# LABYRINTH 2018

## THE SCIENCE JOURNAL OF MANHATTAN HIGH SCHOOL FOR GIRLS

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# LABYRINTH 2018: FOREWORD

Mrs. Brenda From, Chair, Department of Science

In his book, The Ten Most Beautiful Experiments, George Johnson asks, what is beauty in science? In line with that, we asked the question, what is heroism in science? "Hero" conjures up the image of a muscular first defender, prepared to jump into the fray, confident and fearless; free association of "scientist" conjures up the image of a cerebral loner, toiling away at a problem that s/he alone understands. The juxtaposition of the two seems discordant.
In this issue of LAByrinth, we celebrate the bravery, creativity, and dogged pursuit of the quest of scientists, who willingly defied the tide of opposition and criticism to propose novel ideas which altered the paradigm of popular thinking. The pressure these scientist must have felt to conform to prevailing opinion would have broken stronger men.

Consider the following: In 1906 Ludwig Boltzman (founder of Statistical Mechanics, which explains how the properties of atoms relate to the physical properties of matter, forming an integral part of modern physics), committed suicide. In retrospect, it is unbelievable that at the time there was still some opposition by the physics establishment to the belief in the reality of atoms and molecules. While depression was the likely direct cause, all this tumult was probably a factor.

And yet, Albert Einstein, the purported greatest scientist of all time, could not push back against the pressure. At the time when he developed his General Theory of Relativity in 1915, the accepted cosmology considered the universe to be isotropic, without expansion. Contrarily, solutions of his equations correctly predicted an expanding universe. Relying on current thinking, he introduced a cosmological constant into his equations, a fudge factor, to bend his equation and force it to comply with accepted notions. When Doppler shifts of light emitted by distant galaxies confirmed an expanding universe, Einstein admitted this was one of the biggest mistakes of his life.

Labyrinth 2018 is organized around two major themes:

I: *Game Changers and Paradigm Shifts* with contributions culled from the 10th grade Chemistry class.

> Students weaned themselves off superficial answers generated by topical Google and Wikipedia searches. Instead, they plumbed the depths of the internet by utilizing curated databases hosted by the NYPL and the network of local libraries. Instead of relying on the unreliable fare of social media, they learned to critically evaluate the information on the world wide web and test the veracity of the contents, a skill that will stand them in good stead in their academic futures. Contributors culled from the fields of: chemistry, biology, physics, astronomy, immunology, neurology, genetics, cosmology, psychology. Where two students wrote equally well on one topic, they merged their papers and both were equally attributed.

II: *Meeting Modern Challenges Through Technology* with contributions culled from Advanced Science Electives.

> AP Biology: Biomimicry
> AP Environmental Science: Sustaining Sustainability
> Forensic Science: Nothing But the Truth
> Jerusalem Science Contest: Nanotechnology

A project of this magnitude requires the support of a dedicated cadre of unparalleled professionals who happily toil behind the scenes. Mrs. Friedman-Stefansky, Principal, bolstered me and would not let me give up when my commitment to this project flagged. Together with Mrs. Yanofsky, *Mehahelet*, this amazing duo supports commitment

to excellence across all disciplines. To my fellow comrades in the trenches, Dr. Abigail Haka (Forensics) and Dr. Mila Plavsic (AP Environmental Science), I could not ask for a better team. Dr. Shaina Trapedo and her team of student editors provided the literary polish and Mrs. Chani Kanowitz lent her designing wizardry. Most important, this issue of LAByrinth is dedicated to the students of Manhattan High School, who continue to produce exemplary work beyond expectations, and make us all very proud.

Discoveries in science are not just about nature. They are about people as well. It is a human activity just as is art, history, literature and philosophy. As a human activity, science intertwines with those as well and the students have been encouraged to find those embedded connections. In clear and lucid prose, they explain the logic behind the science within the context of the historical, social, and Judaic milieu. Why is it that nature should be logical is one of the greatest mysteries of science. An even greater mystery is that we can begin to comprehend it. That is the greatest gift *Hashem* endows to us.

"מודה אני לפניך מלך חי וקיים"

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## ACKNOWLEDGEMENTS

Mrs. Estee Friedman-Stefansky, Principal, *General Studies*

Labyrinth, our annual science academic journal, reflects the individual achievements of our science department. Produced by our Chemistry, AP Environmental, AP Biology and Forensic Science classes, the essays featured herein reflect our students' intellectual curiosity as well as their scientific literacy skills. Though the skills represent a range in complexity, they all communicate our students love for the natural phenomena and their delight with the wonder of discovery.

This year, our Science teachers have taught abstract topics such as nanotechnology, vaccinations and Neuroscience; making them accessible to our students. Mary Oliver's "Song of the Builders", captures the magic and spark of our science teachers.

On a summer morning
I sat down
on a hillside
to think about God -

a worthy pastime.
Near me, I saw
a single cricket;
it was moving the grains of the hillside
this way and that way.
How great was its energy,
how humble its effort.
Let us hope

it will always be like this,
each of us going on
in our inexplicable ways
building the universe.

I am so grateful to Mrs. From, Chair of our Science department and to Dr. Haka and Dr. Plavsic for inspiring our students to see the beauty of our universe and the place they each hold in our world's grandeur.

# A FORTUITOUS ACCIDENT

Esther Bertram & Elana Newhouse

On Valentines Day, 1942 in New Haven Hospital, Anne Miller suffered a miscarriage while pregnant with her fourth child (3). Her condition deteriorated with symptoms of extreme chills and a fever that spiked to 106°. She had contracted *hemolytic streptococcal septicemia,* more commonly known as blood poisoning.

Each day her doctor, Dr. John Bumstead recorded the number of bacterial colonies found in her blood. On March 1st he recorded an ∞ symbol on his chart, her blood contained countless number of bacterial colonies.

After trying all methods available to save her, he desperately turned for help to another one of his patients, a close friend of Dr. Howard Florey, the leading pathologist in the study of penicillin. Dr. Bumstead hoped that with this connection he would be able to obtain penicillin for Mrs. Miller. This plan worked and on Saturday March 14, Dr. Bumstead received 5.5 grams of penicillin, so rare at the time this was half the total penicillin available in America. Dr. Bumstead gave Anne a test dose at 3:30 pm and when she did not react badly he continued to give her doses every four hours. By Sunday her fever had gone down to 99°. Anne Miller made a full recovery and made medical history as the first person to be cured through penicillin. On that March day in New Haven Hospital a new age of medicine was ushered in, the age of antibiotics had arrived.

The discovery of antibiotics was a major advancement in the medical field. Antibiotics are a group of compounds produced by microorganisms, that have the ability to control or halt the growth of bacteria, the cause of most infectious diseases. The study and discovery of antibiotics began over a decade before Anne Miller's miscarriage. The antibiotic revolution began in St. Mary's Hospital in England at the hands of an disorganized Scottish physician named Alexander Fleming. In 1928 Fleming went on holiday, leaving his workspace a mess. When he returned, he noticed that one of his petri dishes, which was filled with colonies of staphylococcus, had an area that was clear of these colonies in places that had become contaminated with mold. Fleming assumed the mold had entered through an open window. A "clear zone" was present around the mold, and all the bacteria that had previously grown in this zone was now dead. Additionally, the petri dishes that didn't have mold in it, didn't have a "clear zone." He had forgotten to place the

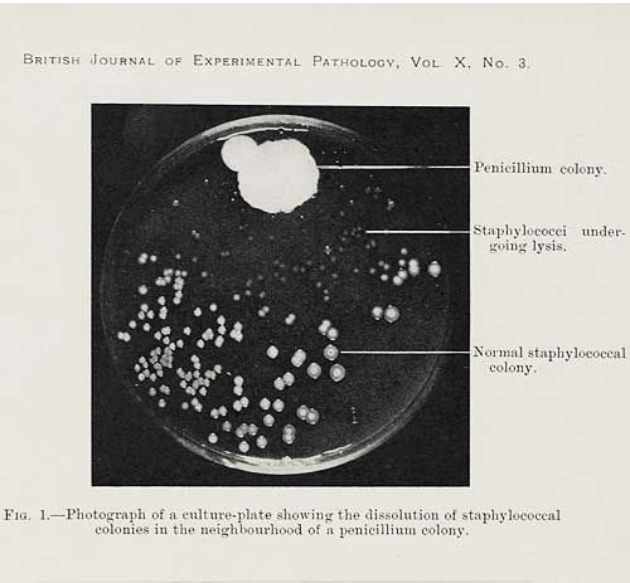


Fig. 1.—Photograph of a culture-plate showing the dissolution of staphylococcal colonies in the neighbourhood of a penicillium colony.

petri dish in the incubator and this allowed the bacteria and mold spores to grow. This was mainly because of the temperature conducive to growth that prevailed during Fleming's two week holiday.

Fleming began to experiment and transferred the mold to a nutrient broth solution (1). All the materials the mold needed to reproduce and grow were present in the solution. Fleming allowed the mold some time to grow and then took out the mold from the solution. Next, he put that nutrient broth onto a petri dish with bacteria growing on it. Fleming saw that the bacteria died and left a clear zone, yet again. Fleming moved on and added the nutrient broth solution that did not have mold growing in it, into separate dish of bacteria. This time the bacteria were not killed and he reached the conclusion that mold had the capability to produce a substance that kills bacteria. Fleming named this substance penicillin because the mold belonged to the *penicillium notatum* family. He concluded that the penicillin had killed the staph bacteria around it.

This was not his first accidental discovery of an antibiotic. Fleming already had an interest in the field of antibiotics and six years earlier had made his first improbable discovery. After completing his degree in medical school, Fleming was elected to be the Professor of Bacteriology, working on the bacteriology of septic wounds during World War 1. This increased his interest in antibiotics since the septics used to treat infected wounds during World War I were ineffective (10). Fleming's 1922 discovery of lysozyme is eerily similar to his discovery of penicillin. A petri dish in his laboratory containing mucus became contaminated with bacteria that entered through an open window; the mucus in the dish killed the bacteria around it. Fleming discovered that mucus contains a natural antibiotic which he named lysozyme (4). The discovery of lysozyme was not as revolutionary as the discovery of penicillin. This is because few bacteria are sensitive to lysozyme, so despite the fact that it's a bacterial killer it only affects specific bacteria.

On the other hand the discovery of penicillin was extremely revolutionary because penicillin has the ability to kill many bacteria in addition to staphylococcus that cause fatal diseases. In order to determine which bacteria were affected by penicillin, Fleming and his assistant Stuart Craddock began to grow more mold and isolate the "mold juice." They then tested the penicillin on different bacteria and concluded that not only was staphylococcus killed by penicillin but so was streptococcus and pneumonia bacteria. When Craddock developed a sinus infection they tested the penicillin on him and it proved effective. They also discovered that certain bacterias are resistant to penicillin such as the bacteria responsible for causing typhus.

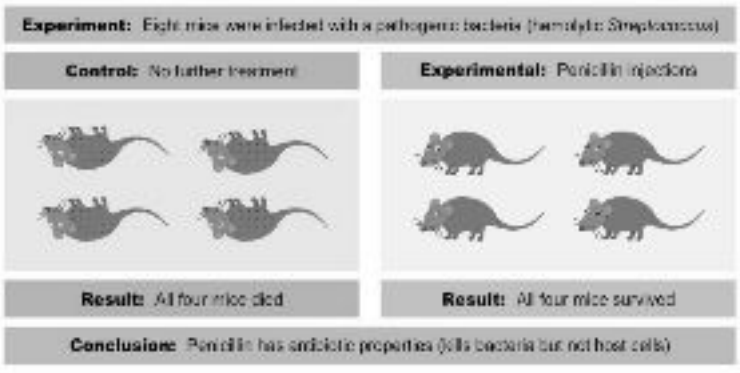
Another aspect of penicillin that made its discovery revolutionary was its specific capability to kill bacteria without killing other cells. Penicillin targets the bacterial enzyme that builds the cell wall. It does this by targeting peptidoglycans, a significant part of the structure of the bacterial cell wall. Without a cell wall, bacteria will die because they cannot maintain osmotic equilibrium. Since animal cells do not have a cell wall, the antibiotic will leave animal cells unharmed. In addition, less than one percent of people are allergic to penicillin, making penicillin a good candidate to treat bacterial infections.

Very little details are known on Fleming and Craddock's experiments. This is possibly due to Flemings disorganization, and although his disorderly workspace led him to discover two antibiotics, it did not lead him to keep organized papers on his research. Fleming and Craddock did not test their "mold juice" on animals, despite this being a typical "next step" experiment for scientists to do when they discover a medication. They neglected to experiment on animals because they were struggling to separate the penicillin from the mold and were therefore working with limited amounts of it. Penicillin was difficult to work with, it was unstable and hard to purify. Fleming did not have the proper resources and tools at St. Mary's that would've enabled him to do serious experimentation. In 1929 Fleming published his work on penicillin in the *Journal of Experimental Pathology* (11) . His publication was largely ignored by the scientific community and in the years after he wrote it it went unnoticed by researchers and scientists.

Years later, in 1937 a group of scientists discovered Flemings publication and kept the antibiotic revolution alive. Howard Florey, a professor of pathology in Oxford led fellow scientist Ernst Chain and fungal expert Norman Heatley in the quest to manufacture penicillin. Penicillin was notoriously difficult to work with because it was so hard to purify. This is the area in which Fleming struggled. He was unable to purify penicillin and therefore only had small quantities of it, which made experimentation difficult (3). Heatley, although the youngest of the team, was tasked with the job of creating penicillin more quickly,efficiently and on a larger scale.

It took months before Heatley determined the most effective process. First, he incubated the fungus on agar, knowing that's what the mold grow best on. Once the mold grew, brewers yeast was added which helped the mold produce the juice or penicillin broth more quickly. Adding the brewers yeast allowed the mold to produce the broth in ten days instead of three weeks. Next, Chain was tasked with the job of purifying the penicillin from the mold. He used advanced filtration machines that purified the penicillin broth which created more effective batches of penicillin. Fleming was unable to do this because he did not have the resources or technology available for his use in St. Mary's, while the scientists at Oxford possessed more advanced technology.

With the availability of larger quantities of penicillin, Oxford team began to experiment. They infected eight mice with streptococcus bacteria (bacteria responsible for causing diseases such as strep throat, and impetigo). Two mice were given 10 milligrams of penicillin and another two received 5 milligrams. Follow up doses of penicillin were given to the four mice at 4:15, 6:20 and 10:00. The four other mice



received no medication and were kept as untreated controls. By 4:00 am the four control mice that hadn't received medicine were dead and the four treated mice remained alive (2).

