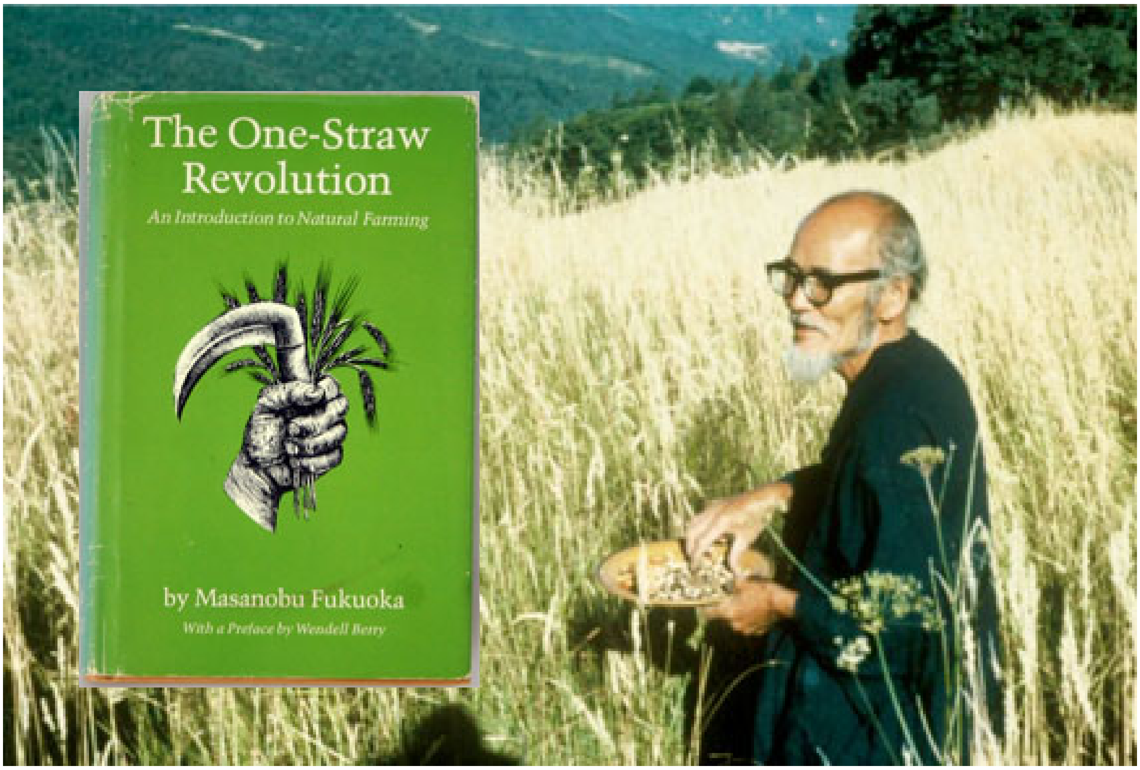
contents



Books to read

The One-Straw Revolution

Masanobu Fukuoka (1913-2008) was a farmer and philosopher who was born and raised on the Japanese island of Shikoku. He is famous for his natural farming methods and his work towards revegetation of desert and desertified lands. He created a new way of farming called "do-nothing" farming which, though it sounds simple, was rather complex to implement.

Fukuoka wrote many Japanese books, scientific papers and other publications, and was featured in television documentaries and interviews from the 1970s onwards. He influenced people not only about farming methods but also inspired individuals to start a movement towards promoting natural foods and lifestyles. He was one of the early people who understood the value of observing nature's principles.

Fukuoka studied plant pathology and was trained as a microbiologist and agricultural scientist. He spent several years working as an agricultural customs inspector in Yokohama. While working there, at the age of 25, he was treated for severe pneumonia and while in hospital had an inspiration that changed his life. He decided to quit his job, return to his home village and put his ideas into practice by applying them to agriculture.

From 1938, Fukuoka began to practise and experiment with new techniques on organic citrus orchards. He used used his practical knowledge to develop the idea of "Natural Farming". For instance, he stopped pruning an area of citrus trees, which caused the trees to become affected by insects and tangled branches. He stated that the experience taught him the difference between nature and non-intervention. In his own words, "To put it very briefly, my theory is that human knowledge and actions have destroyed nature, and thus, if we abandon them and leave nature to nature, nature will recover on its own. This does not, however, mean nonintervention."

Over the next 65 years till the age of 95, he worked to develop a system of natural farming that demonstrated the insight he was given as a young man, believing that it could be of great benefit to the world.

He did not plough his fields, used no agricultural chemicals or prepared fertilizers, did not flood his rice fields as farmers have done in Asia for centuries, and yet his yields equalled or surpassed the most productive farms in Japan.

Fukuoka's system is based on the realisation that living organisms shape an ecosystem in a complex way. He saw farming not just as a means of producing food but as an aesthetic and spiritual approach to life, the ultimate goal of which was "the cultivation and perfection of human beings".

The five principles of Natural Farming are that:

. plowing or tilling are unnecessary, as is the use of powered machines;

. prepared fertilizers and compost are unnecessary;

. only minimal weed suppression with minimal disturbance;

. applications of pesticides or herbicides are unnecessary;

. pruning of fruit trees is unnecessary.

Many people found it difficult to apply his techniques; there are repeated crop failures and it takes a lot of time to adapt the land to makes these principles work. But even today, Fukuoka's family farm is run on the same principles by his children and has a high yield of fruit, grains and vegetables.

In 1975 Fukuoka wrote The One-Straw Revolution, a best-selling book that described his life's journey, his philosophy, and farming techniques. This book has been translated into more than 25 languages and helped make Fukuoka a leader in the worldwide sustainable agriculture movement. He continued farming until shortly before his death in 2008, at the age of 95.

After The One-Straw Revolution was published in English, Fukuoka travelled to many countries. He went to the U.S. and Europe; he visited Somalia and Ehiopia in Africa, where he showed how to re-vegetate dry and arid deserts. In 1988, he lectured at the Indian Science Congress, state agricultural universities and other venues in India. He returned to India many times and also visited Southeast Asia including Phillipines, and China.

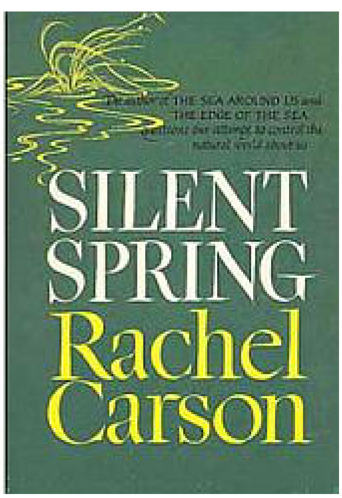
He spent a lot of time and effort in revitalising the deserts of the world using his natural farming techniques. This work is described in detail in Sowing Seeds in the Desert (published in 2012). Fukuoka is also the author of The Natural Way of Farming and The Road Back to Nature. In 1988 he received the Desikottam Award from Viswa-Bharati University in Santiniketan. In the same year, he was given the Ramon Magsaysay Award for public service in the Phiilipines; this is often referred to as the "Nobel of Asia," for Public Service.

Silent Spring

Silent Spring is an environmental science book written by Rachel Carson in 1962. It was one of the first books that not only documented the ill effects of the over-use of pesticides but also highlighted the influences of the powerful chemical industry in such use. It traced the effects of the pesticide DDT on birds in the area.

The book began with a “fable for tomorrow” – a true story using many examples drawn from many real communities where the use of DDT had caused damage to wildlife, birds, bees, agricultural animals, domestic pets, and even humans.

The book first appeared in serial form and Carson used it as an introduction to a very scientifically complicated and already controversial subject. Serialized in three parts in The New Yorker, it was read by U.S. President John F. Kennedy in the summer of 1962. Silent Spring was published in August and became an instant best-seller and the most talked about book in decades.



Carson spent more than six years documenting her analysis that humans were misusing powerful, persistent, chemical pesticides before knowing the full extent of their potential harm. She was passionately concerned with the future of the planet and all life on Earth. In the book and in many talks, she calls for humans to act responsibly, carefully, and as stewards of the living earth.

As her research progressed many scientists also started gathering data on the effects of pesticides both on the environment and on people. She also pointed out that pests could develop resistance to many pesticides, which is exactly what is happening today. Many people from the powerful and influential chemical industry lobbied against her and produced many scientists who opposed her findings, but she did not back out. As many scientists came out in support, a very important finding was made by Wilhelm Hueper of the National Cancer Institute, who classified many pesticides as carcinogens (cancer-causing).

It was for the first time that it was realised that use of pesticides especially by spraying could affect birds, the environment and the people living nearby. One of the most important outcomes was the realisation that the government needed to be involved in a big way. For instance, individuals and groups could question what their governments allowed

others to put into the environment.

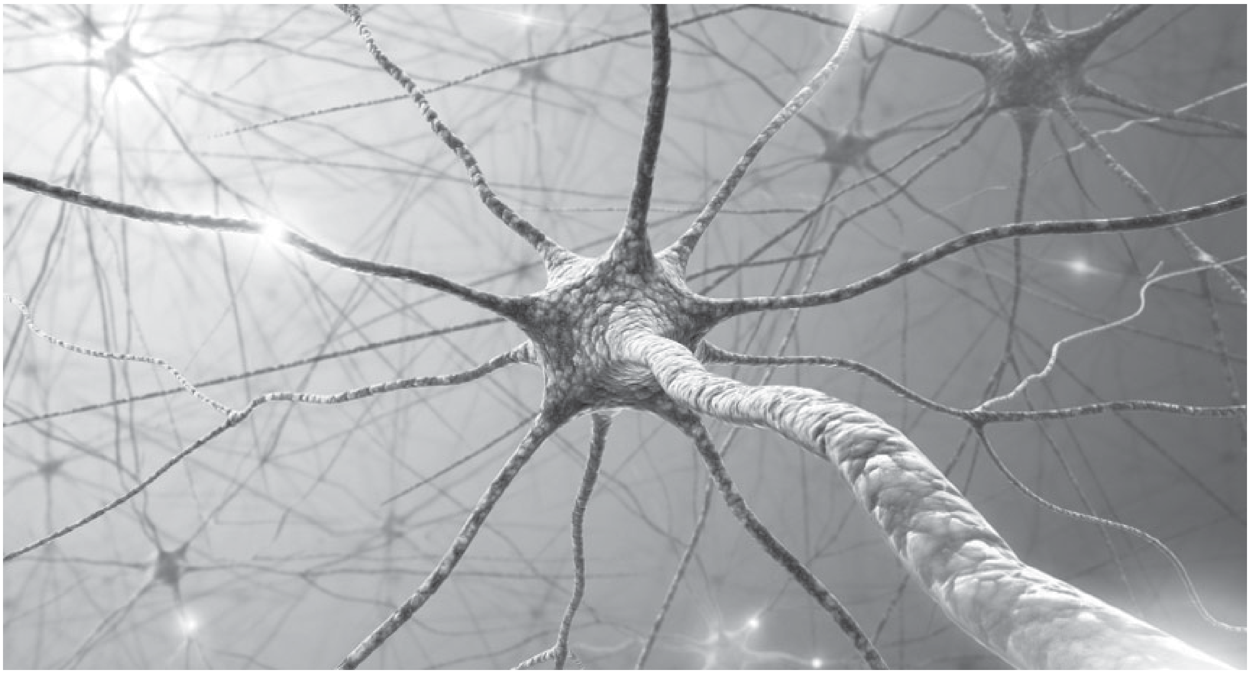
With her book, Carson set the seeds of social revolution. She identified human hubris (excessive arrogance or pride) and financial self-interest (of big companies) as the crux of the problem. She asked if we could master ourselves and our appetites to live as though we humans are an equal part of the earth's systems and not the master of them.

