportionately found among surgeons and M.B.A.s. There are an excessive number of firstborns in Congress as well, and the majority of U.S. presidents were firstborns. It has been suggested that firstborns overpopulate such jobs because it is often in the nature of the position to be conscientious and commanding. In these positions, firstborns often end up being more successful and making more money (1% more than each consecutive sibling along the birth order). Sandra Black, a professor at UCLA, found that firstborn CEOs are more successful because they make incremental and sequential alterations to companies and try to maximize profits, while later-born CEOs tend to throw out whole operations and begin projects anew. Since later-borns are often more comical and free-thinking, when they choose more appropriate fields (according to the Big Five), you could end up with the likes of Voltaire, Mark Twain, and Jonathan Swift, three of the greatest satirists. You could even end up with Stephen Colbert, the youngest of 11 children.3

This surplus of firstborns in such demanding positions clearly supports the hypothesis that firstborns are essentially influenced by society to be leaders of the brood, and be compatible for such jobs, while later-borns are influenced to defy authority while still conforming to the cultural expectation designated to them. With big businessmen driving the economy and doctors providing for the survival of the population, is any surprise that firstborns are favored? After all, doctors, presidents, and 90% of CEOS were college graduates, who perhaps reveled in all of the resources devoted to them.9 As with standardized tests, teachers often tend to cater their lessons for sequential thinkers, presenting notes or information to be memorized and recited for a test. Thus, firstborns may be even favored in academic environments.

On the other hand, in Korea, this is not necessarily the case. Josephine Kim, a psychologist at Harvard University, counters that while the majority of American presidents were firstborns, the majority of Korean presidents were later-borns. "In the U.S., first-born children are raised to be overt leaders among their siblings and this leadership extends to other relationships in life," she says. "In Korea, I believe it is more culturally expected that the firstborns become more covert leaders, with strong encouragement from their parents to be yielding and accommodating to their siblings."6 American firstborns have been "cultured" into believing that they should be on top, while Korean firstborns have been pressured to yield to their other siblings, and pass the opportunities onto them. Perhaps, since these differences in cultures have existed over quite some time (spanning the presidencies), America and Korea have inadvertently selected the strongest predisposed overt leaders and covert leaders respectively to do well in society, thereby selecting what genes that affect leadership continue to be passed on.

In spite of all of this evidence, however, the birth order argument is not entirely foolproof. Some conclusions regarding birth-order effects have been based on studies done between families where differences in socioeconomic status, parental IQ, and family size went unaccounted for, thereby potentially producing spurious results.

Nonetheless, in his novel, Outliers, Malcolm Gladwell suggests that if we want to understand how people are so successful, we should spend more time "looking around them," remarking upon such things as their birthplace and family. New York Times writer, David Brooks, adds to Gladwell's thesis stating, "Exceptionally successful people are not lone pioneers who created their own success. They are the lucky beneficiaries of social arrangements."1 While Gladwell may be right in that nurture is an essential part in cognitive development, you cannot fail to recognize that "nature" in the sense of biological factors also influences intelligence, personality, and success. In the end, the biological, evolutionary argument is culturally and "societally" driven; without the cultural factors, the biological factors may not have the same effect on intelligence, personality, and birth order. In the face of this hefty birth order argument, I can only hope you don't run off to your parents demanding to know how they could have paid more attention to your older sibs, or find yourself awkwardly distancing yourself from your little sibs, the victims of society and human instinct. Just consider that there could after all be an explanation for why J.K. Rowling's Bill, Charlie, and Percy Weasley earned more O.W.L.s (Outstanding Wizarding Levels) than Ron, Fred, and George.



topology & continuity

Atanas Atanasov

1. History and first examples

The last 200 years mathematics has seen a return of geometric techniques at large. For most people, "geometry" is a word reminiscent of theorems about triangles and circles dating back to ancient Greece. However, there have been numerous developments in the subject dating between ancient times and the 1800s, yet what makes the latter period so interesting, both historically and mathematically, is the systematic and rigorous development of topology. Many describe topology as the study of "rubber geometry", or more informatively, of objects which allow deformation. We will attempt to recover the logical sequence of constructions which lead to the modern definition of a topological space by Kazimierz Kuratowski dating back to 1922.