The Oxford scientists published their findings in the *Lancet* at a very opportune time. World War II had just begun and an antibiotic that could keep soldiers from dying was desperately needed. Florey, Heatley, and Chain had successfully figured out how to create penicillin more simply and quickly for experimentation purposes but they still needed help to create penicillin for the masses. They traveled to America where medical companies set up factories and began creating penicillin on a large scale. In 1941 America did not have enough penicillin to treat a single patient but by late 1943 there was enough penicillin to supply the entire Allied forces. Penicillin was heralded by the public as the "Wonder Drug" and by D-Day in 1944 it was effectively being used to treat infectious wounds on soldiers in the fields and hospitals, saving countless lives.

Antibiotics are a necessity in the medical world today. Before the age of antibiotics, there was no effective way to treat even minor infections and certainly not major ones. Doctors would try to cleanse the area and use the treatments they had, which wasn't much. People would often die from minor bacterial infections, like a simple strep throat or pneumonia. It was even dangerous if someone had a small cut since they would end up in the hospitals with blood poisoning and no way for the doctors to cure them.

The antibiotic revolution was a double edged sword that brought along with it what is known as "bacterial resistance." Bacteria have become increasingly resistant to antibiotics. When antibiotics are used, most of the bacteria are destroyed but some remain alive because they have a chance genetic variation that confers upon them resistance to the antibiotic. The resistant bacteria can then reproduce offspring that are resistant to antibiotics as well and pretty soon, the entire population of bacteria is now resistant. One reason why bacteria are resistant to today's medicine is because many people are overusing antibiotics and taking it when not needed. Over time, the bacteria become resistant to drugs and soon, the drugs are ineffective. Scientists are trying to come up with new and stronger drugs to fix the problem of the bacterial drug resistance. Now, bacteria are multi-resistant. Dr. Dennis Dixon, expert in bacterial and fungal diseases explains this, "Bacterial infections that were treatable for decades are no longer responding to antibiotics, even the newer ones."

The overuse of antibiotics in the food industry is another factor in the rise of superbugs or super resistant bacteria. Antibiotics are fed to animals, such as cows on farms, to prevent diseases from spreading in the often crowded and unsanitary conditions. Most of the bacteria in the animals are killed by the antibiotics but there are always some that are resistant and survive, those are the superbugs. The superbugs affect humans when they leave the farm and enter our kitchens via uncooked poultry and meat. When people consume the food they are also consuming the superbugs and the remaining the antibiotics, compounding the problem (5).

While there is no arguing that the discovery of penicillin and the ensuing age of antibiotics completely changed the world, as quickly as the world realized the benefits of antibiotics, the negative aspects became known as well. On March 14, 1942 Anne Miller was given a new lease on life after receiving "The Wonder Drug", the miraculous penicillin. But 76 years later we are fighting a battle against bacteria that can fight back. Scientists and government leaders work hard to combat these resistant bacteria. In 2012 President Obama signed the Food and Drug Administration Safety and Innovation Act. A provision known by the acronym GAIN helps combat bacterial resistance. The need for acts such as this one is frightening; in America alone, two million people are affected by antibiotic-resistant bacteria annually. Over twenty thousand of those people die (4).

The serendipitous discovery of penicillin was truly a happy "accident." But without Fleming's preparedness of mind to take advantage of this accident, antibiotics and the revolution in treating infections would never have occurred. If Fleming would not have been trained in bacteriology and if he lacked the passion for science, he never would have discovered penicillin. Johann Wolfgang Goethe said, "Discovery needs luck, invention, and intellect-- none can do without the other." Discovering something is not based solely on the luck or level of one's intelligence. Fleming was not simply a lucky scientist who "stumbled" upon penicillin. It's very possible that Fleming could've discarded his petri dishes after they became contaminated, proving that luck on it's own can be worthless. Instead Fleming combined his luck with his education, drive, and intellect which ultimately allowed him to discover the wonder drug and change the world.

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# SHULCHAN ARUCH

Sharon Dahan & Noa Klein

On state occasions, when elaborate dinners are prepared, the table is set "perfectly" in order to ensure the guests are satisfied and enjoy to the fullest. Tables actually serve a double purpose. Some are to feed humans and some are to feed chemists and scientists information necessary to pursue their research on the elements.

This "second table" is the Periodic Table of the Elements. And just like the scenario where the host is careful to set everything in its place, this table too has to be set up "just right" in order to fulfill its purpose. If not, the "guests", or scientists, will leave unsatisfied, and mishaps may occur. How did this revolutionary table become the orderly and organized, "perfect" table that it has become?

The Periodic Table, originally developed by Dmitri Mendeleev, had several significant shortcomings. It was through the work of Henry Moseley that these flaws were resolved and the Periodic Table assumed its modern structure. Henry Gwyn Jeffreys Moseley was born in Dorset, England in 1887. He was an intelligent and curious student and received a scholarship to Eton College, where he was awarded the chemistry and physics prizes. He was already scientifically oriented based on his lineage. His father, though he died young, was a biologist and a professor of anatomy and physiology at Oxford University, and his mother was the daughter of a biologist and conchologist (1).

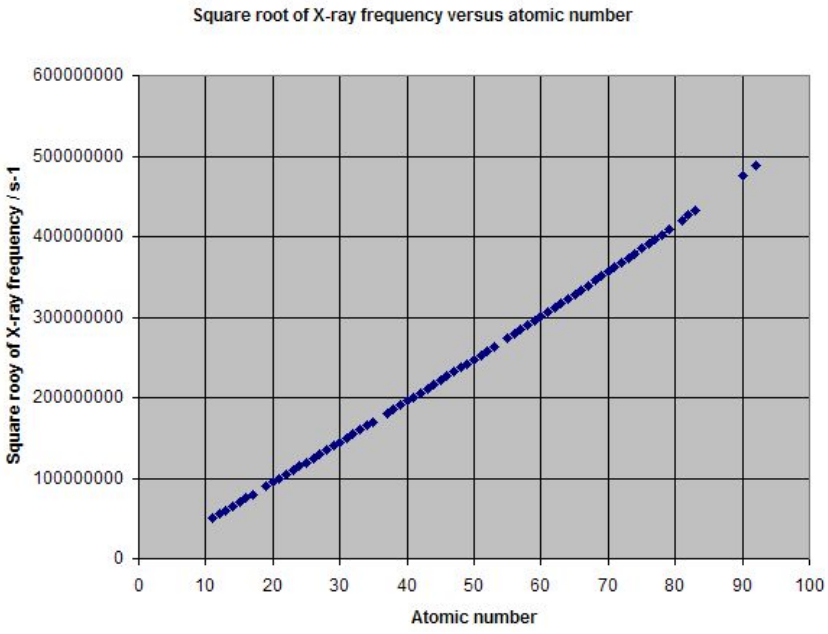
An image of Moseley researching radioactive chemicals in the University of Manchester: (5)

Moseley's research stemmed from his early studies at the University of Manchester, where he joined Ernest Rutherford's research group in 1910. After a few years in the university, Rutherford viewed Mosley as a promising student and had high expectations for the young physicist. Moseley accepted a job from Rutherford at the university and began teaching physics. It did not take long before Moseley realized that he did not enjoy teaching and would rather devote his attention to researching radioactive chemical elements. So, after receiving a bachelor's degree from Trinity College of the University of Oxford, Henry was given his own science laboratory in Oxford. Though he had the burden of having to support his own scientific endeavors, this laboratory gave him the platform from which he would make his world impacting and life changing discovery (2).

Antonius Van Den Broek, a physicist of Moseley's time, had a theory; perhaps the insignificant and arbitrary "atomic number", which simply stated the mere position of an element in order of the elements based upon weight, had a purpose. He hypothesized that the atomic number might be correlated to its element, in that it may be equal to the charge of the nucleus of its element (2). This groundbreaking supposition would mean that the atomic number *defines* an element, since each element has a specific nucleic charge. Henry Moseley's burning question was: how could he experimentally prove it true?

Moseley had two important pieces of the puzzle to work with. The Periodic Table first formulated by Dmitri Mendeleev, a Russian chemist, in 1869, was organized according to the elements' properties and atomic masses. Although Mendeleev's Periodic Table was successful in that he used it to predict the existence of eight new elements and their properties, there were still some anomalies. For instance, not all elements were arranged according to their atomic mass and as a result they didn't always match up to their chemical properties (4). Yet, people still accepted Mendeleev's Periodic Table because their basic understanding was that the elements' fundamental property was their atomic mass. William and Lawrence Bragg, two Nobel Prize winning scientists, had proved about a year prior to Moseley's experiment that when high energy electrons are shot at solids they emit x-rays (6). Charles Barkla, the 1917 Nobel Prize winner in physics, had discovered that the frequencies x-rays emitted are unique characteristic of their elements (7). In other words, each element emitted its own unique wavelength that was a property of that element and no other element. It was another tool in the chemist's toolkit that could be used to identify the elements in a mixture. And so, the young and inspired Mosley knew what he would do.

Through the use of the newly developed, top of the line electron gun, which generated a beam of electrons of precise kinetic energy aimed at his targeted elements, Mosely conducted his experiment and generated data. Upon bombardment by the electron gun, each element emitted x-rays at a unique wavelength, different for each element. Since wavelength and frequency of electromagnetic radiation are inversely proportional, he could convert the measured wavelength into frequency. Moseley began by shooting high energy electrons at numerous elements, from Calcium to Zinc, and measuring the frequencies emitted. In a flash of inspiration, he then proceeded to graph the square root of the frequencies along with the "random" atomic numbers of the elements from which they were emitted (3). Moseley thought he noticed something amazing, but to be sure he shakily drew a line to connect the points. All his points amazingly lay on a straight line, with no deviation or scatter, proving that there was a direct linear relationship between the atomic number and the unique identifying property of the element (3).




This demonstrated that it was the atomic number and the element/position of the element on the Periodic Table had a direct correlation, and not atomic mass. Therefore, the atomic number of an element defines that element! Furthermore, he could use his straight line graph to predict the frequencies of all the elements and then test his prediction by doing the experiment. Sure enough, his theoretical predictions were confirmed by experiment(2). This was Moseley's most notable lifetime achievement.


While at first most scientists questioned whether there was in fact a direct correlational relationship between the number of protons and an element's position on the Periodic Table, they later admitted that his theory patched up many misconceptions. For example, the element cobalt preceded nickel on the periodic table because of its higher positive charge and more protons, despite the fact that the masses would have placed them differently. The placement of these two elements was supported by Mosley's discovery. Prior to this, scientists and chemists knew that the only way they could match up the properties of cobalt- like elements and nickel-like elements was to reverse their position dictated by atomic mass, but scientists didn't understand why until Mosley's discovery. Moseley established that atomic numbers allow a much deeper understanding of the Periodic Table and, in turn, chemistry overall. His research had shown that the atomic number equals the number of protons in the nucleus of the atom and that the atomic number is not just a random positioning. On the contrary - it is intimately tied to the structure of the atom.

This discovery would have everlasting impact. For example, the discovery of the isotope Promethium, which is an element Moseley predicted, would not have been as clear cut; especially if the principles established by Moseley had

not been applied during its discovery, allowing it to be put in the right position on the Periodic Table (8). This unambiguous understanding proved crucial for using Promethium in the function of watches, pacemakers, and missiles, which all contain components, such as beta radiation, of Promethium.

Furthermore, Moseley also indirectly contributed to the expansion of Periodic Table beyond the naturally found elements, The Periodic Table now contains in excess of 118 elements, with new element synthesized in rapid succession. The understanding of atomic number is integral and obligatory for the synthesis of superheavy elements, or elements with an atomic number higher than ninety-two. In order to synthesize superheavy elements, one must change the atomic number of the element, by shooting high speed protons into the nucleus of the atom. This creates a new element, with a higher atomic number than the element it was before.

In addition, this would contribute to the discovery of the "magic number", an amount of nucleons, or protons and neutrons, which forms complete shells (of protons and neutrons) within the nucleus. Elements with a "magic number" have a higher binding energy, or amount of energy necessary to separate particles, which in turn causes the element to be less susceptible to nuclear decay. Scientists predict that there would be an "island of stability" at the superheavy region of the Periodic Table, where the number of protons and neutrons in the nucleus would reach that "magic number" and these elements would be stable long enough to work with. While the island has not been reached yet, the goal remains tantalizingly close. All this was due to the understanding of the role of atomic number.

Mosley was not destined to continue his groundbreaking scientific work. When World War I broke out in 1914, he believed it was his duty to serve his country at war. Although his family and friends, including famous scientists such as Ernest Rutherford, the father of nuclear physics, attempted to convince him to serve his country instead by continuing his research, Mosely refused. Experts considered awarding Moseley with the Nobel Prize for physics in 1926. Unfortunately, Henry Moseley was tragically killed on August 10, 1915, in the Battle of Gallipoli in Turkey (1).

Our hope must be that the extremely powerful instrument of the atomic number will be used only for favorable research, positive developments, and the overall good, and not for destructive purposes. In the meantime, the guests seated at this remarkable table are comfortable in their knowledge that everything is laid out in its proper place.

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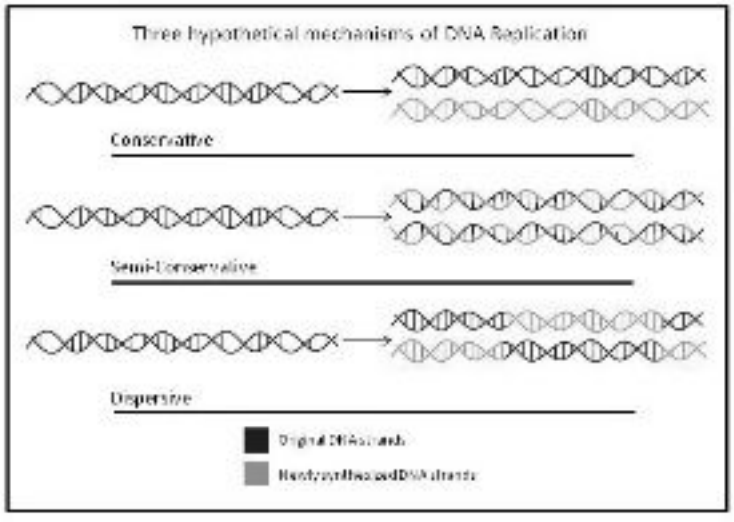
# TRUE SCIENTIFIC BEAUTY

Tamar Dan & Zahava Giloni

The wait was over. The time had finally come for the young couple to welcome their new baby into the world. Happy and healthy, the baby came unscathed and fully grown for its age. It's hard to believe that only nine months earlier, that baby had been a single microscopic cell, a zygote, which slowly multiplied into an unfathomable number of new cells.