Carson expected criticism, but she was personally vilified by the chemical industry and its allies in and out of government. She spent her last years courageously defending the truth of her conclusions until her untimely death from cancer in 1964. When she was viewed on TV, her quiet and persuasive remarks were in strong contrast to the wild accusations of her detractors and soon people came to believe her and her findings. In 1963, Carson testified before U.S. President John F. Kennedy's Science Advisory Committee, which issued its report on May 15, 1963, largely backing Carson's scientific claims.

Her work not only inspired private individuals to begin an environmental movement but also a social and ecological movement with sustainability at its core. In 1970 the U.S. government also started the Environmental Protection Agency, indicating that governments also acknowledged the importance of regulating and protecting matters of environmental concern.

The naturalist Sir David Attenborough has stated that Silent Spring was probably the book that had changed the scientific world the most, after the Origin of Species by Charles Darwin.

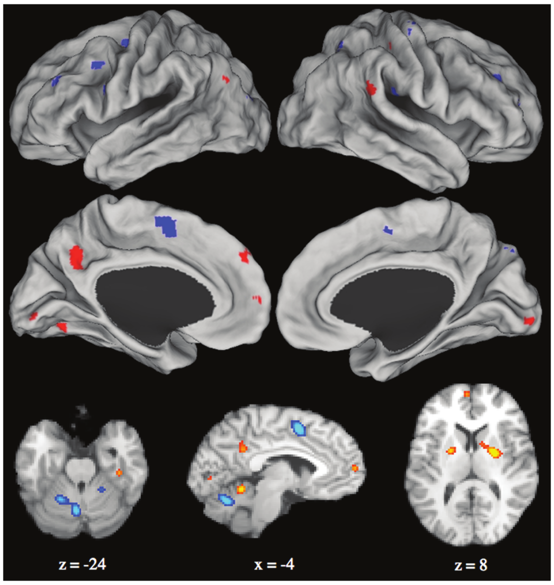
Adapted from http://www.rachelcarson.org/, http://www.onestrawrevolution.net/, and Wikipedia articles.



Learning rewires the brain

Alison Pearce Stevens

Musicians, athletes and quiz competition champions all have one thing in common: training. Learning to play an instrument or a sport requires time and patience. It is all about steadily mastering new skills. The same is true when it comes to learning information — preparing for that quiz



competition, say, or studying for a big test. As teachers, coaches and parents everywhere like to say: Practice makes perfect.

The picture is an artist's depiction of an electrical signal shooting down a nerve cell and then off to others in the brain. Learning strengthens the paths that these signals take, essentially "wiring" certain common paths through the brain.

Doing something over and over again doesn't just make it easier. It actually changes the brain. That may not come as a surprise. But exactly how that process happens has long been a mystery. Scientists have known that the brain continues to develop through our teenage years. But these experts used to think that those changes stopped once the brain matured. Not any more.

Recent data have been showing that the brain continues to change over the course of our lives. Cells grow. They form connections with new cells. Some stop talking to others. And it's not just nerve cells that shift and change as we learn. Other brain cells also get into the act.

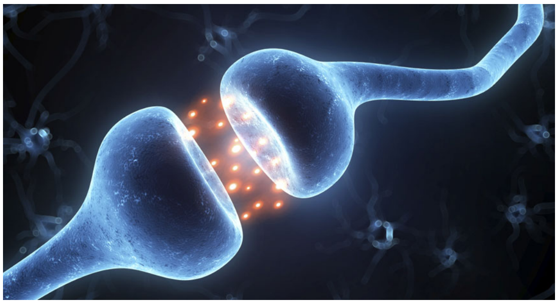
Scientists have begun unlocking these secrets of how we learn, not only in huge blocks of tissue, but even within individual cells.

Rewiring

The brain is not one big blob of tissue. Just six to seven weeks into the development of a human embryo, the brain starts to form into different parts. Later, these areas will each take on different roles. Consider the prefrontal cortex. It's the region right behind your forehead. That's where you solve problems. Other parts of the cortex (the outer layer of the brain) help process sights and sounds. Deep in the brain, the hippocampus helps store memories. It also helps you figure out where things are located around you.

The fMRI

Scientists can see what part of the brain is active by using functional magnetic resonance imaging, or fMRI. At the heart of every fMRI device is a strong magnet. It allows the device to detect changes in blood flow. Now, when a scientist asks a volunteer



to perform a particular task — such as playing a game or learning something new — the machine reveals where blood flow within the brain is highest. That boost in blood flow highlights which cells are busy working — that had greater blood flow when people first learned a task. Blood flow decreased in those areas as they became more familiar with the task. Mind-wandering areas became more active as the task was mastered.

Chemical messengers — called neurotransmitters — leave the end of one nerve cell and jump across a gap to stimulate the next nerve cell. Many brain scientists use fMRI to map brain activity. Others use another type of brain scan, known as positron emission tomography, or

PET. Experts have performed dozens of such studies. Each looked at how specific areas of the brain responded to specific tasks.

Nathan Spreng did something a little different: He decided to study the studies. Spreng is a neuroscientist at Cornell University in Ithaca, N.Y. A neuroscientist studies the brain and nervous system. Spreng wanted to know how the brain changes — how it morphs a little bit — as we learn.

He teamed up with two other researchers. Together, they analyzed 38 of those earlier studies. Each study had used an fMRI or PET scan to probe which regions of the brain turn on when people learn new tasks.

Areas that allow people to pay attention became most active as someone began a new task. But those attention areas became less active over time. Meanwhile, areas of the brain linked with daydreaming and mindwandering became more active as people became more familiar with a task.

"At the beginning, you require a lot of focused attention," Spreng says. Learning to swing a bat requires a great deal of focus when you first try to hit a ball. But the more you practice, Spreng says, the less you have to think about what you're doing. Extensive practice can even allow a person to perform a task while thinking about other things — or about nothing at all. A professional pianist, for example, can play a complex piece of music without thinking about which notes to play next. In fact, stopping to think about the task can actually interfere with a flawless performance. This is what musicians, athletes and others often refer to as being "in the zone."

Spreng's findings involve the whole brain. However, those changes actually reflect what's happening at the level of individual cells.

How neurons function

The brain is made up of billions of nerve cells, called neurons. These cells are chatty. They "talk" to each other, mostly using chemical messengers. Incoming signals cause a listening neuron to fire or send signals of its own. A cell fires when an electrical signal travels through it. The signal moves away from what is called the cell body, down through a long structure called an axon. When the signal reaches the end of the axon, it triggers the release of those chemical messengers. The chemicals then leap across a tiny gap. This triggers the next cell to fire. And on it goes. As we learn something new, cells that send and receive information about the task become more and more efficient. It takes less effort for them to signal the next cell about what's going on. In a sense, the neurons become wired together.

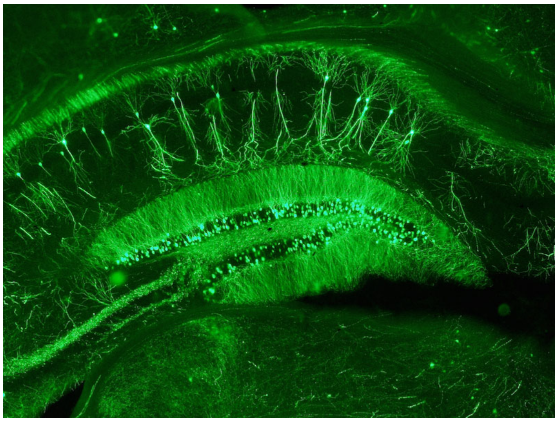
In a study, a mouse was genetically modified to make a a fluorescent protein that glows green so it could be detected easily. As the brain learns, neurons relay information faster and more efficiently. They used less energy to chat. This allowed more neurons in the "daydreaming" region of the brain to increase their activity.

Neurons can signal to several neighbors at once. For example, one neuron might transmit information about the location of a baseball pitch that's flying toward you. Meanwhile, other neurons alert your muscles to get ready to swing the bat. When those neurons fire at the same time, connections between them strengthen.

That improves your ability to connect with the ball.

Learning while you slumber

The brain doesn't shut down overnight. In fact, catching some sleep can dramatically improve learning. That's because as we sleep, our brains store



memories and new information from the previous day. So a poor night's sleep can hurt our ability to remember new things. Until recently, however, researchers didn't know why.

Reverse signalling

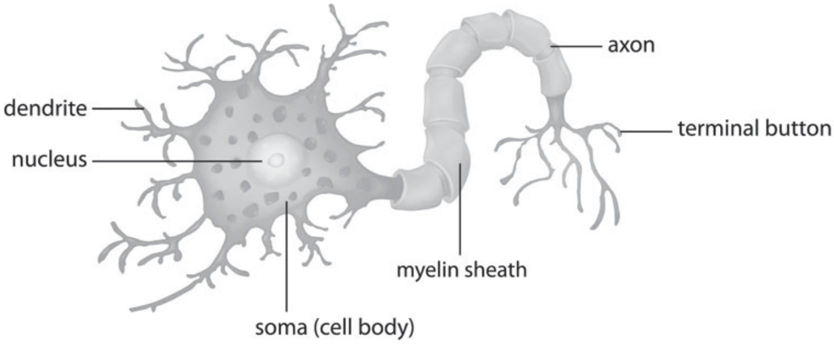
A group of scientists at the University of Heidelberg in Germany provided the first clues. Specific cells in the hippocampus — that region involved in storing memories — fired when mice slept, the scientists found. The photo shows the hippocampus region of the brain of a mouse that was genetically modified with a gene that creates a green fluorescent protein. So the neurons glow green when they fire.

But the cells didn't fire normally. Instead, electrical signals spontaneously fired near the middle of an axon, then traveled back in the direction of the cell body. In other words, the cells fired in reverse.

This boosted learning. It did so by making connections between cells stronger. Again, the action sort of wired together the cells. Research by Olena Bukalo and Doug Fields showed how it happens. They are neuroscientists at the National Institutes of Child Health and Human Development in Bethesda, Md. Working with tissue from rat brains, the scientists electrically stimulated nerve axons. Carefully, they stimulated them just in the middle. The electrical signals then traveled in reverse. That is just what the German scientists had seen.