Our story starts in the early days of calculus during the 17th century. Sir Isaac Newton and Gottfried Leibniz were the two main scholars working on this new exciting field. They developed ideas which have nowadays become an integral part of mathematics - derivatives, integrals, differential equations, and many others. Despite the brilliant foresight of these great men, from a modern point of view their work saw little, if no, rigor. They talked about converging sequences, series and taking limits without really having concrete explanations of what these meant. However, the foundational problems had to wait until the early 19th century to be resolved. Augustin Louis Cauchy was the first to formulate our modern "epsilon-delta" definition of continuity.

Let us consider a map f : R - R, or in other words a function from the real numbers to the real numbers. In fanciful mathematical language, this is the good old graph we plot on the xy-plane. In this context, we can vaguely formulate continuity as the ability to draw the graph with a pencil without having to lift it from the plane. This concept is illustrated in Figure 1.

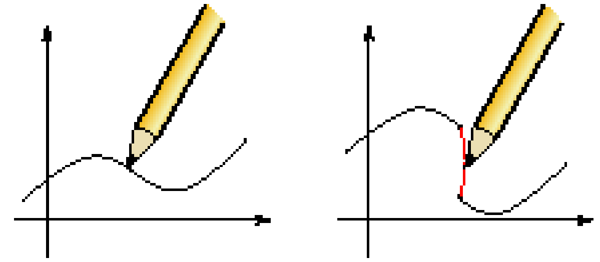
This is an extremely naive definition. There are many questions which cannot be resolved. There are functions which do not jump at isolated points as the one above, but infinitely often in a dense manner. These cannot be graphed in such an idyllic fashion, yet they allow some continuous points. Even more, the mere mention of a "pencil" makes the flaw extreme. Cauchy's "epsilon-delta" definition fixes these issues. According to the definition, the function f is continuous at some point x - R if -" > 0 - > 0 -y : |y - x| < - |f(y) - f(x)| < ".

The symbols -, - refer to the universal and existential quantifiers, which are read "for all" and "there exists" respectively. In plain English, the above expression says: for all " > 0, there exists some > 0, such that if y is no further than from x, then f(y) is no further than " from f(x). It is now clear the notorious nickname of this definition refers to two of the variables used.

2. Metric spaces

Let us take a closer look at the above definition. All of x, y, f(x), f(y) are real values, so to measure distances we used the absolute value function in the expressions |y - x| and |f(y) - f(x)|. Everything we said so far has been adapted to the specific case of real numbers. The real line is possibly one of the simplest geometric objects, so despite the fact that we have a working definition of continuity, it is not a very useful one. For example, most calculus classes cover both single and multiple variables. Hence, the next object of interest is a function f : Rm - Rn, or in other words, a function from m-dimensional space to n-dimensional space. We can adjust our previous definition using Euclidean distances ky -xkm and kf(y)-f(x)kn. It is important to note that the domain and codomain (colloquially referred to as input and output – in this case Rm,Rn) are different sets with possibly different notions of distance. This is to our advantage since we can talk about continuity of a broader range of functions. On the other hand, we are still using subtraction in Rm and Rn. There are many geometric objects of interest which do not allow algebraic operations on them e.g. a sphere.

In order to dispose ourselves from the subtraction, we will start by considering an arbitrary set X. We reduced the definition of continuity in and out of X to providing a means of measuring distance between the points of X (in set theoretic terms, its elements). A metric on X is a function d : X - X - R, or in plainer language, that is a function which takes as parameters two points in the set X, and returns a real number. The motivation behind such a construction is brilliantly clear. It mimics perfectly our idea of measuring distance – given two points, it "measures" the distance between them. There are several conditions we need to impose ond in order to ensure it is well-behaved. Let X be a set and d : X - X - R a map. The tuple (X, d) is called a metric space if the metric satisfies:
(a) non-negativity (for all x, y - X, d(x, y) ≥ 0),
(b) non-degeneracy (for all x, y - X, d(x, y) = 0 if and only if x = y),



continuity discontinuity

(c) symmetry (for all x, y - X, d(x, y) = d(y, x)), and
(d) the triangular inequality (for all x, y, z - X, d(x, z) ≤ d(x, y) + d(y, z)).