Incredibly, each newly created cell still contained the original zygote's genetic makeup, allowing each one to help form the fully grown baby. But what allowed the cells to proliferate in the first place? The answer is the replication of the DNA, which holds all of the cell's information and directs each one to its own job. Many people did not understand how DNA replicates until 1957, when chemists Matthew Meselson and Franklin Stahl conducted the Semiconservative Replication Experiment. The experiment was intricately designed to enable results so stunningly clear and unambiguous, providing undisputable answers as to what the replication process of DNA really is. By all accounts, this experiment is unanimously agreed upon as the 'most beautiful experiment in all biology.'

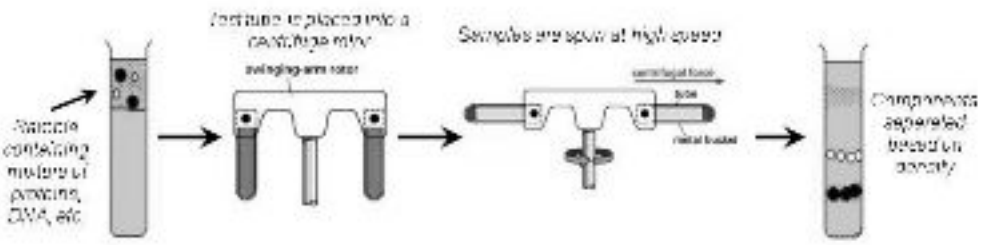
The beauty began at the California Institute of Technology in 1957, when two science PhD students, Meselson and Stahl, stood up to the challenge: to prove the replication process of the Watson and Crick DNA double helix (6). Although Watson and Crick thought their structure naturally favored a semiconservative model, they made no suggestion for experimentation (1). Meselson and Stahl faced two additional potential hypotheses as to what mechanism was used for the replication process. The proposed semi conservative model was that one double helix DNA would split into two strands so that each would become a new half and template for the synthesis of a new daughter DNA, following the base pairing rules (4). The conservative model was that one DNA double helix would replicate into one daughter DNA with both original parent strands and one daughter DNA with two new strands (3), demonstrating that DNA replicates its entire self to form a new double helix (8). The dispersive model was that DNA would break off into pieces which would then replicate and



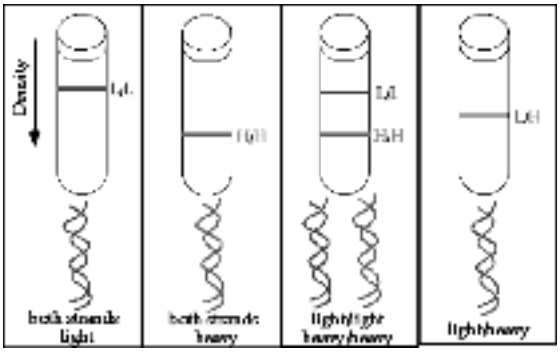
reassemble to form two double helices, each containing random sections of original and newly replicated DNA (8). With these three hypotheses in mind, Meselson and Stahl designed an experiment that would prove the replication mechanism of the Watson and Crick DNA double helix structure (6).

They began their acclaimed experiment with E. coli bacteria grown in a "heavy" isotope of nitrogen, $^{15}N$, until there was a full population of bacteria with this isotope completely incorporated into it (5). The bacteria was then transferred to grow in a medium of "light" isotope, $^{14}N$, allowing its DNA to replicate with this new isotope (5). Next, the bacteria's DNA was removed and, through a process called, "Density Gradient Centrifugation," the amount of each isotope in each generation of DNA was measured and compared (4). This process spins molecules at high speeds to form bands and create a density gradient from the bottom to top of the spinning tube. Bands at the bottom of the tube indicate molecules with greater densities and at the top, ones with lesser densities. The bands allow the differentiation between various molecules based upon differences in weight (7).

With a closer look, each aspect of this experiment was designed with beauty, creativity, and ingenuity. For example, the nitrogen was hand-picked specifically because it is such a major component of DNA. Each time the DNA would replicate, a lot of new nitrogen would also be included.(5) Additionally, the Density Gradient Centrifugation was used to analyze weights of miniscule molecules in the different DNA generations, which can determine the specific isotopes of nitrogen were replicated, light or heavy. This would provide clear and unambiguous results of which of the three mechanism were used to replicate.



The parent DNA produced a coherent band at the bottom of the tube because it was grown in only heavy nitrogen and therefore consisted of only heavy strands. The first generation daughter DNA showed one band in the middle of the tube because it was first grown in the heavy isotope and then in the light. Interestingly, the second generation, granddaughter DNA, indicated two different types of bands. One was at the middle of the tube because it must have also had heavy and light strands, but the other one was at the top of the tube indicating that it must have had only light strands (5).



If the DNA had replicated through a conservative process, two bands would have appeared in the tube after one round of replication, one composed of completely light daughter DNA, and one composed of entirely heavy parental DNA. This would have been because the two "heavy" strands would have been "conserved" to one daughter DNA and two new "light" strands would have been"conserved" to another daughter DNA(4). In reality, the experiment showed a middle band by the first generation daughter DNA. This only supported the dispersive and semiconservative models because both of them include a daughter DNA that is a hybrid, middleweight, of either two different strands or a mixture of the strands. However, this was not in line with the conservative theory and was therefore knocked out of contention.

If the DNA had replicated dispersively, the results would have consistently shown one band in the intermediate region after both generations of replication because the DNA would have been a hybrid of heavy and light DNA. However, there were two different bands after the second round of replication, supporting the semiconservative mechanism but refuting the dispersive mechanism (3).

The semiconservative mechanism was proved correct throughout the experiment. The first generation daughter DNA indicated a middle density band because it was a mix of one "heavy" strand, "conserved" from the original parent DNA, and one new strand of the "light" isotope. Also, the second generation DNA included two different double helices because each "conserved" one of the original strands, either "light" or "heavy," but also had a new strand of the "light" isotope (3). Therefore, the experiment elegantly demonstrated that DNA replicates by conserving one original strand and replicating an additional one. Meselson and Stahl concluded that the Semiconservative method is in fact the accurate DNA replication process and changed the scientific view on DNA replication completely (2).

Meselson and Stahl's experiment had tremendous impacts on the process of experimentation. In his book, "Meselson, Stahl, and the Replication of DNA," Frederic Holmes describes the elegance and complexity of this experiment. He also writes about its appearance in countless textbooks, alluding to the fact that this experiment has not only been accepted into the scientific community, but it is considered an "icon in experimental science" (6). It became a model for all future experiments and has empowered us to prove hypotheses right or wrong.

Scientists now see DNA as strong and tight, yet separable through the Semi Conservative method. The results were so factually correct and unarguable that the entire scientific community was stunned by their experiment and accepted the semiconservative mechanism of DNA replication without question. Even today, there hasn't been any evidence against this claim, as scientists continue to conduct research using the Semiconservative Method, calling it "the most beautiful experiment in the biology". The Semi Conservative mechanism describes the broad outlines of replication. Eventually, the exact steps were explained and all the enzymes involved were characterized, showing just how complex this process is (2). Had this experiment never taken place, scientists would very likely not have advanced in

all of the knowledge that they gained about DNA and its replication because of how all of their research is based of of this experiment.

"The most beautiful experiment in biology" was designed with beauty, creativity, and ingenuity. Besides the extensive effects the experiment has had on experimental science and the study of DNA, it has also provided us with a guide to new scientific discoveries. Meselson and Stahl gave us these specific tools that are necessary to further our knowledge and discoveries. We can continue the beauty of this experiment by implementing these qualities more and more in our research today. The beauty of this experiment has not ended, because true beauty is everlasting.

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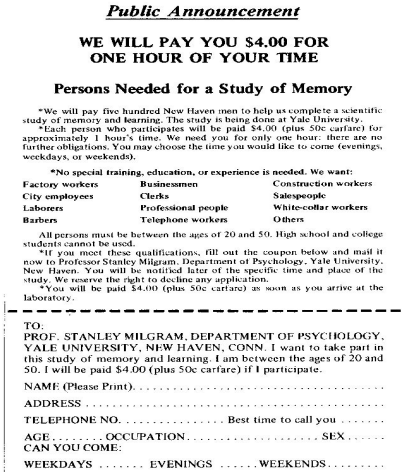
# THE SHOCKING TRUTH OF HUMAN OBEDIENCE

Etta Feuer and Yael Mehlman

In 1945-1946 Germany, the Allies of World War II presided over the Nuremberg Trials. The Nuremberg Trials judged how much responsibility 24 prominent Nazis held for the atrocities of World War II and determined each individual's punishment; twelve of the defendants were sentenced to death.

The foremost justification used by the Nazi soldiers was that they were following their superior's orders, their morals blinded by obedience. Some even went so far as to say they were unaware of what they did (2). These claims highlighted the complexity of judgement. The Allies had to consider whether the Nazi soldiers were inherently evil, or if they were just doing what they were told.

Ricardo Klement was hiding out in Argentina, when in 1960 Israel's Mossad found him and abducted him to Israel. After weeks of investigation, it was confirmed that Klement was the notorious SS officer, Adolf Eichmann. This was nascent Israel's chance to prove itself as a country; the Eichmann Trial in the 1960's became a lengthy exhibition that took nine months from April, 1961 to December, 1961. Even though Eichmann was understood to be guilty from the outset, Israel wanted to extract as much information out of him and convict him for as many crimes as possible. Ultimately, Eichmann's infamous defense was rejected and he was found guilty for purposely sending Jews to their deaths. The Nazi hearings, specifically Eichmann's line of defense, "There is a need to draw a line between the leaders responsible and the people like me forced to serve as mere instruments in the hands of the leaders... I was not a responsible leader, and as such do not feel myself guilty," (7) inspired Stanley Milgram, a social scientist, to test just how much man would comply to authority, even when the instructions misalign with man's morals (6). While Eichmann's story ended on December 15, 1961, Stanley Milgram's just started.



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**WE WILL PAY YOU $4.00 FOR ONE HOUR OF YOUR TIME**

**Persons Needed for a Study of Memory**

*We will pay five hundred New Haven men to help us complete a scientific study of memory and learning. The study is being done at Yale University.

*Each person who participates will be paid $4.00 (plus 50c carfare) for approximately 1 hour's time. We need you for only one hour: there are no further obligations. You may choose the time you would like to come (evenings, weekdays, or weekends).

*No special training, education, or experience is needed. We want:

| | | |
|---|---|---|
| Factory workers | Businessmen | Construction workers |
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All persons must be between the ages of 20 and 50. High school and college students cannot be used.

*If you meet these qualifications, fill out the coupon below and mail it now to Professor Stanley Milgram, Department of Psychology, Yale University, New Haven. You will be notified later of the specific time and place of the study. We reserve the right to decline any application.

*You will be paid $4.00 (plus 50c carfare) as soon as you arrive at the laboratory.

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TO:
PROF. STANLEY MILGRAM, DEPARTMENT OF PSYCHOLOGY, YALE UNIVERSITY, NEW HAVEN, CONN. I want to take part in this study of memory and learning. I am between the ages of 20 and 50. I will be paid $4.00 (plus 50c carfare) if I participate.

NAME (Please Print). . . . . .

ADDRESS . . . . . .

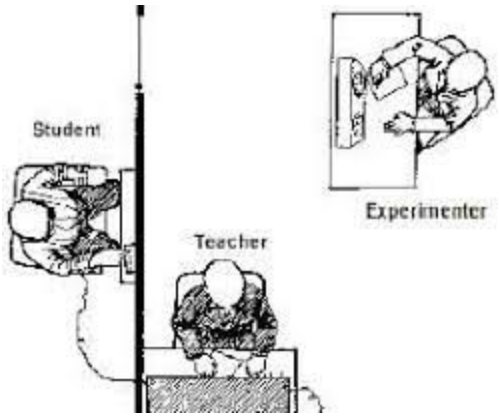
TELEPHONE NO. . . . . Best time to call you . . . . . .

AGE . . . . . OCCUPATION . . . . . SEX . . . . . .
CAN YOU COME:

WEEKDAYS . . . . . EVENINGS . . . . . WEEKENDS . . . . . .

Milgram's Teacher/Learner experiment of 1963 observed the impact of obedience to superiors on the personal consciousness. Milgram put out an ad requesting male participants to aid in an experiment purportedly on memory, taking place in Yale University, with a compensation of four dollars and 50 cents, a current equivalent of closely 30 dollars (4). The participant was asked to draw a paper to determine whether he'd be the "teacher" or the "learner". Rigged, the participant was always the teacher, and the learner was a confederate to the experiment (1). The teacher and learner were then separated to two different rooms. The teacher was instructed to teach a list of word pairs

to the learner. Each time the learner answered incorrectly, the teacher was to administer an electric shock, with the voltage increasing by 15-volts per wrong answer (4). The shocks ultimately increased to a fatal voltage level.




Unbeknown to the teacher, the shock generator was fake and did not harm or inflict pain on the learner. The learner would act as if they were real; if the learner got it right then the teacher would move on, but if the learner would answer incorrectly, he would be shocked. Each time the learner got an answer wrong, he would be shocked in increments of 15 volts. By 75 volts, the learner would grunt after each shock; by 120 volts, he would protest; by 150 volts, the learner would beg to be allowed to leave; by 285 volts, he would scream in pain; and by 330, the learner would refuse to answer. When the learner ceased to respond, the teacher would wait five seconds and then shock him for not giving an answer.. If the teacher were to question the experiment or hold back from giving a shock, the experimenter would encourage him with 'prods' in sequence such as,

Prod 1: *'Please continue' or 'Please go on'*;

Prod 2: *'The experiment requires that you continue'*;

Prod 3: *'It is absolutely essential that you continue'*;

Prod 4: *'You have no other choice, you must go on'* (4).

If the prods did not work, and the teacher, overwhelmed by guilt and fear for the learner's life, refused to continue, the experiment ended. If the teacher switched off his consciousness and robotically abided with the prods, the experiment went on until the experimenter concluded it.