This reverse signaling made the neuron less sensitive to signals from its neighbors, the experts found. This made it harder for the cell to fire, which gave the neuron a chance to recharge, Bukalo explains. When she then applied electric stimulation near the cell body, the neuron fired. And it did so even more strongly than it had before.

Cells involved in learning new information are most likely to fire in reverse during sleep, Bukalo says. The next day, they will be wired more tightly to each other.



LEARNING CHANGES THE BRAIN

C	S	Y	F	J	B	K	K	V	V	P	O	E	K	X	K	Y	A	W	R
T	L	O	J	D	R	U	Q	X	T	E	D	Z	M	P	X	J	Z	Q	Y
D	Y	G	V	K	K	F	R	E	G	N	O	R	T	S	S	Z	M	T	K
T	O	Y	V	Q	I	Y	M	T	K	O	Y	I	G	T	L	E	T	T	R
V	A	K	N	Y	R	W	D	R	J	I	N	O	I	P	M	A	H	C	C
D	F	T	D	E	C	Z	N	O	I	T	A	M	R	O	F	N	I	I	O
V	E	J	T	E	M	B	W	C	B	A	U	N	R	Z	H	R	A	L	X
A	F	S	N	E	C	R	R	L	H	L	H	Y	T	R	T	E	U	L	G
X	Y	P	J	S	N	O	X	A	A	U	L	D	E	C	I	S	I	O	N
M	E	V	Q	R	V	T	M	T	I	S	L	E	E	P	U	C	W	P	C
I	Y	J	V	E	I	O	I	N	T	N	Q	L	C	P	K	R	O	R	J
F	X	S	B	V	M	O	M	O	H	I	E	G	M	Q	U	A	G	E	K
M	E	S	S	E	N	G	E	R	N	G	V	A	U	J	S	M	S	W	I
N	J	T	N	R	T	E	E	F	F	G	C	I	B	P	V	M	Z	W	H
Y	O	T	N	N	O	R	U	E	N	O	Z	E	H	T	N	I	P	N	P
P	A	Q	M	K	U	L	E	R	P	N	D	I	V	F	H	N	F	W	D
F	R	U	M	G	N	I	P	P	A	R	W	I	R	I	N	G	J	F	U
Y	W	E	I	K	M	U	I	G	F	K	B	H	R	T	T	B	I	E	T
X	V	F	A	C	V	H	K	Q	X	K	A	H	X	O	R	C	M	N	N
B	J	X	Q	J	J	M	P	B	Y	D	S	M	I	U	L	I	A	Q	A

ACTIVE
AHA MOMENT
ATTENTION
AXON
BRAIN
CELL BODY
CHAMPION
CRAMMING
DECISION
ELECTRIC
FATTY
FIGURE
FMRI
GLIAL
GLUE
HIPPOCAMPUS
IN THE ZONE
INFORMATION
INSULATION
MEMORY
MESSENGER
MYSTERY
NEURON
NIGHT
NOGGIN
PREFRONTAL CORTEX
QUIZ
REVERSE
SLEEP
STIMULATION
STRONGER
WIRING
WRAPPING

Although scientists don't know for certain, it is likely that repeated cycles of reverse firing create a strong network of neurons.

The neurons relay information faster and more efficiently, just as Spreng found in his study. As a result, those networks reflect an improvement in understanding or physical skill.

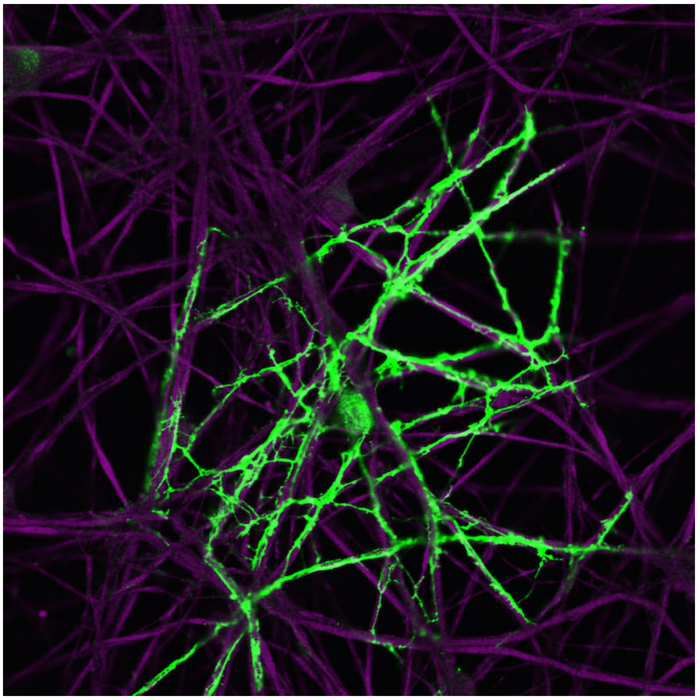
The picture shows a nerve cell in the brain. Glial cells wrap around the axon like a blanket, forming the myelin sheath. As people learn, brain cells change in ways that increase the speed and efficiency with which signals travel down the nerve cells.

Firing faster

Neurons are the best-known cells in the brain. But they are far from the only ones. Another type, called glia, actually makes up a whopping 85 percent of brain cells. For a long time, scientists thought that glia simply held neurons together. (Indeed, "glia" take their name from the Greek word for glue.) But recent research by Fields, Bukalo's colleague at the National Institutes of Child Health and Human Development, reveals that glial cells also become active during learning.

One type of glial cell wraps around nerve axons. (Note: Not all axons have this wrapping.) These wrapping cells create what's known as a myelin sheath. Myelin is made of protein and fatty substances. It insulates the axons. Myelin is a bit like the plastic coating that jackets the copper wires in your home. That insulation prevents electrical signals from inappropriately leaking out of one wire (or axon) and into another.

In axons, the myelin sheath has a second role: It actually speeds the electrical signals along. That's because glial cells force a signal to jump from one spot on the axon to the next. As it hops between glial cells, the



signal moves faster. It's kind of like flying from one spot to the next, instead of taking the train.

The green, octopus-like cell in the center of the picture is a type of glial cell that creates the myelin sheath. Here, the tips of the tentacles are in the early stages of wrapping around several different axons. As the brain learns, the glial cells grow, change and help increase the efficiency with which axons move signals.

Fields has found that when new skills are learned, the amount of myelin insulating an axon increases. This happens as the size of individual glial cells increases. New glial cells also may be added to bare axons. These changes improve the ability of a neuron to signal. And that leads to better learning. A thicker myelin sheath helps improve all types of brainy tasks. These include reading, creating memories, playing a musical instrument and more. A thicker sheath is also linked with better decision-making.

Nerve cells continue to add myelin well into adulthood, as our brains continue to grow and develop. The prefrontal cortex, for example — that area where decisions are made — gains myelin well into a person's 20s. This may explain why teens don't always make the best decisions. They're not finished sheathing their nerve cells. But there is hope. And getting enough sleep certainly can help. Glial cells, like neurons, seem to change most during certain stages of sleep.

Exactly what causes the glial cells to change remains a mystery. Fields and his colleagues are hard at work to figure that out. It's exciting, he says, to launch into a whole new field of research.

Slow and steady

These changes in the brain allow for faster, stronger signaling between neurons as the brain gains new skills. But the best way to speed up those signals is to introduce new information to our brains — slowly.

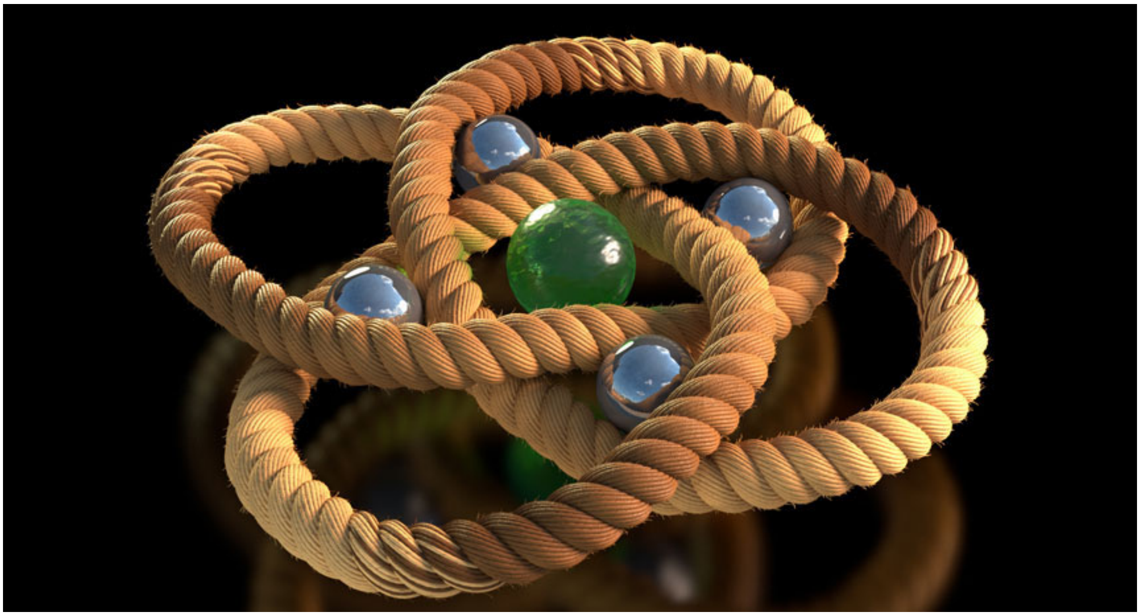
Many students instead try to memorize lots of information the night before a test. Cramming may get them through the test. But the students won't remember the information for very long, says Hadley Bergstrom. He is a neuroscientist at the National Institutes of Alcohol Abuse and Alcoholism in Rockville, U.S.

You may not know it, but learning to play an instrument will remodel the brain. With practice, anyone who has mastered a skill can perform it well — even without having to pay attention.

It's important to spread out learning over many days, his work shows. That means learning a little bit at a time. Doing so allows links between neurons to steadily strengthen. It also allows glial cells time to better insulate axons. Even an "aha!" moment — when something suddenly becomes clear — doesn't come out of nowhere. Instead, it is the result of a steady accumulation of information. That's because adding new information opens up memories associated with the task. Once those memory neurons are active, they can form new connections, explains Bergstrom. They also can form stronger connections within an existing network. Over time, your level of understanding increases until you suddenly "get" it.

Like Fields and Bukalo, Bergstrom stresses the importance of sleep in forming the new memories needed to gain knowledge. So the next time you study for a test, start learning new information a few days ahead of time. The night before, give your brain a break and go to bed early. It will allow your brain a chance to cement that new information into its cells. And that should boost your chances of doing well.

Adapted from Science News for Children: https://www.sciencenewsforstudents.org



Molecular knot

Meghan Rosen

A new molecular knot (representation shown) is the most complex one ever described. It forms a triple braid, with four iron ions (silvery-blue) and a central chloride ion (green) guiding the formation.