These are all properties which we normally assume when talking about distance. Part (a) imposes that no two points can be at a negative distance from each other, (b) that two points are distance zero from each other if and only if they are the same point, and (c) that the distance from x to y is the same as the distance from y to x. The most involved condition is the triangular inequality (d), which requires going from x to z directly is closer than going from x to y and then to z.

At this point we can state Cauchy's definition in full generality. Let (X, dX) and (Y, dY) be metric spaces. A map f is called continuous at x - X, if -" > 0 - > 0 -y - X : dX(x, y) < - dY (f(x), f(y)) < ". If f is continuous at all points x - X, then we call it continuous. The definition of a metric space and the associated form of continuity are due to Maurice Fr´echet who introduced them in 1906. Despite the additional level of abstraction, it is clear that the above is nothing more than a restatement of Cauchy's original definition with the exception of a few cosmetic changes. Furthermore, the conditions (a)-(d) imposed on a metric space are a very natural choice. On the other hand, it is important to note that metric spaces encompass numerous objects of interest to geometry, analysis and other areas of mathematics. They also cover much more than we could have initially expected. For example, under certain conditions the set of continuous functions between two metric spaces can itself be turned into a metric space, which is the most basic example functional analysis studies.

3. Topological spaces

The final goal of this article is to understand the concept of a topological space. In our first attempt to formalize continuity, we discussed the possibility of drawing the graph of a function without lifting the pencil. Our formal investigation has yielded Fr´echet's formulation of a metric space as a means of encoding geometric data. In order to reach a functioning definition, we were forced to introduce the distance metric, yet originally we had no intent of incorporating such an object. Furthermore, we described topology as the study of rubber geometry. As one deforms an object, different parts could be contracted or expanded, hence modifying the distance between points. These remarks suggest there should be a more intrinsic formulation of continuity and a means of incorporating geometric data in general, which does not refer to a distance function. The object which we are alluding to is called a topological space.

There are several issues to address before we would be able to provide a concrete explanation. Let us consider a metric space (X, d), which we will often refer to simply as X. Any subset Y - X induces a metric space (Y, d|Y -Y). Formally, the metric d on X restricts to d|Y -Y : Y - Y - R which acts as a metric on Y . From this point of view, any subset of points could possibly act as a subspace of X. However, in practice not all subsets yield spaces worthy of interest. There are two special types of subsets which we will be focusing on – respectively called open and closed. If x - X is a point, and r > 0 a positive real number, then the ball of radius r or r-ball around x, denoted BX(x, r), is the set of all points y - X no further than r from x, that is BX(x, r) = {y - X | d(x, y) < r}. Such balls are often referred to as neighbourhoods of x. Note that the subscript at B indicates the metric space we are working in. We call a subset U - X open, if for all x - U, there exists some radius r > 0 such that BX(x, r) - U (we often refer to such sems simply as opens). This means every point of the open U contains a neighbourhood fully contained within U. Provided with this definition of metric openness we call a set C - X closed if its complement X \ C is open. To give an example, consider the real numbers R with the standard metric given by d(x, y) = |x-y|. For any x - R and r > 0, the r-ball around x is nothing more than the interval (x-r, x+r). It is not difficult to see that for every two real numbers a < b the interval (a, b) - X is open, since for every c - (a, b) the ball BR(c,min{b - c, c - a}) is contained in (a, b). That is in fact the largest ball around c contained in (a, b). Similarly, the interval [a, b] is closed since its complement (-∞, a)-(b,∞) is open. These properties are often attached to intervals without justification of the underlying topological concepts. Now that we fully understand the real line, let us consider a higher dimensional example.

Consider space Rn with the metric induced by Euclidean distance d(x, y) = kx - ykn. Opens in Rn can be colloquially described as regions which do not contain their boundary, much like opens intervals do not contain their endpoints. Analogously, regions which contain their boundary are closed. Once again, we are describing open and closed sets without any specific reference to the metric we are using, yet the rigorous path to formulate these concepts in the case of metric spaces employs a distance function. These observations suggest there must be a different solution to the problem we are looking at.