Prior to the experiment, Milgram was curious what fellow psychologists and professors would predict. The expected result came to be that the noncompliant rate would be much higher than the obedience rate. It was assumed that only 1-3% of the participants would continue up to 450 volts and that anyone in the 1-3% must have psychopathic tendencies. The prevailing theory was that most people would not harm another even when urged into doing so. It seemed obvious that people would choose to save a person even if it means harming themselves. Even Milgram expected the obedience rate to be fairly low, therefore the results were shocking to all.

*Shock Levels at Which Milgram's Participants Disobeyed (n=40), Compared to Predicted Disobedience by Psychiatrists*

| Voltage | Actual Number of Defectors | Percentage | Actual Cumulative Percent of Defectors | Predicted Cumulative Percent of Defectors |
|---|---|---|---|---|
| 75 | 0 | 0.0 | 0.0 | 15 |
| 135 | 0 | 0.0 | 0.0 | 44 |
| 150 | 0 | 0.0 | 0.0 | 68 |
| 210 | 0 | 0.0 | 0.0 | 86 |
| 300 | 5 | 12.5 | 12.5 | 96 |
| 315 | 4 | 10.0 | 22.5 | 96 |
| 330 | 2 | 5.0 | 27.5 | 97 |
| 345 | 1 | 2.5 | 30.0 | 99 |
| 360-435 | 2 | 5.0 | 35.0 | 99 |
| 450 | 0 | 0.0 | 35.0 | 99.9 |

Milgram drew his horrifying conclusions based on the percentage of teachers adhering to the experimenter. He concluded that 65% of participants went all the way until 450 volts. His results show that people are more susceptible to follow orders than previously thought. The experiment confirmed that the human mind can be hijacked by authority even when asked to commit acts which conflict with his/her morals and that authoritative demands and obedience to administration is a big factor in why a man would impose pain on another man.This led Milgram to conclude that malevolence is capable by all when under distinct circumstances.

The dangers of unrelenting obedience were introduced as an innate human tendency (2). It was now understood that if anyone was in the same circumstance and position as the Nazi soldiers, it's very likely that they would have behaved and complied to Hitler in an identical manner in the absence of fear of G-d. After the conclusions of the experiment were announced, people began to realize with a shudder that, under specific circumstances, the neighbor next door could be as apathetic as the Nazis were to the Jews (6). At this point, we can understand and appreciate the wisdom of our Sages that the only safeguard against evil is the fear of G-d.

To confront this issue is unnerving, but it is important. As Gregorio Billikopf Encina from the University of California put it, "So entrenched is obedience it may void personal codes of conduct." Now with high tension worldwide, it is crucial to think beyond our small sphere of life and consider how to uphold our moral and ethical beliefs in the face of an untrustworthy government. Authority is not inherently evil, especially compared to anarchy, but the APA recommends being more aware and knowledgeable of the rules set in place. While it is hard to imagine jumping off a bridge if told to do so, we must think of how much control we really have over our lives. Perhaps the more important question is, would you push someone else of a bridge if told to do so? Psychologists and scientists still struggle with this experiment, but with time the results may change with people recognizing the need to take responsibility for their actions.

Post-Holocaust society, who just witnessed intense inhumanity, accepted Milgram's conclusions. However, many contemporary scholars have argued against Milgram's claims after meticulous observation of his investigation. They

noted that Milgram barely left any leeway for disobedience due to his demanding prods (2). If the participant teacher was to refute or question the malevolent teaching method, the superintendent of the experiment would push him with prods that justified the action rather than giving the participant a chance to justify the action himself (3). Also, because Milgram lied to the learner about the experiment, some might say he did not get informed consent. The learner agreed to harm another person in the pretend experiment, but it is not certain if that was enough. In an article for The Atlantic, Cari Romm wrote about the issues with the experiment, insinuating that Milgram's data may be inaccurate (11). With all this, Milgram said at the beginning of the controversy, "illusion is used when necessary in order to set the stage for the revelation of certain difficult-to-get-at-truths." Would the results been different had he incorporated women? Could it be that this trait of submissive conscious only applies to that generation?

Jerry M. Burger, PhD's replication of Milgram's experiment (2009) addressed the refutations against Milgram's original study. Although Burger's experiment was regulated by the IRB (Institutional Review Board), thus slightly differing from Milgram's, the results were alarmingly similar. In order to reduce stress levels in the participants, Burger lowered the maximum voltage to 150. This pleases those who were highly bothered by the ethical issues in Milgram's experiment. The obedience rate of those willing to go up to 150 volts for Burger was 70% while it was 82.5% for Milgram. Burger found that a large quantity of teachers, roughly the same as Milgram's, were willing to administer "painful" shocks. Additionally, Burger noted that women's compliance rates were analogous to men's (5).

So it seems, that despite the fact that man is in control of his every action and the choices we make are our own responsibility, this research into human behavior is a frightening prospect and must give us pause to reflect. The responsibility for our behavior cannot be projected on to our fallible leadership, especially in this day an age. The Holocaust is the most tragic instance and is what brought Stanley Milgram, to start his research into human obedience, but there are other examples too. President Truman's decision to drop atomic bombs on Hiroshima and Nagasaki was carried out by someone. Those pilots who ultimately dropped the bomb obliterated 129,000 Japanese people. While they may say that they were just following orders, what makes them different from Eichmann?

There is no room for sympathy in such atrocities, only a lesson to be learned. Milgram's work revealed to us the imminent dangers of human acquiescence. The kindest of people, when placed under pressure by authority, risk the ability to create chaos and barbarity. It is a scary thought to understand that we, as humans, are capable of being influenced to such a gross degree by anyone with a higher stance. However, this unavoidable tendency does not justify any crude actions. Rather, it gives us an obligation be wary people in position of power and the control they hold over us.

Man is created with two eyes, yet he can only see outward, the world around him. Thus, it is only natural for man to be unaware of his shortcomings, oblivious to his faults. He would never think himself to be capable of evil; evil is for monsters. He provides for his family, goes to work, and plays sports… like any civilized person would. He could

never be guilty of any such abominable savagery. Despite his egotistical beliefs, reality has struck man with the blatant fact that he is the mass destructor, responsible for and capable of extreme damage and malign activities. History has proven that the moral compass often staggers when in competition with war. How can man be so susceptible to depravity?

We as Jews have only one answer to this. We cannot rely on our own moral compass to rescue us from our ethical uncertainties. Only fear of G-d can help us curb evil tendencies and dictate proper choices. How fortunate are we to have the Torah, the absolute standard by which we can measure our behavior.

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Figure 1- Braunwarth, Joe. "THE MILGRAM EXPERIMENT." *Grossmont*, Grossmont College, 14 Nov. 2014, www.grossmont.edu/people/joe-braunwarth/files/POSC-120-Readings/milgram-experiment.aspx

Figure 2 - Kokot, Amy. "Shock Levels at Which Milgram's Participants Disobeyed (n=40) Compared to Predicted Disobedience by Psychiatrists." *Results of the Milgram Experiment*, Mount Holyoke College, 2001, www.mtholyoke.edu/~apkokot/results.htm.

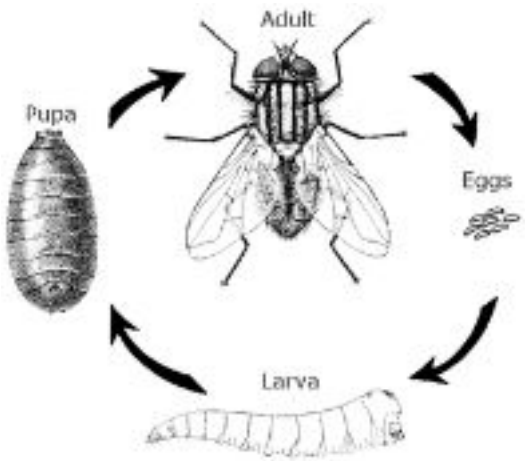
# SOMETHING FROM NOTHING

Yael Feygin & Sara Nordlicht

Did you know that people who lived over 2,000 years ago believed that a gooseneck barnacle, or an alga that attaches to ship bottoms, could become a goose (2)? Nowadays we would think those people were crazy, but they were trusting what their eyes were showing them, which is something we still do today (2).

This belief that a living thing could emerge spontaneously from a non-living object is called spontaneous generation. One of the earliest to posit the theory of spontaneous generation was the Greek philosopher Aristotle. He was going for a walk on a rainy day, and noticed some fish swimming in a small pond formed from rainwater (2). As there was no obvious source of life in the pond, Aristotle theorized that the mud and water must have been what gave rise to the fish. In other words, inorganic objects could give rise to organic objects. Non-living things could generate life. He figured that these inorganic objects had an inherent vital force that could give rise to simple life forms. This hypothesis of Aristotle's was shared by many across the centuries. In the seventeenth century, Francesco Redi was the first to try to refute the long-standing theory, and initiated the slow death of spontaneous generation (4).

In addition to being a physician, Francesco Redi was also a poet and was very knowledgeable in classical literature. He was once reading the nineteenth book of the *Iliad*, in which Achilles asks his mother to protect the corpse of his friend from the flies and worms that attack the bodies of the men that were killed at war (6). Redi didn't understand how Achilles' mother would be able to protect the body from flies settling on it because, according to Aristotle, flies and worms could emerge directly from rotting flesh (6).




From that passage, Redi began to question the theory of spontaneous generation. He theorized that instead of maggots (worm-like living things) emerging directly from decaying flesh, flies approach a corpse and proceed to lay their eggs on it (6). Therefore, when the eggs hatch, it may seem like the maggots were created directly from the meat because the eggs were barely visible, but this is not the case. Also, at that time it was not understood that the life cycle of the fly included the adult fly stage, in which eggs are laid. Once the eggs are laid, they hatch into maggots which eventually mature into adult flies. Since all three stages look different, people then did not understand that

they are all stages of the same insect's maturity. To disprove the popular misconception that living maggots arose spontaneously, Redi devised an experiment that would help refute the theory of spontaneous generation.

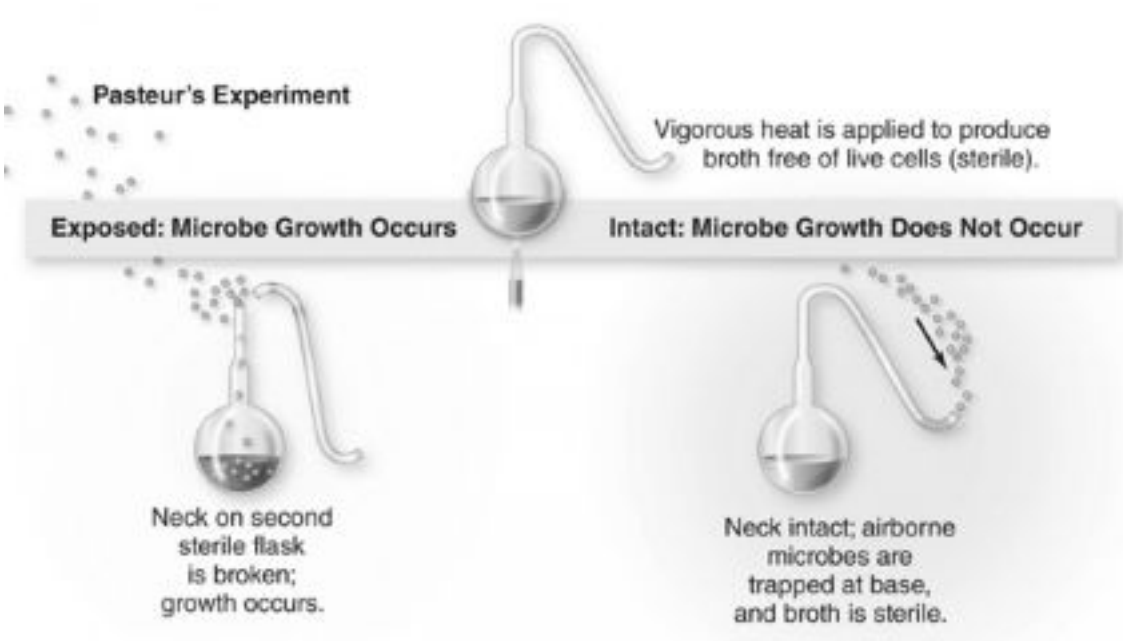
In 1688, Francesco Redi put two pieces of rotting meat in separate jars, one which was covered and one which was left open. Unsurprisingly, the uncovered meat was infested with maggots in a matter of days, but in the closed container, no maggots appeared on the meat (1). Redi thought this would disprove spontaneous generation, as the meat only generated maggots when exposed to the environment. People remained skeptical of Redi's ideas, though, and this experiment did not change anyone's ideas. This was simply because the closed container that Redi used did not allow air to enter. The flies would not be able to survive regardless of whether or not they were generated by the meat; they wouldn't be able to survive due to simple lack of air. Therefore, this experiment of Redi's did not disprove spontaneous generation, it only proved that maggots need air to survive, which people had already known.

Redi devised a new experiment to dispel all doubt. He placed meat in a container with a metal gauze on top, that would allow air to enter, but no pesky flies (2). After several days, no maggots appeared on the meat. Redi was hopeful that people would now take his findings seriously. Sadly for Redi, the vast majority of people still disbelieved him. This was because the maggot and the fly look so radically different, so people did not understand that they are really the same organism at different stages of life. People now thought that it was oxygen that gave rise to life, as the maggots appeared every time there was air present in the container. Even Redi continued to believe spontaneous generation occurred under some circumstances because firmly entrenched beliefs are challenging to uproot, even in the face of proof (4).

The debate continued in 1745 when John Needham, an English clergyman, suggested testing if microorganisms will appear spontaneously after boiling since everyone knew that boiling kills microorganisms (4). Needham cooked chicken broth and put it into a flask, sealed it and as expected microbes grew (4). He established that microorganisms don't grow from eggs and proposed another theory of spontaneous generation: that living things can develop from the non-living matter, at microscopic levels (3). John Needham's experiment nullified Francesco Redi's development and continued what seemed to be the never-ending debate over the legitimacy of the spontaneous generation theory. In 1859, the argument would be officially laid to rest by the French chemist, Louis Pasteur (4).

Pasteur wanted to refute spontaneous generation as well, so when the French Academy of Sciences held a contest for the best experiment to either prove or disprove spontaneous generation, he was ready. Pasteur took two flasks, put the broth in both of them, and boiled them up to kill the microbes in the broth. He then immediately heated the neck of the flasks and bent them into the shape of an S (4). By doing that, he was allowing air to enter the flask, but the microorganisms in the air would get trapped in the neck of the swan-like flask (4).