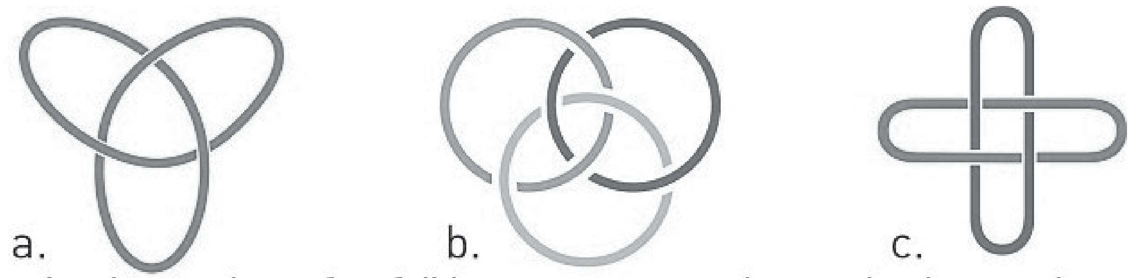
One hundred and ninety-two atoms have tied the knot. Chains of carbon, hydrogen, oxygen and nitrogen atoms, woven together in a triple braid, form the most complex molecular knot ever described, chemists from the University of Manchester in England report in the January 13 issue of Science magazine.

Learning how to tie such knots could one day help researchers weave molecular fabrics with all sorts of snazzy properties. "We might get the strength of Kevlar with a lighter and more flexible material," says study coauthor David Leigh.

That's still a long way away, but molecular knot tying has an appeal that's purely intellectual, too, says University of Cambridge chemist Jeremy Sanders. "It's like the answer to why you climb Everest," he says. "It's a challenge."

Mathematicians know of more than six billion types of prime knots, which, like prime numbers, cannot be broken down into simpler components. "Prime knots can't be built up by sticking other knots together," Leigh explains. For years, chemists were able to synthesize just one type of prime knot out of small molecules. "We thought that was pretty ridiculous," says Leigh.

That molecular knot was a trefoil, like a three-leaf clover. Jean-Pierre Sauvage and colleagues wove it from chemical strands in



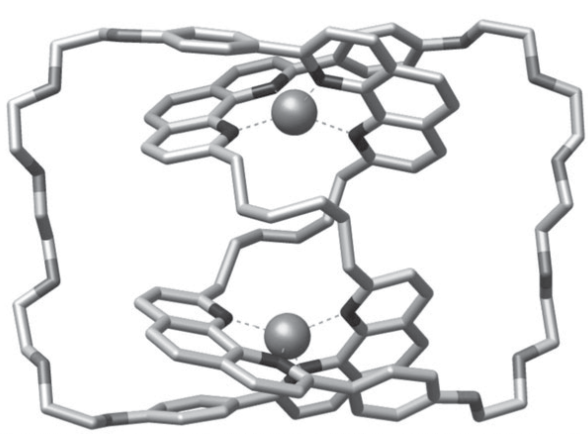
Molecular versions of trefoil knot, Borromean rings and Solomon's knot

1989. Sauvage won a Nobel Prize in 2016 for earlier work that used the same principles explored in his knots.

In the decades since Sauvage's trefoil, chemists have tried to synthesize other types of molecular knots, but "they've always found it incredibly difficult," says chemist Sophie Jackson, also at the University of Cambridge.

Persuading nanoscale strands to interlock together in an orderly fashion isn't simple. "You can't just grab the ends and tie them like you would a shoelace," Leigh says. Instead, scientists choose molecular ingredients that assemble themselves.

In 2012, Leigh and colleagues used the self-assembly technique to make a molecular pentafoil knot, a star-shaped structure made up of 160 atoms and with strands that cross five times. This latest knot, with eight crossing points, is even more intricate.


Crystal structure of a molecular trefoil knot by Sauvage and coworkers

Leigh's team mixed together building blocks containing carbon, hydrogen, oxygen and nitrogen atoms with iron ions and chloride ions. "You dump them all in, heat them all up and they self-assemble," he says. Sticky metal ions hold the building blocks in the correct position, and a single chloride ion sitting in the middle of the structure anchors it all together. Then, a chemical catalyst links the building blocks, forming the completed knot. The new knot is the tightest ever created, Leigh says, with just 24 atoms between each crossing point.

It's beautiful, Sanders says. "It's a string of atoms rolled up in a spherical shape, with an astonishing amount of symmetry." Sanders is reluctant to speculate how such a knot might be used, but it's round and very dense, he says. That could give it some interesting materials properties.

Leigh suspects that different molecular knots might behave differently, like the various knots used by fishermen and sailors. "We want to make specific knots, see what they do and then figure out how to best exploit that," he says.

Collapse of Larsen Iceshelf in Antarctica

Thomas Sumner

The Larsen Ice Shelf is a long ice shelf in the northwest part of the Weddell Sea, extending along the east coast of the Antarctic Peninsula. It is named after Captain Carl Anton Larsen, the master of the Norwegian whaling vessel Jason, who sailed along the ice front as far as 68°10' South during December 1893. From north to south, the segments of the ice-shelf are called Larsen A (the smallest), Larsen B, and Larsen C (the largest) by researchers who work in the area. Further south, Larsen D and the much smaller Larsen E, F and G are also named.

The breakup of the ice shelf since the mid 1990s has been widely reported, with the collapse of Larsen B in 2002 being particularly dramatic. The figure shows how Larsen systematically receded over the years, from 1998 onwards, leaving behind a small remnant seen in the bottom of the map. The breaking up of the ice-shelf is due to undue warming at the location, due to anthropogenic global warming, or man-made global warming.

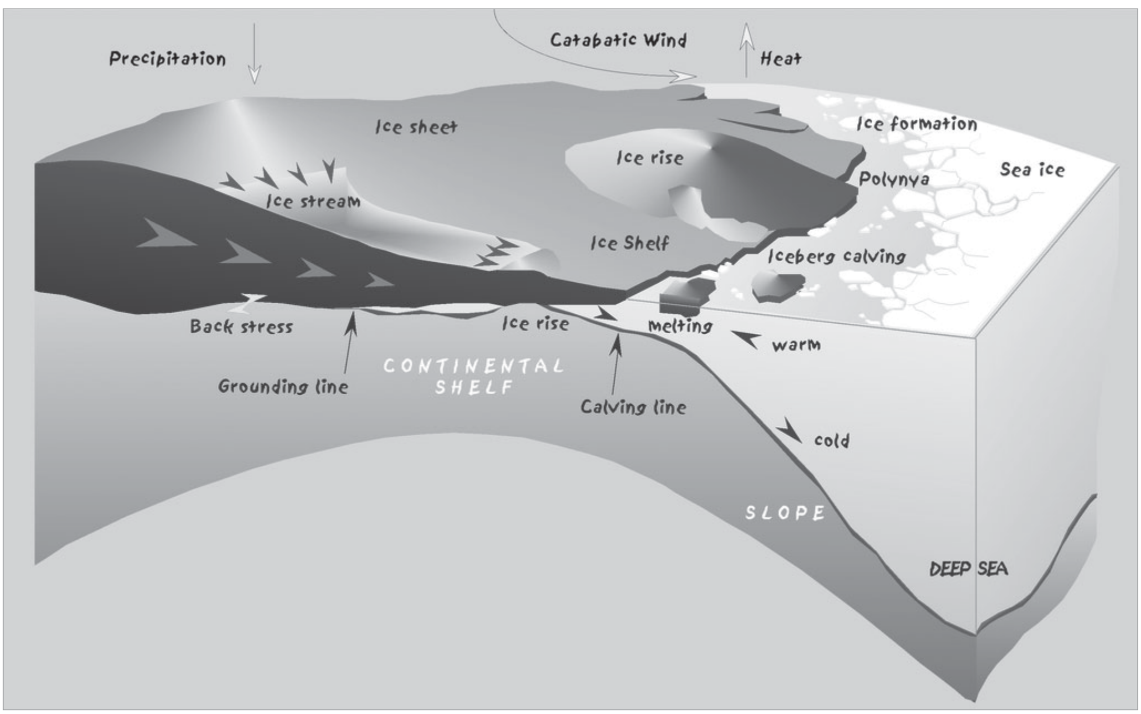
The processes around an Antarctic ice-shelf that causes it to break up are shown in the schematic figure. Larsen A shelf, which was the furthest north (in fact it is outside the Antarctic Circle), had previously broken up and reformed only about 4,000 years ago, before finally breaking up in 1995. The former Larsen B had been stable for at least 10,000 years. Despite its great age, the Larsen B was clearly in trouble at the time of the collapse. With warm currents eating away the underside of the shelf, it had become a "hotspot of global warming." What especially surprised glaciologists was the speed of the breakup, which was a mere three weeks (or less).

Factors they had not anticipated were the powerful effects of liquid water; ponds of meltwater formed on the surface during the near 24 hours of daylight in the summertime, then the water flowed down into cracks and, acting like a multitude of wedges, levered the shelf apart.

The oldest ice on the current shelf dates from only two hundred years ago. Larsen C is the fourth largest ice shelf in Antarctica, with an area of about 50,000 square km.

In 2004, a report concluded that although the remaining Larsen C region appeared to be relatively stable, continued warming could lead to its breakup within the next decade. News reports in the summer of 2016 suggested that this process has begun. On November 10, 2016, scientists photographed the growing rift running along the Larsen C ice shelf, showing it running about 110 kilometres long with a width of more than 91 m and a depth of 500 m.

A colossal crack in this ice shelf abruptly grew by 18 kilometers during the second half of December 2016. (That was the height of the region's summer.) Members of Project MIDAS, an Antarctic



research group, reported the crack's dramatic growth on January 5. This separating ice is now only about 20 kilometers from Larsen C's edge.

Ice sheets and glaciers

Satellite images in 2014 revealed that a crack in Larsen C rapidly extended across the ice shelf. If the crack reaches the ice shelf's edge, it could snap off a large area of ice; this is called calving. This will reduce Larsen C's size by about 10 percent. That's enough to shrink the shelf to its smallest size in recorded history. And it could potentially kick start the shelf's disintegration.

Daniela Jansen is a glaciologist at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. She led the 2015 study. At that time, she had expected the crack might chip apart Larsen C within five years. "We should keep a close eye on Larsen C," she had argued. "It might not be there for so much longer." Larsen C covers about 55,000 square kilometers. That makes it the largest ice shelf along the Antarctic Peninsula. Since Larsen C's ice already floats in the ocean, the big break-off won't immediately raise sea levels. If all the ice that the Larsen C shelf currently holds back were to enter the sea, it is estimated that global waters would rise by 10 cm.

The scientists can't say for certain when Larsen C will break off. But they think it could be soon. Usually, researchers camp on the shelf during the Antarctic summer to conduct their science. But this year, the British Antarctic Survey announced it would halt this practice. Scientists will still be allowed access to the area. But they will be restricted to day trips only — with rescue aircraft waiting nearby.