Let X be an arbitrary set. We will consider a collection of subsets T of X and declare these open. This is a very drastic approach to defining openness. Disposing ourselves of the metric structure, we are left with nothing else but to "define away" the problem. If the opens in T are to behave analogously to the case of metric spaces, we need to impose several conditions: (a) both the empty set and the entire space are open (-,X - T); (b) finite intersections of opens are open (if U1, . . . ,Un - T , then T n i=1 Un - T); (c) arbitrary unions of opens are open (if U - T for all - A, then S2A U - T).

A pair (X,T) which satisfies the above three properties is called a topological space. We often omit the collection of opens T and refer to a topological space simply by its set of points, in our case X. Before continuing, let us take a closer look at the definition above. Part (a) is very simple, but (b) and (c) could be very confusing. In particular, it is not clear why we restricted intersections to be finite, yet allowed unions to be arbitrary (possibly infinite). The simple answer is this mimics the familiar case of metric spaces and the definition of openness there. It is easy to check that the union of an arbitrary collection of open sets in a metric space is again open, and similarly, that any finite intersection of opens is also open. The finiteness condition is imposed, since it is possible to construct an infinite collection of open subsets in a metric space whose intersection is not open. If for any integer n ≥ 1 we let Un denote the interval (-1/n, 1/n) in R, then T1 n=1 Un = {0}. The single point set {0} is definitely not open, which explains the rational behind the definition of a topological space. The version we provided was given in 1922 by the Polish mathematician Kuratowski. In turn, he was introducing minor generalizations to earlier work of Felix Hausdorff from 1914. It is important to understand that topological spaces are not removed from metric spaces. As a matter of fact, every metric space (X, d) induces a topology T on X (given by the open sets in the metric sense), which turns (X,T) into a topological space. The converse however is not true. Not every topological space (X,T) is induced by some metric d on X. If such a metric exists, we call the topological space metrizable. Studying conditions which ensure metrizability is a major topic of interest in point set topology.

Introducing rigorously topological spaces was a significant detour from our discussion of continuity. It is only logical to proceed by explaining when a map between two topological spaces is continuous. Once again our definition will be inspired by analogies with the metric case. In particular, continuity of maps between metric spaces was defined explicitly using the distance function. Consider a continuous map f : X - Y between two metric spaces. We can reformulate the continuity of f by saying that -x - X -" > 0 - > 0 : f(BX(x,)) - BY (f(x), ").

> "Current spaceship design would be deadly if applied to space habitation."

This follows directly from the definition of a ball and some simple logic. Since all balls are open, it seems this reformulation is on the right track. It is a slightly more difficult exercise to show that f is continuous if and only if for every open U - Y , its preimage f-1(U) - X is open too. This follows from the definition of metric openness and the above statement. Note that this way of expressing continuity has finally disposed ourselves of the distance function, and only refers to open sets. It is also considerably simpler to comprehend in comparison with the earlier postulate which incorporated three quantifiers. We can now state the final version of continuity we have been aiming for. Consider two topological spaces (X,TX), (Y,TY), and a map f : X - Y . We say that f is continuous if for every open U - Y (that is U - TY), its preimage f-1(U) is open in X (meaning f-1(U) - TX).

It is now apparent what the advantages of working with topological spaces are. Firstly, concepts such as continuity have simpler reformations which are often easier to deal with. Secondly, they encompass an even broader array of objects. We observed how formulating novel geometric objects and formalizing well-known concepts have interacted both historically as well as mathematically. In conclusion, it is important to make several remarks regarding the approach we took. Our discussion started by treating bare sets, and we proceeded to define two types of objects (metric and topological spaces) which add structure on top of a set. Many constructions in mathematics follows this trend. In fact, topological spaces are only the basis for numerous further constructions which add more and more structure to them. To mention a few examples manifolds, sheaves and schemes are all objects which build on the basis of topological spaces. The modular approach to definitions often reduces the simplicity of exposition and allows scholars to easily build on earlier work.

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