As Pasteur had expected, no microbes grew in the broth because the broth was not contaminated by any microbes. In the broth of the flask that's neck was broken, bacteria reached the microbe-free broth and microorganisms grew, spoiling the broth. Pasteur concluded that microorganisms are created and grow from one another, and they are everywhere, even in the air. He was able to prove that the contamination of the broth didn't come from any vital force inherent in the oxygen, but rather from bacteria that was inherent in the air. When the bacteria was filtered out, the air did not spoil the broth. This was completely different from what the people of the time believed. Louis Pasteur's discovery was the final nail in the coffin for the theory of spontaneous generation, and it was finally put to rest after this experiment.




Pasteur's experiments also proved instrumental in developing one of the major tenets of cell theory, that all living things come from previously existing living things. Cell theory is the foundation of all biology (5). We now know that disease is spread through airborne microorganisms. Previously it had been thought that disease came from within the body, but now it was apparent that disease came from airborne germs (7). With this knowledge, we can take preventative measures to prevent disease from spreading. For example, we now know to cough/sneeze into our elbow and to quarantine the seriously ill. However, this is not the only positive outcome of the experiments that disproved spontaneous generation. These investigations led to answering a much broader question regarding the origins of life.

Those who conclude that there is no spontaneous generation are left with the question, where did the first living thing come from? The near acceptance by the scientific community of "The Big Bang Theory," which implies that the universe is not eternal and not in a steady state, ironically implies the acceptance that there must have been an origin to life, a *sibbah l'chol ha'sibbot,* and a First Cause for original spontaneous generation. An extension of that line of reasoning to its logical conclusion is there has to have been a Creator who created the first living thing, who is able to

create "יש מאין". We, as Jews, know with absolute certainty that the Master of the World created the universe at *Ma'aseh Bereishit,* and continues its maintenance for eternity. The scientist who seeks the truth and opens his mind to the obvious facts, will come to the same indisputable conclusion that many scientists already see.

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# CHILDBED FEVER: THE TRAGEDY THAT LED TO DISCOVERY

Ettie Guelfguat & Sara Gittel Palley

A strange phenomenon took place in the Vienessian streets in the mid nineteenth century: women who gave birth in the hospitals had greater mortality rates than those who gave birth in the streets. The Vienna General Hospital had two obstetrics clinics that would admit patients on a daily rotation while on weekends admitting everyone to the First Clinic.

It was known by all women that the First Clinic had a greater death rate than the Second Clinic, due to puerperal fever also known as childbed fever. Thus, all women pleaded to be admitted to the Second Clinic (6). When not admitted to the Second Clinic, many women resorted to giving birth on the streets. Surprisingly, these women had lower mortality rates than those who were admitted to the clinics.

In the twentieth century it is unheard of for women to die in a regular childbirth, but during mid 19th century childbearing was extremely dangerous and the chance of death was very high. The world renowned author of *Frankenstein*, Mary Shelley, grew up without a mother. Mary Wollstonecraft, the mother of Shelley and also a writer, died a few days after childbirth. Her placenta was surgically removed which resulted in a life threatening infection. This infection is now known to be puerperal fever, which was one of the main causes of death for women in the 19th century. It was an infection in the female reproductive tract, which worsened over the course of a couple days. The symptoms of this disease were headaches, a cold, heat fits and heavy sweating. As the days progressed, abdominal pain, nausea, vomiting, and increased pulse added to the mothers discomfort. Usually by the third day, the woman was dead. This was a tragic and painful way to die, and it took the lives of many women (5).

**Table 1. Annual births, deaths, and mortality rates for all patients at the two clinics of the Vienna maternity hospital from 1841 to 1846.**

| | First Clinic | | | Second Clinic | | |
|---|---|---|---|---|---|---|
| | Births | Deaths | Rate | Births | Deaths | Rate |
| 1841 | 3,036 | 237 | 7.7 | 2,442 | 86 | 3.5 |
| 1842 | 3,287 | 518 | 15.8 | 2,659 | 202 | 7.5 |
| 1843 | 3,060 | 274 | 8.9 | 2,739 | 164 | 5.9 |
| 1844 | 3,157 | 260 | 8.2 | 2,956 | 68 | 2.3 |
| 1845 | 3,492 | 241 | 6.8 | 3,241 | 66 | 2.03 |
| 1846 | 4,010 | 459 | 11.4 | 3,754 | 105 | 2.7 |
| Total | 20,042 | 1,989 | | 17,791 | 691 | |
| Avg. | | | 9.92 | | | 3.38 |

Death from childbirth was occurring so frequently that a doctor in the Vienna General Hospital, Ignaz Semmelweis, decided to explore and find out the source of the dease in order find a cure. He was troubled by the strange mortality rates of the two clinics and did not agree with the contemporary approach about disease prevention. During the nineteenth century, there were two main theories for how disease spread. The first theory was expressed by Hippocrates, a Greek physician, who believed that

the Four Humors, blood, yellow bile, black bile, and phlegm influence the state of a person. An imbalance of the Four Humors, also known as dyscrasia, would cause disease. Many methods were suggested for a person to achieve stability in the body which included bloodletting, puking, purging, sweating, and a new diet. Doctors who believed in this theory expected that these methods would heal the women suffering from puerperal disease (1).

The second theory of the time was that disease was generated by miasmas, a bad odor in the surroundings, therefore sterilization was necessary to rid the hospital rooms of the bad odor (2). Many hospitals infused the wards with chloride gas for one to two days, washed the walls with chloride of lime, re-painted the walls, replaced the beds, and other similar routines in order to remove any miasmas. Sometimes these sterilization processes were successful in ridding the hospital from puerperal fever for a period of time, but it eventually returned (7).

In order to determine the true source of the disease, Semmelweis wanted to eliminated all differences between the two clinics. This included climate and even religious practices (1). He noticed that women in the First Clinic who had a prolonged labor of 24 hours or more were more vulnerable to puerperal fever and died along with their infant. However, the women who gave birth faster in the First Clinic were not as susceptible to the fever. Semmelweis was intrigued if there was a correlation between labor duration and prevalence of puerperal fever.

Semmelweis noticed that in the Vienna General Hospital, the practice was for the medical students to visit their patients after conducting autopsies. The students would have dirty hands during these visits since it was uncommon to wash hands after procedures. These medical students would follow a doctor on rounds to perform several internal exams on the patients. The women in labor for longer were simply visited more and were therefore exposed more to the "cadaverous particles" that were on the medical personals' hands. Thus, Semmelweis concluded that the etiology of puerperal fever was the hands of the doctors and students. When the doctors and medical students examined the mother in labor with their "cadaverous" hands, the blood of the mother was contaminated and then led to the disease. If the mother was examined after she gave birth then only she would get puerperal fever, and not the baby. On the other hand, if she was examined prior to childbirth, the contamination was transmitted to the fetus which became diseased along with the mother (8).

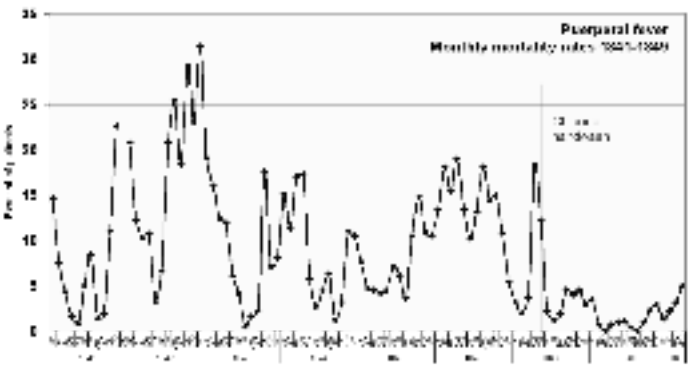
While Semmelweis pondered the bizarre mortality rates, Professor Jakob Kolletschka, a friend of Semmelweis, suddenly died. The professor was overseeing an autopsy by medical students when his finger was cut by a knife that was used to dissect the cadaver. He developed lymphangitis and phlebitis, an inflammation in the lymphatic vessels of the arms, and later died from swelling in the membranes of the lungs. Semmelweis recognized that the maternity patients who died from puerperal fever died with the same symptoms as his friends (3).

After Semmelweis discovered how puerperal disease was being spread in the Vienna General Hospital, he was able to explain the glaring difference in the mortality rates of the two clinics. He reasoned that puerperal fever was more prevalent in the First Clinic because the patients were treated by male doctors and students who also conducted

autopsies on dead bodies. However, the Second Clinic did not conduct autopsies, so less women were exposed to "cadaverous particles" (6).

As a result of his discovery, he instituted hand washing with chlorine before the examination of women in labor. Previously, chloride solutions were used to remove the toxic odors of decaying materials. Accordingly, Semmelweis reasoned that a chloride solution would be the perfect agent to rid the bad smell of the cadaverous particles from the autopsies. He also made sure that the linens were washed after each birth. In May 1847 he instructed for a dispenser of a chloride liquid to be put in the entrance of the First Clinic along with small brushes to disinfect the area under the nails. After one year of maintaining these practices, the mortality rates in the First Clinic decreased to 1.2 percent and in the Second Clinic decreased to 1.3 percent. Within seven months only 56 out of the 1,841 women admitted to the Frist Clinic died from puerperal disease. After the new protocol was instituted, the First Clinic never experienced consecutive death or sickness from childbed fever (7).

The greater medical community, unfortunately, did not accept Semmelweis's ideas. His proposal was not in line with with the existing theories of disease being caused by the imbalance of the Four Humors and miasmas. Many leading scientists and doctors disagreed with him because they felt that his ideas had no basis in science (1). For example, Rudolf Virchow, a German physician, believed there could be other causes to puerperal disease. Semmelweis had a difficult time refuting his opponents and gained a negative reputation because of his vulgar language during debates with his opposers (8). Additionally, some doctors rejected his ideas because they believed that it was impossible for a gentleman to have unclean hands. Thus, his ideas were mostly rejected by the medical community.




In response to Semmelweis' discovery, cleanliness was taken more seriously and was integrated into everyday life. Hand hygiene is one of the most important ways to prevent the spread of infection. This is the source for routine hand washing after the bathroom that is in use today. Additionally, floors, dishes and other household items are often washed and disinfected in order to avoid spread of infection (9).

Although the medical community rejected Semmelweis's ideas, the Jewish population practiced his ideas long before they were proposed. While all of the washing of hands and bodily immersion, as mandated by *Halacha*, are of spiritual nature and preparations for holy experiences, nevertheless, one of the fringe benefits of these observances provides for cleanliness on a physical level as well. This keeps Jews physically and spiritually clean at all times. It is for this reason that the mortality rates in the Jewish community during the Black Death were considerably lower than those of the Christian population. It is reasoned that this is because Jewish law mandates for every person to wash their hands

numerous times a day, to bathe before the Sabbath, to keep the sewage away from the house, and to bury the dead as soon as possible. Although the cities in the Middle Ages had poor sanitary conditions and were overcrowded, allowing for diseases to spread quickly, the Jews remained protected from the plague (4). It was the adherence to *Halachah* that enabled the survival of the Jewish population.

Much like the Jews, Semmelweis was ahead of the medical community. He had the ability to observe and then give a sophisticated reason for a new medical approach when there was no knowledge about the cause for infectious diseases. In the future, his ideas were expounded upon and proven true by Louis Pasteur and Joseph Lister who revolutionized the medical world with the Germ Theory. This provided the greater scientific proof that Semmelweis was trying to tap into (1). Ignaz Semmelweis' discovery was a turning point in medical history because he revolutionized cleanliness and more specifically, hand hygiene. His work is greatly honored today because of the lives that he saved and the healthy habits that he promoted.

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Photos


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# WHILE YOU WERE SLEEPING

Anni Jacobowitz and Chani Shulman

"So, what will it be like?" I asked my oral surgeon. "The anesthesia? Oh- it will be just like falling asleep and before you know it, you'll be up." He was right. An hour or so later I had woken up to a ziplock bag containing my extracted wisdom teeth- available for disposable or to take home as a souvenir.

I chose the second option. Yet, had I lived two centuries ago, I would not have qualified for oral surgery; patients who underwent pre-anesthetic surgery were either diagnosed with "dire situations" or were considered brave, which I am not (8).

Before anesthesia, surgery was considered a last resort, with no more than one per month. An elderly Boston physician equated surgery (pre-anesthesia) to the Spanish Inquisition. Doctors employed a multitude of different methods to dull the pain: marijuana, hypnosis, stinging nettles (acting as a counter-irritant), or a sturdy blow to the jaw- with hopes of knocking out the patient. Not only were surgeries abhorred by patients, but by surgeons as well, many vomiting or crying beforehand (6). Even if a patient could withstand the exorbitant pain that accompanied surgical procedures, many patients died anyway due to an excessive loss of blood. (Robert Liston, known as "'the fastest knife in the West End", was considered to be the most successful surgeon after only losing one in ten patients.) (8)

Now that anesthesia is available to the public at large, people can undergo all different types of surgery- whether it be a minor surgery, like appendectomy, or something as serious as heart transplant- all while being completely sedated/asleep. However, the journey from anesthesia's conception to its use in operating rooms was a long one . Since 4,000 BCE, anesthesia has been a topic of discussion, with many trying to discover or create an anesthetic. The Sumerians, Assyrians, and Greeks tried to come up with ways to create a gas or oral medicine to sedate or numb the patient during operation, but they were unsuccessful.