Cotton clothes make the man

Kamal Lodaya,
The Institute of Mathematical Sciences, Chennai

Cotton bolls on tree

Cotton has been grown in Asia, {Gossypium arboreum}, as well as in Peru, {Gossypium barbadense}, for more than 5,000 years. It was grown in Mohenjodaro, Pakistan, around 3000 BCE. The Vedas from around 1500 BCE talk about spinning and weaving. Cotton fishing nets in Peru date to 2400 BCE.

Cotton seeds were used as fodder in Egypt in 2500 BCE, and in Mehrgarh, Pakistan, are dated to as far back as 4500 BCE. Cotton was planted in Mexico, {Gossypium hirsutum}, in 3400 BCE. Another species, {Gossypium herbaceum}, comes from Sudan in Africa.

Cotton grows in tropical climates. The humans who settled in colder climates would have worn animal skins or fur. Dyed flax, 30,000 years old, is found in a cave in Georgia, Asia, which suggests clothes were made from it then. Clothes were also made from grasses and linen, known for 12,000 years. Ramie (sometimes called China grass) and silk are known in China for 9,000 years. Sheep have been reared for their wool for 4,000 years.

Until the 19th century, the leading

Cotton flower

manufacturer of cotton textiles was the Indian subcontinent. Cotton was harvested by hand. Then a roller gin was used to remove seeds, and a bow was used to remove dirt and knots from the ginned cotton. Then a spindle was used to make thread out of the cotton, and this was woven into fabric with a {charkha} or spinning wheel.

This technology was recorded in India around 750 CE, but was known much before that, perhaps a thousand years before. Wheels were used in China to spin silk in the 3rd century. Later looms were hung between trees to weave the cloth.

Arab and Turkish traders took Indian textiles westwards. Europeans marvelled at the fineness of the fabric. Their imagination of the plant was that something like sheep grew out of the earth, which seems funny to us today.

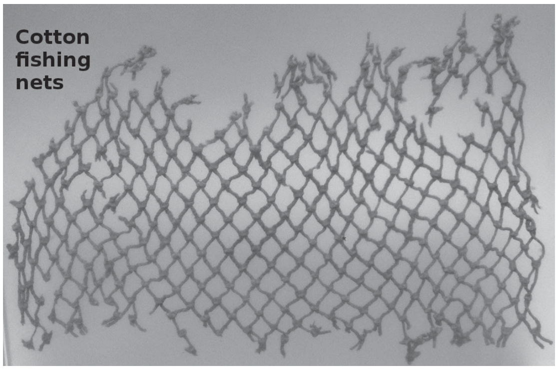
There was a huge demand for Indian cloth in Africa, and Gujarati traders supplied the East African markets.

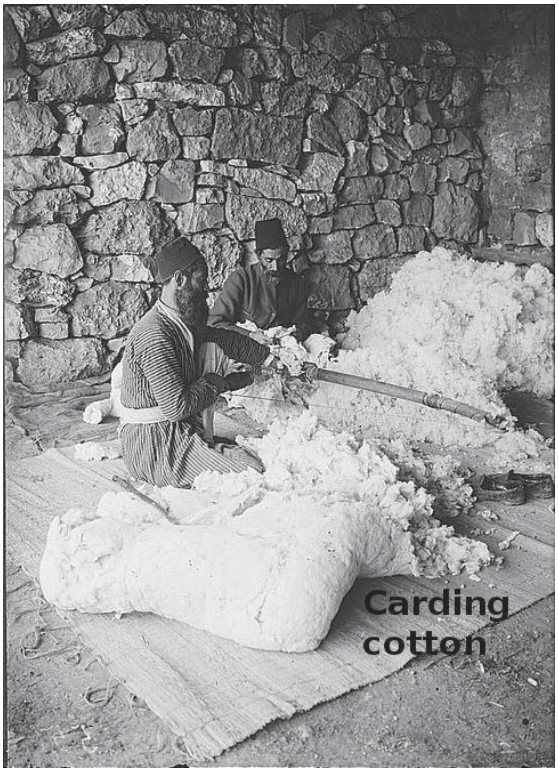
What may surprise you is to know how much of the Industrial Revolution revolved around cotton textiles. Why then did it take place in Europe and not in India?

Europe as the centre of the world

Christopher Columbus reached the Caribbean in 1492, and the Spanish empire soon destroyed the native populations living in Central and South America. They were greedy for the gold and silver from there, this loot also financed their expeditions to other parts of the world.

Meanwhile cotton from Peru and central America also started moving to Europe. Once the local people were decimated, the Europeans set up plantations where "cash





crops" like sugar, rice, tobacco and indigo were grown for Europe. But who was to grow these crops?

Vasco da Gama reached Calicut in 1498. The Portuguese destroyed the Arab and Gujarati cloth trade in the Indian Ocean, between Malabar and the Middle East and East Africa, and also the spice trade between the Coromandel and Southeast

Asia. They wanted to make do without these "middlemen" and directly get to the fabled cotton textiles and spices of Asia. They were later joined by the Dutch, English and French.

With the money plundered earlier, the Europeans purchased textiles from India. Some of these were traded for spices in Southeast Asia. Textiles were also traded in the African market, and African slaves were bought. These slaves were sold to plantations in the "New World", to grow cash crops and again make money for the Europeans. Between 1500 and 1800 CE 80 lakh slaves were transported from Africa, more than half of them in the last hundred years. Each slave was bought against colourful Indian cloth designs which were popular in Africa.

Indian clothes also reached Europe. The writer Daniel Defoe, no friend of India, talked disparagingly about British closets, bed chambers, curtains, cushions, chairs and beds all of "calicoes" (the word comes from Calicut, the port), that is, made of Indian cottons.


Cotton plants as imagined by John Mandeville (14th century)

European traders had warehouses (then called "factories") in Indian ports, where agents of European companies placed orders with {bania} merchants for cloth. They advanced cash to several middlemen, some of whom travelled through Indian villages, advancing funds to weavers and contracting the finished cloth.

These traders belonged to chartered companies, like the East India Company. They had cannon-filled boats to dominate the seas, and soldier-traders and armed private militias to manage the land conflicts. They were not directly connected to European governments.

Soon they realized that to increase profits they would have to monopolize weavers, who would only work for them and not for others. Increasingly these companies began to get into political control of Indian territories. By the 18th century Europeans had entered Indian credit networks, using Indian agents hired by the company. Disobedience was punished with violence. Even then, the Europeans did not get much control over Indian cotton production. They had to continually engage with local rulers, power structures, landowners and ways.

The heart of the transformation to a unipolar Eurocentric world was the slavery in the Americas, for slaves could be controlled exactly as required for crop production. Of course, before slavery came the elimination of the native population, so land was available for free.

America comes in

Raw Indian cotton came to London in the 1690s. But not much reached Europe. Indian agriculture was never export-oriented. India's largest exports were to China. Their technology continued to be to gin their cotton by footroller or by {charkha}.

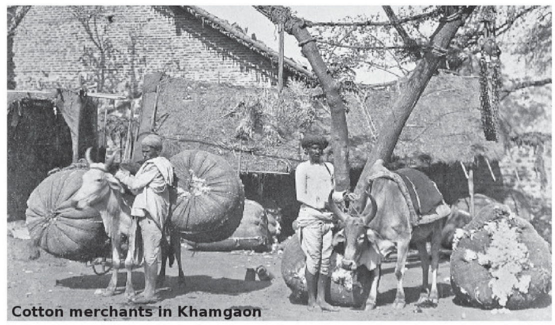
Around the 1760s Caribbean planters, who had slaves arriving almost daily from Africa and easy availability of land, started growing cotton in the West Indies as a cash crop. They quickly outcompeted Turkey and India. By the 1780s the Caribbean and South America produced most of the cotton sold on world markets. The newly independent United States in 1776 realized this was a good market to get into. With plentiful land and plentiful slaves it became the dominant cotton producer in the world. The most commonly used phrase to describe the growth of the American economy in the 1830s was "cotton is king". New Orleans became the leading cotton-exporting port in the world.

Tying up with governments

It was only in the 17th century that cotton manufacturing started in Lancashire in England. Many manufacturers were prosperous with the money acquired during the earlier trade. The port of Liverpool became a huge centre of imports of cotton and exports of textiles.

The main tool used to expand the European industry was to "protect" their products. Duties (taxes) were put on calicoes, these taxes were later doubled. Then import of printed cotton was banned. Then printed calicoes were banned if they came from India. These protections were meant to help the domestic wool and linen industry, which suffered from the competition with cotton. But instead they spurred domestic cotton manufacturing in Britain.

Gandhiji with mill workers



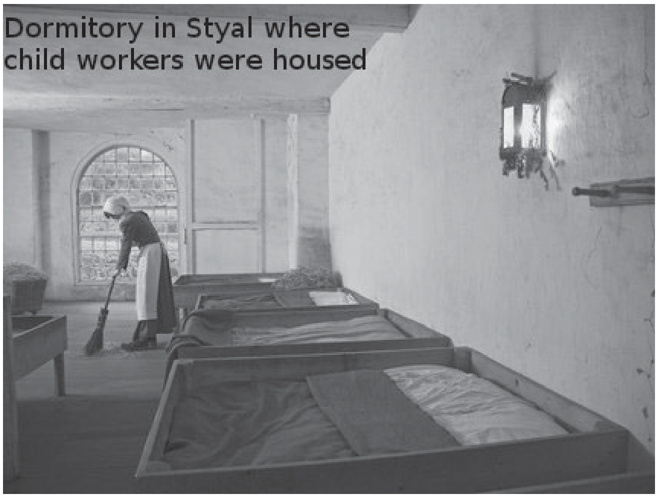
Cotton merchants in Khamgaon

By 1780, cotton textile manufacturers in Glasgow in Scotland were pressurizing the British government to allow them to gain access to export markets in Africa, America and Asia.

Meanwhile Europeans were studying and producing reports, for example on woodblock printing techniques in Ahmedabad, on how the artisans of Pondicherry produced chintz (glazed textile with designs), on how silk and cotton were dyed in Bangalore. This knowledge was used by entrepreneurs in Britain.

Then came some splendid inventions. The inventors were not very renowned at that time, but their inventions spread fast. In 1733 John Kay invented the flying shuttle, which doubled how much yarn a weaver could produce. In 1769 Richard Arkwright's water frame was invented, and in 1779

Samuel Crompton's mule. By 1784 Samuel Greg set up the first textile mill with his water-powered spinning machines. Later the mills would become steam-powered. British cotton manufacture mushroomed. By 1830 one out of six workers was in cotton texiles, and 70 per cent of these workers were in Lancashire. The success of this industry made possible the railway network, the iron industries and later other industries. But who were the workers in these mills?


Dormitory in Styal where child workers were housed


Children harvesting cotton in Uzbekistan

Britain replaced Indian cotton clothes on the world markets. Centres like Dhaka, Bangladesh, known for its fine muslin cloth, went into decline. A French observer said that more than the capture of the trade, more than the industrial revolution, "England has arrived at the summit of prosperity by persisting for centuries in the system of protection and prohibition." Cotton textile manufacturers fought off competing interests, like the East India Company or aristocratic landowners, to lobby for the attention of the state, its politicians and its bureaucrats.

Return of Asia

In the United States, cotton mills and manufacturing came up mostly in New England, in the northeast. The tension between these states and those in the south led to the American civil war in 1861. It soon brought an end to slavery. This led to panic among the European manufacturers. Where were they to get their cotton? Now they started developing other centres of production.

The British acquired Berar (Varhaad in Maharashtra) in 1853 from the Nizam of Hyderabad. Its lands were devoted to cotton for export to Britain. The railway line from Bombay reached Khamgaon in 1870. Along came the telegraph. Now a manufacturer in Liverpool could place an order and in about six weeks get delivery of his cotton.

British mills used a staggering number of child workers. As in America the struggle for better conditions for industrial workers led to a decline of British industry.

In 1861 Ranchhodlal Chhotalal's Shahpur mill used steam-powered spinning machines imported from Britain in Ahmedabad. Rich Ahmedabadis, mainly Vaishnav and Jain banias, turned to this lucrative new industry. Around the same time, people in Brazil, China and Japan had the same ideas. As colonial empires collapsed and the countries of the South regained their independence, many of them put their faith in getting their place in the cotton economy. Cotton production has grown sevenfold since 1920.

By the 1960s Britain only had about 3 per cent of the world's cotton cloth exports. Only about 30,000 workers remained. Today there are 25,000 highly subsidised cotton farmers in the United States. Brazil even argued successfully at the World Trade Organization that the cotton subsidies violated the U.S.'s own previous trade commitments.

Today only 14 per cent of the world's cotton is grown in North America. China is the leader with 29 per cent, followed by India and Pakistan. China, India, Pakistan and Turkey spin and weave the most cotton yarn and fabric. China supplies the United States with 40 per cent of its garments, followed by Vietnam, Bangladesh, Indonesia, Honduras, Cambodia, Mexico, El Salvador ...

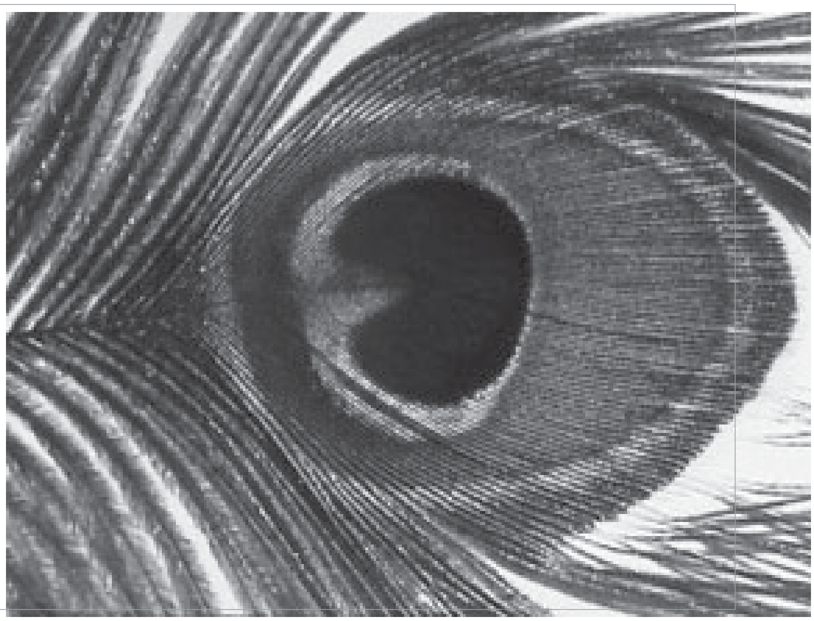
Uzbekistan is one of the top ten cotton exporters in the world. This is in spite of the fact that the irrigation required for the crop has drained a large part of the Aral Sea, one of the world's largest lakes, and much of its land has become salt flats. Its record of using child labour is not enviable. Tajiki cotton farmers are locked into cycles of debt and forced cotton production. Hundreds of cotton farmers in Maharashtra have killed themselves after their crops failed.

From the 1990s modern merchants source and organize production globally. Cotton grown in Togo, Africa, might make its way through a textile mill in Hong Kong, then to a Vietnamese sewing shop, and then be sold by a mass retailer in the United States. Merchants focus their attention on creating brands, such as the American Gap, the German Adidas, or the Chinese Bonwe, and also with the development of retail chains such as the American Walmart, the Brazilian Lojas Americanas and the French Carrefour.

As earlier these merchants rely on governments, but now less on any one specific government. They foster competition among nations to get their products. Workers are increasingly at the mercy of corporations which can shift any form of production from one part of the world to another. To understand the history and the world of cotton, always look at the constantly shifting geographical rearrangement of labour, production and manufacturing.

Based on
{Empire of cotton}, by Sven Beckert

What is the colour of a peacock's feather?



D. Indumathi,

The Institute of Mathematical Sciences, Chennai

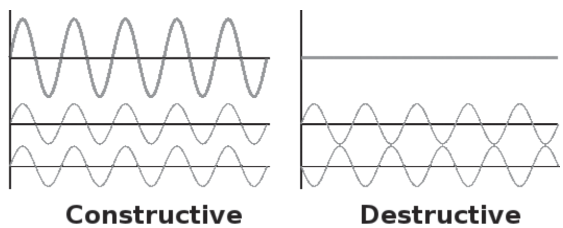


Fig 1: Inteference

``A peacock's feather has many colours,'' is the obvious answer to the question in the title. It turns out that a peacock's feathers are actually coloured brown due to melanin.

Then what causes the brilliant colours we associate with a peacock? The answer to this question first came from the scientists Isaac Newton and Robert Hooke many centuries before. The answer is ``structural colouration'', a phenomenon due to wave interference.

Wave Interference

You may have learnt that light can be thought of as a wave, just like water waves, with crests and troughs (peaks and valleys). The spacing between two peaks or two

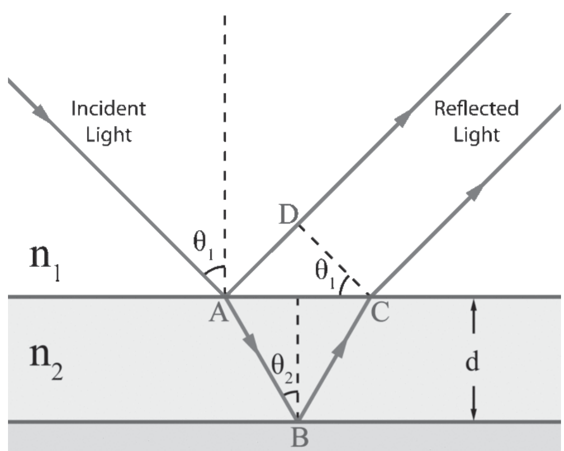


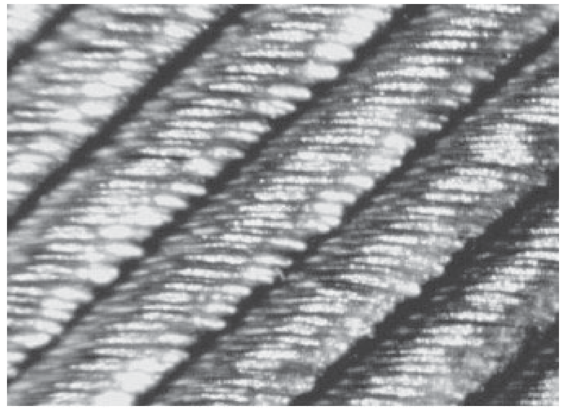
Fig 2: Interference

Feather: 50x magnification

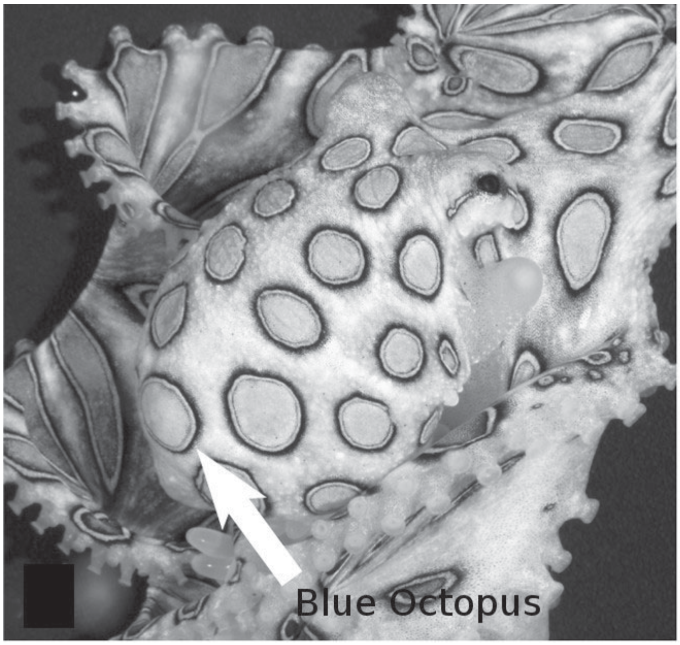
direction, they can add to each other or cancel out, depending on whether the peaks of each match (left side of Fig. 1) or whether the peak of one overlaps the trough of the other wave (right side of Fig 1). In the figure, the original waves are shown below and their resultant wave is shown at the top. Here both the waves have the same wave-length and so correspond to the same colour. If they had different wave-lengths they would never match exactly and so there would be a partial addition or cancellation of the two colours.

Iridescence

An oil film on the surface of a road, or the surface of a soap bubble has two surfaces which are very close together (because the film is thin). You may have noticed that such films also show several beautiful colours which appear to shimmer and change as you observe them from different angles. This happens because the light falling on the surface can reflect from both the top and bottom surface. Since the angle of reflection from both surfaces is the same, both the reflected waves of light are travelling in the same space, in the same direction. But the two waves have travelled different distances (as seen from Fig. 2) and so their peaks and troughs may not match exactly. This depends on the angle and the colour (wave-length) of the light.



Feather: 100 magnification



For instance let us assume that you are watching the bubble and it is red in colour. This means that for this angle, the waves of red light reflected from the two surfaces have matched to give a strongly red colour. The waves of other colours do not match well and so more or less cancel out. If you look at it from different angles, different colours will be visible. This observation of shimmering colours that change with angle of observation is called iridescence.

Structural Colouration

This is a phrase that means that the colour comes from the structure of an object and not its pigmentation. An example is the iridiscence of a peacock feather. The feathers have several parallel lines on them formed by parallel thin layers which are microstructures not visible to the human eye.

The peacock feather has many branches, with ``twigs'' coming off them; these are called ``barbules''. The reflections from the front and back of these barbules interfere to give the colours we see. This was investigated in detail by researchers at Fudan University in China and Osaka University in Japan. They took photos of the barbules at very high magnification to see these effects.