A dentist, Horace Wells, discovered that nitrous oxide can be used in surgical procedures to "knock out" a patient, who would then forget the pain of going under the knife. Along with his apprentice, William Morton, the two planned to demonstrate the beneficial effects of nitrous oxide at a public demonstration in the Massachusetts General Hospital. For the demonstration, a medical student volunteered to have a bothersome tooth removed. However, because Wells had not prepared enough gas, when he pulled the tooth, the student groaned in pain. After they heard the groan, the crowd erupted: "Humbug! Humbug!" A year later, William Morton discovered that diethyl ether could be used as anesthetic. To see if diethyl ether was an anesthetic, Morton tested the drug on his father's farm animals. After successful outcomes, Morton decided to demonstrate his findings at the Massachusetts General Hospital (in 1846). He joined Dr. Warren who would be removing a tumor near the jawbone. Upon arriving late, Dr. Warren told

Morton: "Your patient is ready." After Morton successfully knocked out the patient, he wheeled him over to Warren and smugly replied, "*Your* patient is ready." When Warren finished the surgery, he turned to the audience and said, "Gentleman, this is no humbug," where he was met by an eruption of cheers. (8)

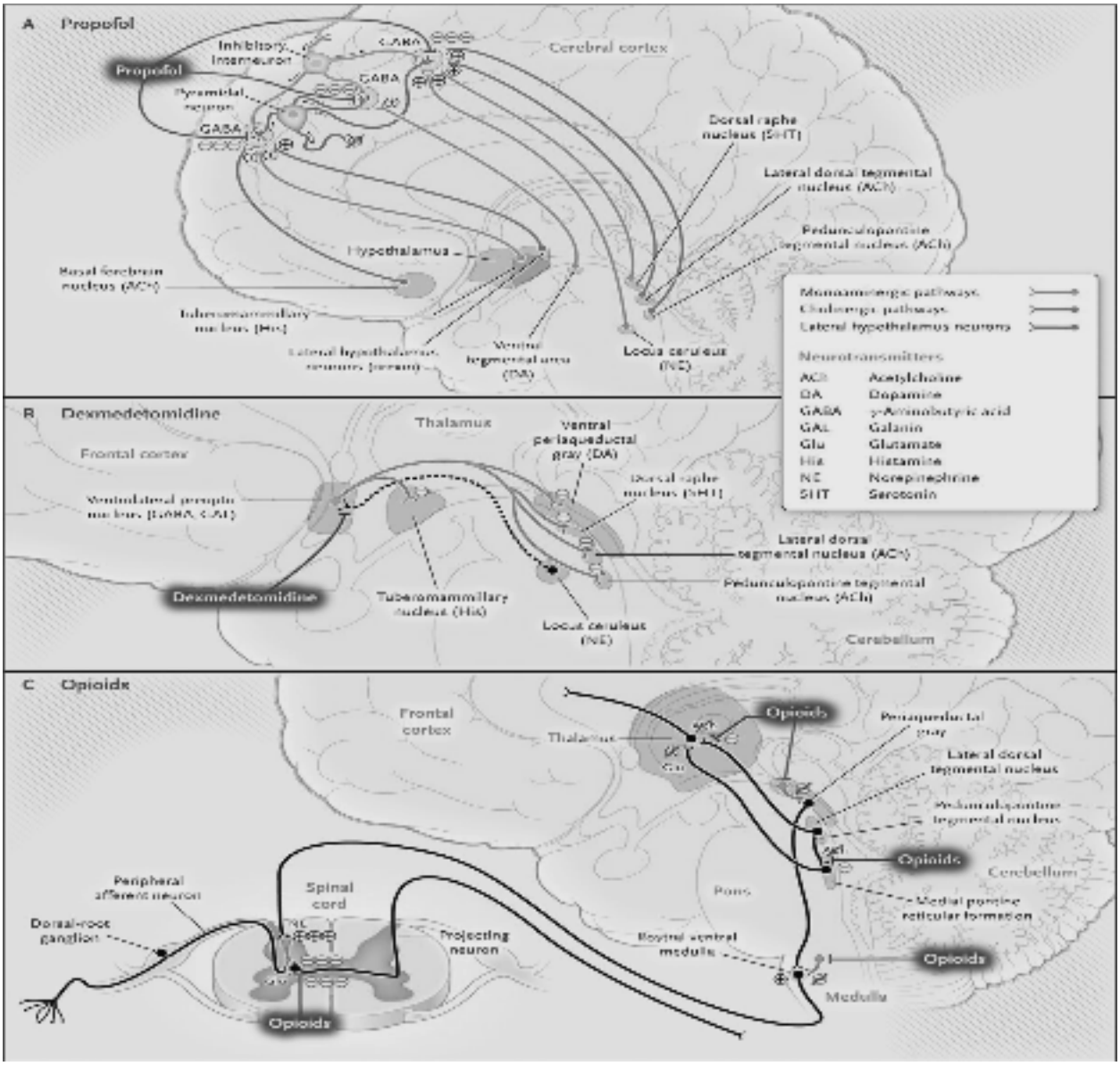
Another important figure in the history of anesthesia is Henry Jacob Bigelow, a member of one of the founding families of Massachusetts. Bigelow was born on March 11, 1818. After graduating from Harvard in 1833, he began to study medicine with his father and later became a surgeon in Boston. Although Bigelow did not actually perform surgery using anesthetics, he was the first surgeon to write about it. Bigelow was an astonishing surgeon, teacher, writer, and originator of procedures. Additionally, his students looked up to him and recognized him as the country's most prominent surgeons. He resigned his professorship in 1882 and died eight years later on October 30, 1890 (4).

Before scientists started testing anesthesia on people, they experimented on animals. When scientists and researchers use animals to test new anesthetics, it doesn't cause much stress to the animals. Scientists experiment with anesthesia using mostly mice and rats. The first anesthetics were inhalants- where mice would breath in vapor emitting from a mouthpiece. The experiments were beneficial for society, showing that multiple uses for anesthesia, as well depicting the harmlessness of anesthesia- freeing people of any hesitations against receiving anesthesia. Sadly, the rats did not have as great an outcome and many were harmed in the process; countless rats developed blood diseases as a result of these experiments (7). Scientist continue to look for new ways to experiment and hope for better outcomes. (See Figure 1)

*Figure 1: Pictured on the right is a tool used to test anesthetics on mice: an induction chamber. The arrow shows the flow of direction for the induction.(7)*

In his book, *Caesar's Last Breath*, Sam Kean mentions that we do not really know how anesthetic drugs interfere with the neuron function; we just know that it does. He also mentions how the brain does not just "shut off" when anesthesia is administered. The patient is still aware of sounds and smells, but is unable to stimulate a response because "the rest of the brain never hears about [the sounds and smells]." (8) In The New England Journal of Medicine's article ("General Anesthesia, Sleep, and Coma"), Dr. Emery Brown explains the different stages of General Anesthesia and how the EEG (electrical activity of the brain) waves appear at each stage. The low-frequency, high-amplitude activity in general anesthesia is similar to the signal waves of a coma (as opposed to that of sleep). (In fact, many doctors refer to anesthesia as "sleep" so it will not alarm the patient. "Sleep" is definitely more comforting than "drug-induced coma".) Dr. Brown also notes what the anesthetic drugs do: "[they] induce unconsciousness by altering neurotransmission at multiple sites in the cerebral cortex, brain stem, and thalamus." (10) (See Figure 2)

*Figure 2: The anesthetic drugs inducing unconsciousness with the alteration of neurotransmission at the cerebral cortex, brain stem, and thalamus (10).*




New evidence to support the method of anesthesia is often found in PET-scanners, MRIs, and rodent models of general anesthesia. General Anesthesia has been proven to enhance Gamma Amino Butyric Acid, GABA, a neurotransmitter that blocks impulses between the nerve cells in the brain (10). Because of this, patients receive signals during anesthesia, but can't perceive it (8); and these enhanced GABA neurotransmitters leads to unconsciousness. Unconsciousness has been reversed when injecting cholinergic agonists, which mimic acetylcholine, an excitatory neurotransmitter which facilitate the transmission of impulses between neurons, into the central thalamus. Therefore, the reverse must be true. If anesthesia is able to enhance GABA neurotransmitters- which **block** impulses between nerve cells (the **opposite** function of acetylcholine)- in the thalamus, then it should be able to

induce unconsciousness; just as cholinergic agonists reverses unconsciousness (10) (See Figure 3).

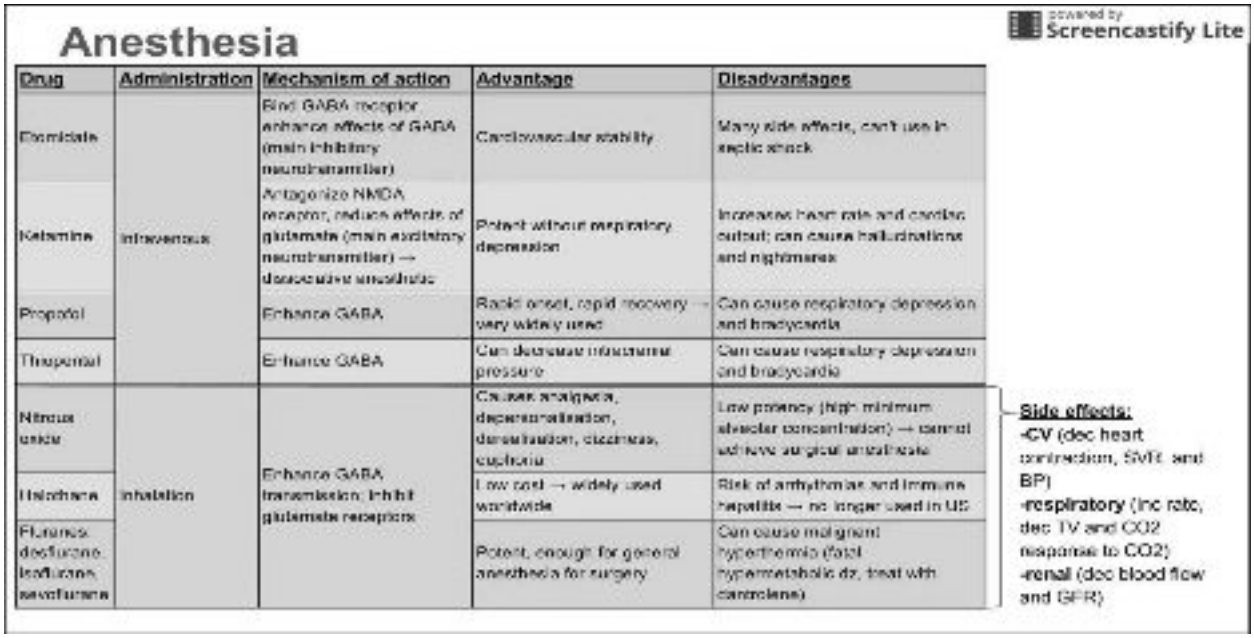



*Figure 3: Different types of anesthesia, how they are administered, their advantages and disadvantages, and their relationship with GABA (10).*

Anesthesia has continued to change and modernize. Ether has been replaced by safer drugs and many new drugs have been introduced as anesthetics or as a means to reduce pain. (2) Anesthesiologists work meticulously to combine different drugs to act as either a local anesthetic (loss of sensation in that particular area), general anesthetic (complete lack of consciousness), or sedative (inhibits anxiety): "...anesthesia usually consists of a cocktail of several drugs, each of which targets a different physiological function. Some of them slow breathing down, some paralyze muscle; others relieve anxiety or interfere with memory formation." With careful attention to blood pressure and body temperature (and other signs), anesthesiologists can infer which drugs to administer and how much more is needed. (8) Just as an aside, and just as surprisingly, it has been scientifically proven that redheads require higher doses of anesthesia. (2)

Anesthesia could either be administered intravenously (through the veins) or through inhaled induction (via mask). When administered intravenously, propofol is the main player in the anesthetic procedure; while with inhalation, sevoflurane is the main anesthetic. When a gas inducing mask is used, the patient takes five to eight breaths and then immediately falls asleep. (And afterwards, anesthetic drugs are injected to "deepen anesthesia, facilitate control of the airway, and maintain anesthesia as appropriate.") With an IV cannula, it usually takes a minute until the patient is knocked out. When chloroform (a gas- based anesthetic) was introduced, many adults disliked the pungency and force of the gas upon inhaling. Therefore, many doctors assumed adults would prefer the anesthesia be administered through IV Cannulas, and would not even offer the inhaled induction route for adults. Many anesthesiologists falsely assumed that children are the only ones with a fear of needles. In fact, when a study of two hundred and forty patients

undergoing anesthesia was done, it was found that seventy-eight (33%) patients chose IV induction, one hundred and twenty (50%) selected inhaled induction, and forty-two (17%) were undecided. One hundred and fifty-four patients received anesthesia through mask inhalation: one hundred and twenty chose to do so, thirty-two were undecided and were offered the inhaled induction, and two selected the IV induction, but switched to the mask after IV cannulation was deemed too "difficult". (It happens to the best of us.) (5)

Although the studies on anesthesia continue to evolve, there is still a major issue in the world of anesthetics. The purpose of anesthesia is to induce patients into a deep sleep, preventing them from feeling any pain; however, it is not guaranteed that a patient will remain asleep through the whole surgery. This concern is called anesthesia awareness and has reportedly happened numerous times (7). Despite being relatively rare, there are multiple stories of people who recall waking up in the middle of their surgery and are traumatized to this day. Carol Weihrer, a patient who experienced anesthesia awareness while undergoing eye surgery, says."I could hear the surgeon telling his trainee to 'cut deeper into the eye. I was screaming, but no one could hear me. I felt no pain, just a tugging sensation. I tried to move my toes or even push myself off the operating table, but I couldn't move. I thought I was dying." (9). There is no permanent solution for these rare occurrences, but there are ways to decrease the chances of it happening. Anesthesiologists should keep a close eye on the patients statistics and heart rate, as well as being careful to check on the patient frequently. Although anesthesiologists can monitor the patient throughout the surgery, it is still possible for patients to experience anesthesia awareness. In the future, anesthesiologists will hopefully be more equipped with the knowledge to put an end to this nightmare (12).

Anesthesia was a historical paradigm shift in how it impacted societal view of surgical procedures. Nowadays, surgical patients don't need to think twice about experiencing possible pain during surgery. If the patient is nervous it is likely due to thoughts involving the aftermath of surgery or the anxiety of being a first time patient embarking on a new experience. From a pain standpoint, there is no need for the patient to be worried because anesthesia will prevent them from feeling any form of sensation.

Surgery, which was once considered a "last resort", is not only being utilized as an after- the- fact measure, but also as a means to screen for cancerous risks. Once adults have reached the age of fifty, they are recommended to undergo a colonoscopy to screen for colon cancer. Furthermore, not only has anesthesia developed in its extension of available anesthetics, but also in its opportunity to choose its administration: intravenously or via inhaled induction. The field of anesthesia has continuously grown since its finding, with over 35,000 anesthesiologists in the U.S. alone. Anesthesiologists are constantly learning more and more about the inner workings of anesthesia, and it continues to thrive as one of the most fundamental scientific discoveries.

Most people take anesthesia for granted now that we've had it for about two hundred years, but pain from surgery pre-in surgery anesthesia is unimaginable. So, one should be thankful for anesthesia and realize what an important role

the anesthesiologist plays. When one takes a look into an operating room, most of the time the focus is on the talented surgeon or the patient on the table. There are few who give credit to the doctor not holding the knife: the anesthesiologist. However, without them, the surgery would never begin! People should research more about anesthesia to see how fascinating the world of anesthesia really is; because without anesthesia who knows if you would even be reading this right now (13)?