50 times magnification

A ProScope is a handheld microscope that attaches to a computer via its USB slot. The software activates the ProScope which enables you to capture single snap shots. These images aretaken at timed intervals.

The rows of colored elements are visible at 50 times magnification in a ProScope. See Fig. 3. These "barbules" can be considered to be arranged in regular horizontal or vertical layers.

100 times magnification

At 100 times magnification, the variations in the filaments are more evident and so the colors seem to shimmer. See Fig. 4. The visible color will be different at different angles of view. The structures which produce the colors have an array spacing of about 150 nm. (1 nm is 1/1000000000 m).

Other colourations

Structures in nature can be more complicated and elaborate than just a single thin film. For instance, many films can be stacked up to give strong iridescence. Each mechanism offers a specific solution to the problem of creating a bright colour or combination of colours visible from different directions. For example, diffraction is another property associated with light. When light falls on structures that have a regular or periodic arrangement, it can split into several beams, each with different colours. The skeletons of many insects contain chitin. Layers of chitin and air together makes a diffraction grating that gives rise to the iridescent colours of various butterfly wings.

Fig. 5 shows a butterfly wing at different magnifications. The rows of chitin can be clearly seen in the bottom part of the figure. This microstructur of chitin acts as a diffraction grating and gives the beautiful colour to butterfly wings.

Variable structures

In both cases, the animal has fixed structures that cause the colouration. In some animals, the structures are not fixed but can be changed. For example, in sea animals such as squid, there are reversible proteins which can switch between two shapes or configurations, depending on electric charge. One configuration is tighter than another and so the layer spacing changes and hence the colour that is reflected from the surface. The squid uses this to change its colour rapidly for camouflaging itself when prey is near. The blue-ringed octopus does something similar, contracting its muscles and changing to yellow colour with bright blue rings when provoked.

So next time you see an iridescent butterfly or bird winging its way past you with its brilliant colours, think of the wonderful and marvelous properties of light!

Sources:

http://hyperphysics.phy-astr.gsu.edu/hbase/vision/peacock.html

https://en.wikipedia.org/wiki/Structural_coloration

Integer Partitions

M.V.N. Murthy,
The Institute of Mathematical Sciences, Chennai

Many of you may have seen the recent film The Man who knew Infinity. The film deals with the life of the famous mathematician, Srinivasa Ramanujan. In one dramatic sequence in the film there is a conversation between Ramanujan and another mathematician, Major P.A. MacMahon, in the presence of another mathematician, G.H. Hardy, about partitions. So what are these partitions and what were they talking about?

What are partitions

Integer partitions is an important part of a larger field in mathematics called Number Theory to which Hardy and Ramanujan made very important contributions. Let us first start with the definition of partitions.

Consider any positive integer n, n=1,2,3,... This can always be written as a sum of positive integers less than n. The number of ways in which n can be written as a sum of positive integers less than n is called as the partition of n and is denoted as p(n). Here are some examples:

$$
\begin{aligned}
1 = 1, &\qquad p(1) = 1 \\
2 = 2, 1+1, &\qquad p(2) = 2 \\
3 = 3, 2+1, 1+1+1, &\qquad p(3) = 3 \\
4 = 4, 3+1, 2+2, 2+1+1, 1+1+1+1, &\qquad p(4) = 5 \\
5 = 5, 4+1, 3+2, 3+1+1, 2+2+1, 2+1+1+1, 1+1+1+1+1, &\qquad p(5) = 7
\end{aligned}
$$

Of course we take it for granted that 2+1 and 1+2 are the same and therefore the partitions are written as a non-increasing sum of positive integers.

Here are a few more:

$$
\begin{aligned}
p(10) &= 42 \\
p(100) &= 190,569,292 \\
p(1000) &= 24,061,467,864,032,622,473,692,149,727,991
\end{aligned}
$$

You can easily check that number of possibilities and hence the partition, starts growing very fast, in fact exponentially. These are very large numbers which can be calculated in recent times using powerful computers but not during the time of Ramanujan nearly a century ago.

Generating functions

As it happens, Leonhard Euler had already made some progress in computing these partitions more than hundred years before Ramanujan. In number theory results for large n are usually expressed as formulae or generating functions. A generating function is represented as a power series:

$$F(x) = 1 + f(1)x + f(2)x^2 + f(3)x^3 + \cdots = 1 + \sum_{n=1}^{\infty} f(n)x^n \qquad (1)$$

This is a series in powers of x and hence it is called---no marks for guessing this---a power series. The dots simply mean that you can go on adding terms in increasing powers of x with appropriate coefficients. The last part of the equation is a short-hand notation for writing the power series. The strange symbol is called Sigma and f(n) is the coefficient of each power which can be any real number. The symbol Sigma stands for summation, and the limits of the summation are given as n=1 to infinity. It indicates that the series is written by summing over terms where n goes from 1 to infinity. Here is an example of a series:

<eq2.jpg>

The right hand side is true if and only if x lies between 0 and 1: 0<x<1. It is easy to show that this series sums to 1/(1-x) simply by dividing 1 by 1-x as in any normal division with real numbers. Try it and see.

Geometric Series

We may also construct series like

$$1 + x^2 + x^4 + x^6 + x^8 + \cdots = \frac{1}{1-x^2}, \qquad (3)$$

$$1 + x^3 + x^6 + x^9 + x^1 2 + \cdots = \frac{1}{1-x^3}, \qquad (4)$$

<eq3_4.jpg>

where we simply replaced x by x^2 and x^3 respectively. These series are examples of what is called a geometric series.

Suppose we multiply these three series as follows:

$$(1+x+x^2+x^3+\cdots)(1+x^2+x^4+\cdots)(1+x^3+x^6+\cdots)=\frac{1}{(1-x)(1-x^2)(1-x^3}), \quad (5)$$

<eq5.jpg>

We get

$$\frac{1}{(1-x)(1-x^2)(1-x^3)}=(1+x+2x^2+3x^3+\cdots) \quad (6)$$

<eq6.jpg>

Notice that the coefficients of powers of x are 1,2,3, omitting the first entry which always 1. Let us continue in the same manner with four terms:

$$\frac{1}{(1-x)(1-x^2)(1-x^3)(1-x^4)}=(1+x+2x^2+3x^3+5x^4+\cdots) \quad (7)$$

<eq7.jpg>

$$\frac{1}{(1-x)(1-x^2)(1-x^3)(1-x^4)(1-x^5)}=(1+x+2x^2+3x^3+5x^4+7x^5+\cdots) \quad (8)$$

Now the coefficients of powers of x up to x^4 are 1,2,3,5. With five terms we get

<eq8.jpg>

Now the coefficients of powers of x up to x^5 are 1,2,3,5,7. You can see a pattern emerging. The coefficients are simply the partitions of integers up to 5 as given in the beginning. Therefore to get the partitions up to p(n), all we need to multiply in the

$$\prod_{n=1}^{\infty}\frac{1}{(1-x^n)}=\frac{1}{(1-x)(1-x^2)(1-x^3)(1-x^4)(1-x^5)...}=1+\sum_{n=1}^{\infty}p(n)x^n. \quad (9)$$

denominator terms like (1-x) up to (1-x^n); since n can be as large as we want, we can write a very general formula like

<eq9.jpg>

The middle part of the equation is just a short form of writing the products that are in the left hand side (LHS) of this equation. Just as there is a symbol for summation, there is also a symbol for product which is called Pi. The LHS is usually called the generating function of partitions since when expanded each power of x gives the partition of that power.

Calculating the partitions

Though Euler outlined the general method of generating functions, actual calculation of partitions was left to another mathematician, Percy Alexander MacMahon. MacMahon was a contemporary of Hardy but had earlier served in the army including a stint in Madras in the 1870s. He had the reputation of being a great calculator. He put his skills to good use for calculating the integer partitions using the method given by Euler. It was not straight forward as you can easily check by taking n to be even as small as 20, let us say. There were no calculators and every thing had to be done by hand. He did this by using yet another result of Euler related to what is called Euler's Pentagonal Numbers using which one can get a recursion relation for integer partitions.

A recursion relation is one in which if you know some partitions for small n, it can be successively used to calculate partitions of larger integers. MacMahon laboriously prepared a table of integer partitions, up to about n=100 or so, which became a benchmark to check any result on partitions during his times.

Approximation Methods

Unlike most mathematicians of his time, Ramanujan was not averse to trying out approximations, especially when the answer involved large numbers like in integer partitions. You first start by getting the order of magnitude of the answer, to which you can keep on adding successively smaller corrections. With each correction term the error keeps reducing. This is now part of a well known field called Asymptotic Approximation Methods but was not very popular during the time of Ramanujan. Hardy and Ramanujan started with the Euler's generating function, using a method that they invented (which came to be known as the Circle Method) he obtained an approximation for integer partition p(n) given by

$$p(n) \approx \frac{e^{\pi\sqrt{2n/3}}}{4\sqrt{3}n}, \qquad (10)$$

<eq10.jpg>

where e=2.718281828459045... is the well-known constant called the Euler constant (see box for more details). It is one of the transcendental numbers like pi. The formula above, though approximate, is extremely simple. It gives increasingly better approximation as n increases and we call such formula as an asymptotic formula.

More significantly the formula given above can be evaluated, even without a calculator, to get the order of magnitude of p(n) for any n. In fact as the story goes, Ramanujan surprised MacMahon by giving the answer for the partition of 200. He took less than a day to calculate that p(200) is approximately equal to 4x10^{12}. The exact result, p(200)=3,972,999,029,388, would have taken weeks if not months for MacMahon to calculate using recurrence relations.

Restricted Partitions

The method used by Hardy and Ramanujan allows us to provide such approximations for integer partitions even with some restrictions. The integer partitions discussed above are called unrestricted partitions. However, we may further improvise by putting restrictions. For example Ramanujan considered partitions in which no integer occurs more than once in the sums. For example consider

$$\begin{aligned} 1 &= 1, & q(1) &= 1 \\ 2 &= 2, & q(2) &= 1 \\ 3 &= 3, 2+1, & q(3) &= 2 \\ 4 &= 4, 3+1, & q(4) &= 2 \\ 5 &= 5, 4+1, 3+2, & q(5) &= 3. \end{aligned}$$

<eq_before11.jpg>

Notice that each integer is written as a sum without repetitions unlike earlier. These are called distinct partitions. It is not difficult to write the generating function for distinct partitions. It is given by

$$(1+x)(1+x^2)(1+x^3)(1+x^4)(1+x^5)+\cdots = 1+x+x^2+2x^3+2x^4+\cdots = 1+\sum_{n=1}^{\infty} q(n)x^n. \quad (11)$$

<eq11.jpg>

The coefficients of each power of x is a distinct partition of the power itself. Once again Ramanujan came up with an asymptotic formula for approximately evaluating q(n) given by

$$q(n) \approx \frac{e^{\pi\sqrt{n/3}}}{4(3)^{1/4}n^{3/4}}, \qquad (12)$$

<eq12.jpg>

This is also surprisingly simple.

Partitions with odd numbers only

Another interesting case of integer partitions is the question: In how many ways can an integer be written as a sum of only odd numbers? This is the same as writing

<eq_after12.jpg>

$$
\begin{aligned}
1 &= 1, & o(1) &= 1 \\
2 &= 1+1, & o(2) &= 1 \\
3 &= 3, 1+1+1, & o(3) &= 2 \\
4 &= 3+1, 1+1+1+1 & o(4) &= 2 \\
5 &= 5, 3+1+1, 1+1+1+1+1, & o(5) &= 3.
\end{aligned}
$$

You may be surprised that up to 5, we find q(n)=o(n) just by inspection. Actually this is a very general result and in fact it is true for all n.

Partitions using primes only

You may also ask if one can partition an integer into sums of prime numbers. This is the additive equivalent of the prime number theorem which states that every positive integer can be written uniquely as a product of prime numbers and their powers. However, the partition is not unique, and one can approach the problem the same way as we have done above. An asymptotic answer to this question was found long after Ramanujan and is still a field of active investigation.

Ramanujan himself generalised many of the ideas of integer partitions. He derived asymptotic approximations for partitioning an integer into sums of squares with and without repetitions. He improved the asymptotic formula of unrestricted integer partitions by including corrections terms. He played with integers and infinite series with relish. As mathematician Littlewood commented, integers were like Ramanujan's friends. He could do any thing he wished with them.

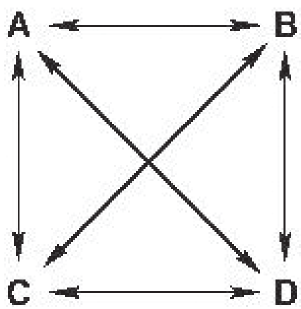
Partitions and Physics

The analysis of integer partitions by Hardy, Ramanujan and later mathematicians has a deep connection to Physics. Suppose you consider a volume of gas whose total energy is some E. You can ask the question how this energy is distributed among the individual molecules of the gas. This then becomes a problem of partitioning energy E, usually a real number instead of integers alone, among its components just as how an integer is partitioned as a sum of integers. This is a central problem in the field of Statistical Mechanics. The generating function in number theory is called the partition function in statistical mechanics.

Mathematics of how rumours spread

R. Ramanujam,

The Institute of Mathematical Sciences, Chennai

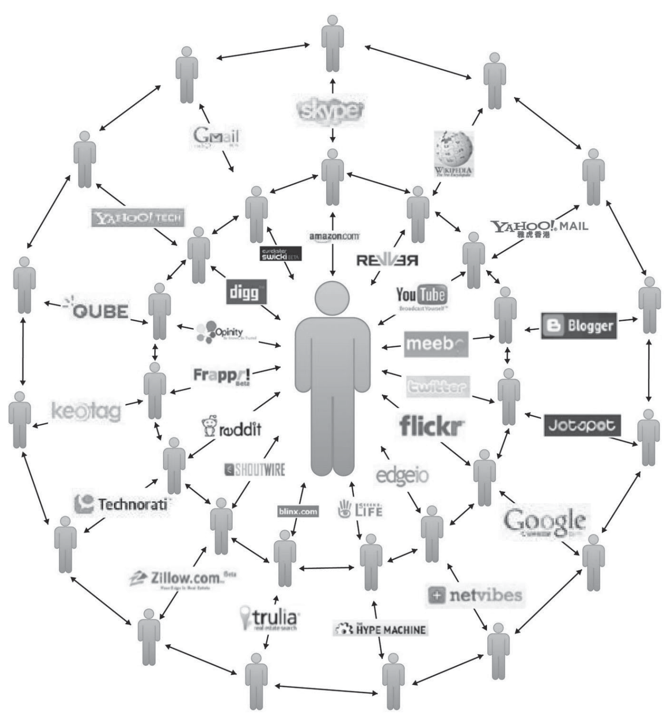


How many of you are on facebook, whatsapp and other social media? When you hear a rumour, say "tomorrow is a holiday for all schools", or "a cyclone is on its way", what do you do? Do you immediately forward it to all your friends?

Gossip and spreading rumours have always been a favourite of human beings. In villages everyone very quickly finds out what happens to any

one. But in recent times, the Internet and the social media (like facebook, whatsapp, etc.) have led to rumours spreading very fast indeed. They are also used a lot in political campaigns these days too. This can lead to people being highly misinformed, and at some stage, people stop distinguishing what is unreliable rumour and what is reliable information.

Is there a scientific way to study how



rumours spread? Perhaps if we understand how misinformation spreads, we can also try and counter it. We might be able to also use the science to help spread information fast: for instance, when a tsunami is about to strike our coast, it is critical to inform everyone living close to the coast as quickly as possible.

There is indeed a way, and the answer is mathematical.

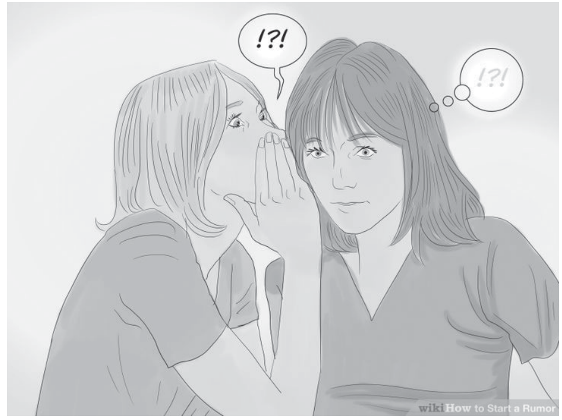
Suppose there are four persons: Alka, Balu, Chetan, Devi. Let us say that each of them has a secret, and can only communicate pairwise, and at once immediately learn each other's secret. How many communications are sufficient for everyone to learn each other's secrets? It is easy to see that 6 calls will do the job for sure: Alka - Balu, Chetan - Devi, Alka - Chetan, Alka - Devi, Balu - Chetan, Balu - Devi. Can you do with fewer calls? Of course, if we assume that during the call each learns not only the other's secret but whatever each person knows (about others' secrets as well), then fewer calls should do. (Five? Four? Fewer?)

When you have a population of thousands, you cannot analyse information spreading like this. For this, mathematicians proceed differently. Let us assume that every one in the population is of three types:

1. Spreaders: Anyone, who when they hear the rumour, passes it on to everyone they are connected to.

2. Ignorants: Those who have not heard the rumour yet.

3. Stiflers: Those who have heard the rumour but do not pass it on.



We can now try and describe how rumours spread.

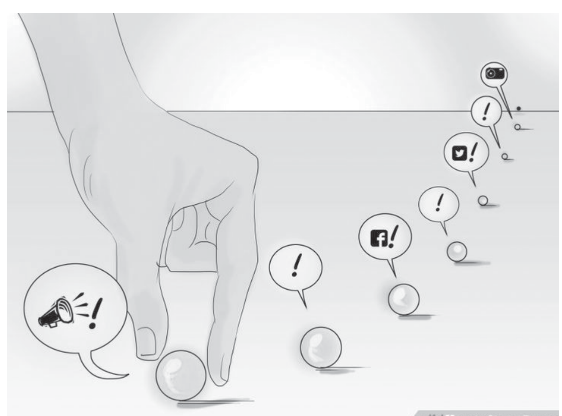
(a) Initially there are only Ignorants and Spreaders.

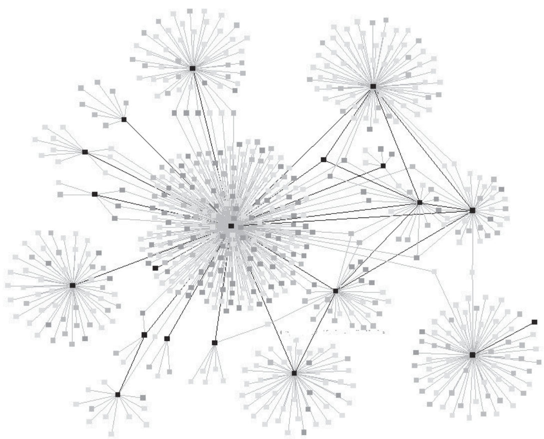
(b) Ignorants turn into Spreaders as and when they first hear the rumour.

(c) Spreaders tell the rumour to everyone they meet until they come across either another Spreader, or a Stifler — at this point they decide that the rumour is known and become a Stifler.

(d) The rumour ends when there are only Ignorants and Stiflers remaining.

All this is done with formulas, and numbers like 0.7 etc (probabilities for what





How viruses spread

is the chance of a person of one type meeting another of the same type or a different type). Some equations are also used to describe the rate at which "interactions" happen. With all this one can try and estimate what percentage of the population the rumour reaches. With just about a small percentage of spreaders initially, this number comes to about 80%! Perhaps also surprisingly it comes to only 85% even if half the population were spreaders initially.

A paper written last year by A J Ganesh, a mathematician in the UK, studies all this in what is called the "random graph" model (where connections between people form by random processes). He shows that if every one is as likely to be connected to every one else (which is of course unrealistic, but mathematically simple to analyse) then among n persons, 2 log n communications are enough to spread the rumour fully (in technical terms, to "saturate the network"). If n is the human population, and each communication takes place over one day, it would only take 45 days for all the world to know the rumour!

BOX

log n stands for "natural logarithm" or logarithm to the base 2 here.

If 2 ^k = n then log n = k.

What about finding the source of a rumour? In 2010, Devavrat Shah and Tauhid Zaman of the Massachusetts Institute of Technology, USA have come up with an algorithm that sets out to do just that. They show that if the network is "complex enough" then there is a one in three chance of detecting the source. But their algorithm worked only for networks of particular shape ("tree-like"). A few months ago, Lei Ying and Kai Zhou of Arizona State University have come up with an algorithm on random graphs, which scientists believe is very general.

Why bother to study these? With such mathematics, we can also learn how viruses multiply, epidemics spread, ... And that is very important to our health!

Publisher
C.S.Venkateswaran
TNSF, Chennai 600 086
Typeset at
Fineline
Design, Illustrations and Layout
Basheer
Rajeswari
Printed at
Print Specialities,
186, V.M.St, Royapettah,
Chennai - 600 014.

Bank Details
Jantar Mantar, Indian Overseas Bank, Dr. RK Salai Branch, Chennai - 600004
AC No: 029101000031081 IFSC Code: IOBA0000291

Front Cover:

Peacock showing off its colours at Sultanpur National Park. Photo by Jatin Sindhu, courtesy Wikipedia

Back Cover:

Cotton merchants in New Orleans, painting by the famous artist Edgar Degas, 1873. Photo courtesy www.edgar-degas.org.

Gossypium arboreum, the Asian cotton plant, with lustrous cotton bolls, photographed by Kenpei in Osaka, Japan. Photo courtesy Wikipedia