*Figure 4: A picture of Anesthesiologists prepping their patient for surgery in the OR.*

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# BLUE EYED BLONDE: EUGENICS THEN AND NOW

Mia Lubetski

On December 11, 1961, after a four-month recess, the three judges returned to the bench with a verdict. The time had come for Eichmann to be judged. It had been a year and a half since his capture, and 16 years since the liberation of the Nazi camps. The courtroom was hushed as Eichmann stood to hear his verdict.

He maintained his innocence all along, saying he was just following orders. The judges disagreed and found him guilty of all 15 counts against him; the particulars of his rank and function were no excuse. With this verdict, the judges had effectively shut the case on the eugenics movement and declared it unethical and immoral.

The term eugenics was originally coined by Francis Galton, an English scientist, in 1883. Eugenics is a set of beliefs and practices that aim to perfect the quality of the human population. Francis Galton was among the first to realize the implications that Darwin's Theory of Evolution would have on mankind. Darwin based his Theory of Evolution by natural selection on the volume of historical evidence of selective breeding experiments in farming and agriculture. Darwin's theory stated that a population evolves into more sophisticated, improved individuals as time goes on, as they adapt to their surroundings. The eugenics movement was an outgrowth of Darwin's Theory of Evolution. Eugenicists took this theory into their own hands and tried to speed up the process by identifying the traits they viewed as desirable and selectively eliminating those who exhibited traits they did not want to pass onto the next generation. The English eugenics movement, headed by Galton, promoted eugenics by selectively breeding for positive traits, while the eugenics movement in America focused on eliminating negative traits. (4)

The science that supported the eugenics movement was the success of selective breeding. There was a whole body of work on selective breeding of plants and animals that showed that it was possible to selectively breed for certain traits by mating two individuals that both exhibited the trait of interest. Scientists already knew some information about how traits are passed on from Mendel's experiments on pea plants and about dominant and recessive alleles. Mendel had done his experiments on pea plants about 20 years prior to the beginning of the eugenics movement. The eugenicists believed they could do the same with humans. The results that were expected on humans were loosely based on Mendel's conclusions (9). They proposed that the breeding of two living beings that exhibited the desirable traits would result in an offspring that was even better, more successful and efficient. For example, if they bred two fat cows, that both produced delicious milk, their offspring would most likely carry these traits as well. Beyond this, there were many additional experiments done by scientists such as Robert Bakewell proving the same idea (11). After it had

been shown that selective breeding was successful, people understood the importance of genetics and how it could be used to the population's advantage to further sophisticate mankind.

At the start of the eugenics movement in America, scientists thought it was a positive development that would further sophisticate mankind. Although there wasn't a specific body of human research, the scientists assumed that if this worked on plants and animals it would work in humans as well. Their hypothesis was correct regarding what the outcome would be when breeding two plants or animals with desirable traits and they could see no reason why it should be equally true of humans..

The eugenics movement began in America in approximately 1905, when the first U.S. national eugenics organization was formed by the American Breeders' Association (4). However, in the United States, the extent of the eugenics movement had mainly been sterilization of women with undesirable traits so not to continue birthing children with these characteristics. Uneducated African American women were tricked into the procedure, by saying that it would improve their quality of life and raise their social station. Twenty five percent of women that were sterilized, were sterilized unknowingly and unwillingly (6). Carrie Buck was a patient in the Virginia State Colony for Epileptics and Feeble-minded. Buck herself didn't know about her sterilization until decades later, as at the time she was told that she was receiving an operation to remove her appendix (3). In the Supreme Court case Buck v. Bell, Justice Oliver Wendell Holmes argued for allowing the forced sterilization of Carrie Buck with the statement, "Three generations of imbeciles is enough."

African American woman protests. (1971)

Another example of an effect of the eugenics movement were the immigration quotas that were enacted at the turn of the 20th century. Starting in 1914, the Surgeon General and a number of senior officers in the Public Health Service took significant roles in eugenic organizations and published articles to support the eugenicists' position on the immigration restriction debate. (7)


Carrie and Emma Buck at the Virginia Colony for Epileptics and Feebleminded, taken the day before the Buck v. Bell trial in Virginia. (1924)

Unfortunately, about 30 years after the eugenics movement was introduced in America, the infamous leader of the Nazi party, Adolf Hitler took the theory of eugenics to its demonic conclusion, targeting the Jews. He exterminated people he believed did not conform to societal norms and were thereby polluting the Aryan race. These people primarily included

Jews, gypsies, handicapped people, and others. This extermination process resulted in over ten million people murdered. In fact, the Nazis defended and justified their actions by saying they were simply copying and extending what the American eugenics movement had started. However, after 1945, historians began to portray the American eugenics movement as distinct and distant from Nazi eugenics. (2)

Shortly after the end of World War II, the use of eugenics declined significantly. During the eugenics movement in America, scientists, doctors, and judges truly believed that they were doing the right thing in sterilizing people that had undesirable traits so the population could grow in the way of perfection. The U.S. government genuinely believed this movement was legal and ethical, and it was not until the excesses of the German eugenics that people began to realize how wrong it was. The statistics taken following the eugenics movement showed that over 64,000 people were forcefully sterilized during the eugenics movement in America, and over 10 million people were murdered in the "purification" of the Aryan race.

It is hard to believe that nobody thought progressively enough to realize how immoral this was. It was a complete transgression of moral and ethical values. It is hard to understand now how the U.S. government, not only condoned the eugenics, but supported it. However, it is important to stress that the scientists truly considered it their moral and ethical duty to eradicate the undesirable traits from the population and help the population move towards a perfected state. The understanding of the world completely shifted as nowadays the eugenics movement is obviously viewed to be completely immoral and unethical.

Thankfully, the eugenics movement is now long gone and is viewed in retrospect with much negativity and embarrassment. It brought an understanding to the world, that although something may be scientifically sound, it doesn't justify the murdering of millions. It is important to think critically about developments in science and take great caution when moving forward on sensitive issues.

Finally, it is interesting to note that today the eugenics movement has reemerged in a different guise. It is now possible to tailor one's unborn children to the parents' preference, selecting the gender and height. Doctors are able to test in utero for certain illnesses and take preventative measures that may even include aborting the baby. Many agree with testing for childhood illnesses and diseases that could strike later in life. Scientists have been testing for Down Syndrome and Tay-Sachs for years with no controversy; it is the cosmetic and personality engineering that many find issue with. IVF clinics already test embryos for fatal childhood diseases, such as cystic fibrosis. In a survey published in 2015 in the Journal of Assisted Reproduction and Genetics, it was apparent that the majority of adults agreed with testing embryos for fatal childhood illness, while a smaller portion of the adults agreed with testing for later life diseases. An overwhelming majority of adults disagreed with testing embryos for gender and personality traits.

Today, scientists can only test for gender and height with almost always accurate results, but testing for things like weight and IQ are on the horizon. A physicist from Michigan State University, Stephen Hsu developed a genetic

"predictor" to estimate height, to within three centimeters, from a person's DNA, therefore enabling a person going through IVF treatment to choose the fetus with the desired height. "I fully predict it will be possible," says Hsu of selecting embryos with higher IQ scores. (10) At the moment, few think that it is moral to choose the specifics of the appearance and personality of one's child and it is doubtful that this would ever be accepted and done on a mass scale.

Society at large has always had a drive towards perfection, which is valid. None the less, the need to think carefully to decide where to draw the line in using the science that is made available to us is increasingly critical. Scientists need to keep in mind today, that despite the wealth of scientific knowledge at their disposal, it is important to learn from the past, when a scientific discovery may have seemed sensible in the beginning but was taken to illogical conclusions. Obviously, the broad application of eugenics in its classical sense and in its modern incarnation is unacceptable and antithetical to *shomrei Torah u'mitzvot* on any and every level.

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# THE VACCINE THAT VANQUISHED POLIO

Yael Weinberg

The year was 1938. The United States was about to be led into war by their strong and courageous president, Franklin Delano Roosevelt, who was held in highest esteem by the American people. To them, he was a perfect president who would lead them to victory. Yet no one knew what was happening in his private life.

Since there were no televisions in those days, the image the nation had of their leader was that of an inaccurate newspaper cartoon or what they imagined based on his voice crackling over the radio. However, behind the intense security of the White House, Mr. Strong and Mighty President was operating in a wheelchair due to paralysis in both of his legs. He was diagnosed with poliomyelitis in 1921, a dreaded disease that in 1916, took the lives of approximately 6,000 people, mostly children, and affected around 27,000 people ("Polio communities NMAH" 5).

Roosevelt took action as a result of his disability and founded an organization that was then known as the Foundation of Infantile Paralysis and is now known as the March of Dimes. Its mission was to find a vaccine or cure for poliomyelitis (Meldrum, Marcia 7). Indeed, in 1955, Jonas Salk developed the first effective polio vaccine that was funded by the Foundation for Infantile Paralysis and saved thousands of lives.

Poliomyelitis is a disease that plagued the United States during the twentieth century and reached its height in the 1950's. This dreaded disease sometimes led to paralysis and even to death. Symptoms are largely not present but when they are, which is in about twenty five percent of patients, they could range anywhere from flu to paralysis. Flu symptoms include a sore throat, fever, headache, nausea and commonly weakness in arms and legs. More extreme paralysis symptoms are paresthesia, which is a feeling of pins and needles, and meningitis which is an infection that affects the spinal cord and brain. At the height of the the epidemic in 1954, there were almost 57,628 cases. ("Polio communities NMAH" 5) These numbers desperately demanded a vaccine.

The first attempt of a polio vaccine was started in 1935 and it was followed in short order by many more. Although these trials proved unsuccessful, they still laid a basis for the Salk and Sabin vaccine to come. Professor John Kolmer and Maurice Brody were the first to unsuccessfully develop a vaccine. Professor John Kolmer used a live form of poliovirus and proceeded to test thousands of children. His attempt was an unmitigated disaster because it caused paralysis in a substantial portion of the children he vaccinated and some cases even resulted in death. Maurice Brody created a different type of vaccine which was made up of killed form of poliovirus. He tested it on animals but since people were so traumatized from Kolmer, he was not allowed to test it on humans and therefore it was shut down immediately.

A little while later, in 1948, John Enders discovered a way to grow the poliomyelitis virus in a lab on a culture. This was a major discovery as it eventually helped Salk create his version of the vaccine. John Enders won the Nobel Prize for this discovery in 1954 ("John F. Enders - Facts"6). In 1950, Hilary Koprowski made the first successful vaccine yet it took five years to truly develop and finalize and by that time, the Salk vaccine was already in use. His vaccine was made of live poliovirus like all the vaccines that had been made before Salk. Koprowski's work did not go to waste because he later took it abroad to Poland, his birthplace. After Koprowski, Jonas Salk developed the first successful and widespread poliomyelitis vaccine.

Salk was born in 1914 to Jewish immigrant parents who hailed from Russia and had always encouraged him to pursue an education. He obtained his medical degree from New York University of Medicine and proceeded to work as a scientist at Mount Sinai Hospital. He created the first influenza vaccine with colleague Thomas Francis in 1938 in the University of Michigan, and following his appointment to the Director of the Virus Research Center at the University of Pittsburgh School of Medicine, he developed the poliomyelitis vaccine ("History of Salk 3). He then proceeded to test around 1.6 million children in what was known as the Francis Field Trials.

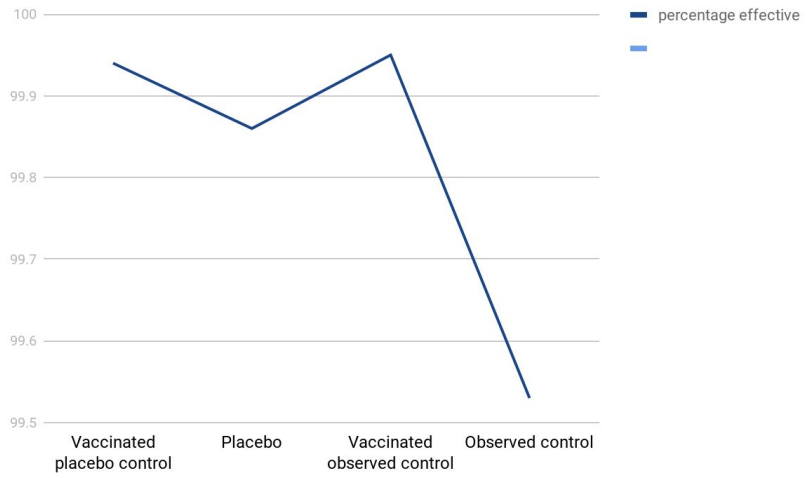

The makeup of Salk's vaccine was revolutionary. He used a deadened form of the once alive poliovirus. When injected into the body, the protein antigens on the surface of inactive poliovirus trigger the immune system to create antibodies that stay in the bloodstream ready to recognize and fight off any future presence of the disease. His vaccine is called the IPV which stands for inactive polio vaccine because it uses an inactive form of the poliovirus. People were skeptical of his idea at first until it was found that the antibodies created against the dead virus would still be capable of deflecting future invasions of the live virus. Although these antibodies are not as strong as ones fighting an active virus, they are still effective in getting the job done.

Salk created the vaccine in 1953 and presented it to Basil O'Connor and Thomas Rivers of the National Foundation of Infantile Paralysis who, although initially skeptical, were quickly swayed by its effectiveness (Meldrum, Marcia 7). They quickly pushed for a mass field trials to test the real strength of the vaccine. However, many virologists on the immunization committee of the foundation did not think the vaccine would be successful because of the killed poliovirus. Their critique did not hold the trials back yet another problem arose. In order to inject an inactive poliovirus, large amounts of poliovirus would be needed. This is where John Ender's discovery was put into play

because they could now grow the poliovirus in a lab which would be able to provide for the mass field trial (John F. Enders - Facts" 6).

Trials started in 1953. While many states hopped on board, others did not due to the fact that the vaccine was not being supported by scientists but rather by an organization made up of lay intellectuals. O'Conner enlisted the support of Thomas Francis of the University of Michigan who had previously worked with Salk on the influenza vaccine. For the Francis field trials, it was decided to use two types of controls to ensure the safety and efficacy of the vaccine, a placebo group and an observed group. An observed group is a group that is just watched to see the regular things that were happening at this time during the epidemic. This means the children with polio within all ranges from mild to severe were being observed as well as children with no traces of the disease at all. The observed group was used to compare what children without the vaccine looked like. The control of the placebo was put in place to make sure the vaccine was actually effective and not just mental persuasion. In order for the placebo to actually work, the children, their parents and evn the doctor injecting the vaccine could not know that the vaccine did not contain the real poliovirus. This "double-blind" experimental setup ensures that not only the subject's mind is fooled into believing it is receiving the actual vaccine, but inadvertent experimenter bias is eliminated as well.

In 1954, around one million children from the first through third grades were used as an observed group while around 600,00 others from the same age group were injected with a vaccine or a placebo. The foundation collected the data in each age range and the results were astounding. The vaccine was over ninety percent effective. In the first experiment where the placebo was used as a control, the number of children vaccinated was 200,745 compared to 201,229 children who received the placebo. The second group included a vaccinated group as well as an observed control whom received no vaccine. The number of children vaccinated was 221,998 while the observed control had 725,173 children participating. The results turned out very positive. The vaccine prevented all forms of polio including those with minor symptoms ("Monto, and Arnold S 8").




This proved the success of Salk's poliomyelitis vaccine as both the placebo as well as the observed controls had more cases of polio. Salk was not the last to create a successful vaccine as seen with Hilary Koprowski as well as Albert

Sabin, who had been in a long time competition with Jonas Salk over who would be first to introduce the vaccine. In the end, Salk's vaccine preceded Sabin's by five years.

Albert Sabin created a second effective polio vaccine in 1960 that had a different makeup than the vaccine of Salk and is more effective yet also opens a door for new dangers. The Sabin vaccine is administered through the mouth therefore causing it to be called an OPV or oral polio vaccine. The vaccine was made up of a weakened but live form of poliovirus which is stronger because it penetrates deeper into the body. Sabin discovered how to make the antibodies travel all the way into the intestines which Salk's vaccine could not do. From 1956 to 1960, Sabin worked with Russian scientists to develop and perfect the vaccine. Since he was not allowed to hold a field trial in the United States because of the already present "killed" polio vaccine made by Jonas Salk, Sabin, an American, held his field trials in the USSR right in the midst of the cold war. The danger of the polio disease and the quest to find a solution annulled all tension and any pride intervention. Eventually his vaccine proved a lot more effective and that is why it replaced Salk's poliomyelitis vaccine in the United States in 1961. However over the next few years, new cases of polio were found and they were soon traced back to the OPV itself. This live poliovirus sometime would develop into a full fledged disease because the immune system was not strong enough to fight it, defeating the purpose. Consequently, the United States switched back to using an updated form of the IPV in the year 2000, resulting in a decrease in the risk of new bouts of polio ("Global Health"2).

As seen with the OPV, a virus injected into the body can sometimes overpower the strength of the immune system and develop into the full fledged disease. This defeats the purpose of the whole vaccine as seen with the replacement of the Sabin vaccine. Therefore, scientists are trying to come up with new ways to ensure the safety of vaccines. One way they have achieved this is by genetically engineering vaccines. By isolating the genes for the antigenic proteins and inserting them into a totally non pathogenic vector, the immunogenic response will be activated and antibodies will be produced without endangering the patient. ("Vaccine Engineering" 1). This technique was successfully used on the hepatitis B vaccine. Hepatitis B is a disease that affects many people worldwide. Therefore scientists were always struggling to develop a vaccine to decrease the numbers of people affected each year. Scientists genetically manipulated a yeast known as saccharomyces cerevisiae to trigger an immune response to the Hepatitis B virus ("Micro-Discoveries Online" 10) Since this yeast is not the actual virus, it is incapable of turning into a real form of the virus. This shows how a genetically modified vaccine can be very effective and scientists are hoping to apply the concept to many more viruses in the future. Maybe one day the polio vaccine will be genetically engineered so the risk of contracting the poliovirus will decrease by significant numbers.

The polio vaccine can still spread naturally in a three places in the world. Therefore these places are in dire need of the vaccine and teams of doctors are encouraged to go administer the vaccine there. Pakistan is one of these countries. In 2011, the CIA heard that Osama Bin Laden, a terrorist from Al Qaeda responsible for blowing up the twin towers and killing thousands was hiding in Abbottabad, Pakistan. Since this piece of information was only a rumor, they needed

factual proof that he was being hidden in Abbottabad. Therefore they wanted his family's DNA to see if he was hidden there. Previously his sister died in Boston so the CIA had her DNA for comparison. In order to obtain the DNA, they set up a fake free vaccination program for Hepatitis B to encourage all Abbottabad residents to get vaccinated and therefore in the process, the vaccination workers would take DNA without them knowing. This plot was unsuccessful and later uncovered which greatly angered the Pakistani people. They therefore started attacking all vaccination workers including those administering the polio vaccine which is actually needed there. This endangers the whole world because polio can be easily spread to even a polio free country. The Taliban banned vaccinations in certain parts of Pakistan and around 20 vaccination workers were murdered by local villagers in response to the CIA's plot ("Scientific American" 4). Many courageous individuals who want to give over their time voluntarily to administer the vaccine who travel to these three countries, Pakistan, Afghanistan and Nigeria, may be scared off. This story proves the relevance to polio in today's world and how we are still battling the dreaded poliomyelitis.

The polio vaccine traveled a long way since 1935 with the first attempt. Today, in the United States, every child receives four doses of the IPV. The first dose is given at two months followed by four months and then given another dose between the ages of six to eighteen months. The last dose is given when the child is between four to six years old. The CDC is still trying to eradicate polio from all over the world and prevent any cases from arising in the future. This is why they established the STOP program which stands for Stop Transmission Of Polio. The program sends health care professionals to countries that still contain polio within its borders in order to administer the vaccine ("Global health"2). The process and development that came from the brilliance of Jonas Salk and Albert Sabin led to the miraculous vaccine that eradicated the scourge of poliomyelitis from almost all over the world.

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# THE INS AND OUTS OF INTRONS AND EXONS

Shira Zelefsky

With the completion of the sequence of the entire human genome in 2003, biologists hoped that the mysteries of molecular genetics would be revealed; however these scientists found that things were far more complex than they had anticipated. One of the most surprising revelations was that the human genome contained only on the order of 30,000 genes and downward

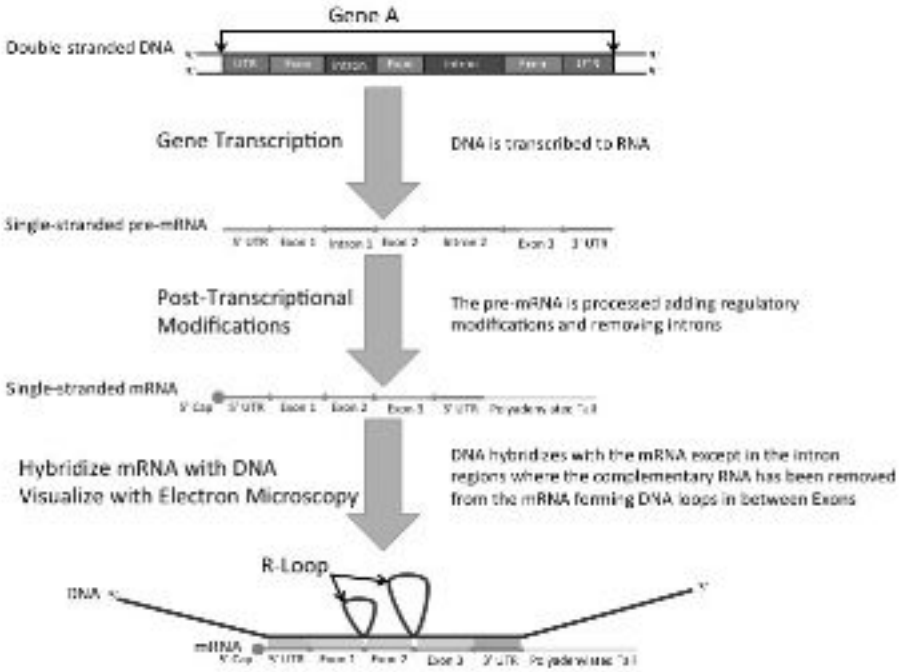
With the completion of the sequence of the entire human genome in 2003, biologists hoped that the mysteries of molecular genetics would be revealed; however these scientists found that things were far more complex than they had anticipated. One of the most surprising revelations was that the human genome contained only on the order of 30,000 genes and downward. It was difficult to reconcile the "one gene, one product" paradigm with the fact that the immune system alone is capable of producing over 1 million antibodies. Where were all those genes hiding?

One concept that helped clarify this conundrum was the discovery of introns and exons. Unlike the common misconception that every gene, consisting of a consecutive string of nitrogenous bases (A,C,T,G), codes for a protein, it was instead discovered that genes are split into segments called introns and exons. The exons are the segments of DNA that code for sequence of amino acids as commonly believed. Introns, on the other hand, are segments of DNA that don't lead to expression of proteins and rather, get spliced out before translation. This led scientists to ask a fundamental question - if introns get spliced out before being translated into a protein, what purpose do they serve?

In the 1960s and 1970s, many experiments demonstrated that the RNA in the cytoplasm is shorter than the RNA in the nucleus. However the nitrogenous bases on the ends of nuclear and cytoplasmic RNA are the same. To research this phenomenon, Dr. Philip Sharp conducted an experiment with isolated Ad2 DNA (DNA isolated from adenovirus) and Ad2 mRNA, the mRNA used for the protein hexon.

First, the DNA was gently heated to break the hydrogen bonds that held the two strands together. With the nitrogenous bases exposed, the now single stranded DNA could base pair with complementary RNA. The RNA would then hybridize to the complementary DNA, and where the DNA isn't complementary, it would form an R-loop of displaced, non-matching DNA (8). (See figure 1) He also discovered that the 5' end of the cytoplasmic AD2 mRNA had about 200 bases on the RNA that didn't attach to the DNA. One possible explanation for this is that the 5' end was less stable than the rest of the RNA-DNA hybrid. This was then tested by hybridizing complementary RNA to only a part of the single stranded DNA. Once again the 5' end of the RNA branched out,

which proved that the exon RNA was not an exact match to the Ad2 DNA. Sharp hypothesized that after the Ad2 gene is transcribed into RNA, specific regions that are inexpressive (introns) are removed and the expressive regions are spliced together to form a shorter mRNA (1).

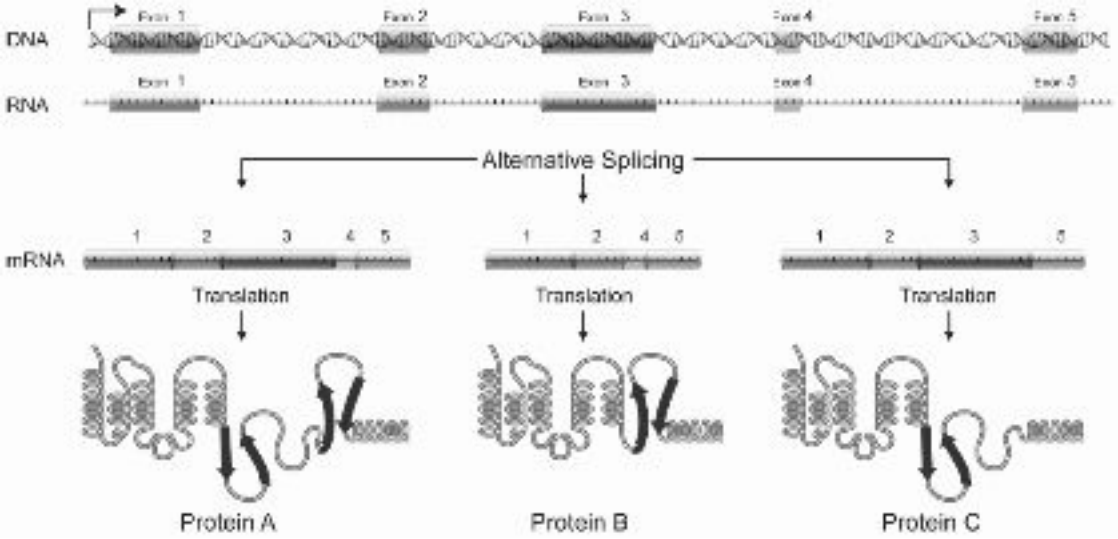



Before Sharp's experiment, the prevailing theory was that there are 20,000-30,000 genes in the human genome and each gene codes for a specific protein, meaning that each nucleotide of DNA would match to a specific nucleotide of RNA. It was unclear how the immune system alone had over 1 million antibodies. Sharp's experiments demonstrated that the DNA would form R-loops when hybridizing to the matching RNA strand. This could only be explained by the existence of introns, or non- expressive regions of genes, that are spliced out of the RNA before translation. Because the RNA contains only exons, when hybridized with the matching DNA (which includes introns and exons), exons on the DNA attach to exons on the RNA. However the introns on the DNA do not correspond with any component of the RNA. Therefore, the introns form a loop away from the RNA so that the exons surrounding the intron can attach to the now back to back exons on the RNA (8).

This phenomenon was discovered independently by both Drs. Phillip Sharp and Richard Roberts who shared the Nobel Prize in Physiology or Medicine in the year 1993(4,5). They also discovered that introns are surrounded by specific nucleotide sequences that are identified by the spliceosome, the molecular machine used for splicing, and then removed from the mRNA before leaving the nucleus to be translated into a protein (7).

The discovery of introns greatly deepened our understanding of the complexity of a process gene expression is, and was able to pave the path for newer discoveries to be made. The discovery of introns finally explained how proteins exist in multiplicity, despite there being few genes to code for them. The presence of introns allows for exon shuffling by moving exons to different regions in the gene. Exon shuffling is useful because it can lead to new proteins that have a higher chance of being beneficial;instead of relying on random mutations, genes can evolve using exons that have been proven to fold into stable proteins (1).

Additionally, through the extensive analysis of the introns and exons in the Ad2 gene, it was found that each individual RNA transcript can become multiple different proteins through alternative splicing. Alternative splicing involves splicing exons out together with the introns, which ultimately leads to the formation of multiple proteins out of one gene (See figure 2). This is important because this allows for a greater amount of proteins to be formed through the genes in the genome that exist in lesser quantity (1).




One clinical example where introns can lead to disease is Familial Dysautonomia. Familial Dysautonomia, also called Riley-Day syndrome, includes many symptoms, such as decreased sensitivity to pain, increased or decreased production of tears, decreased ability to feel pain and temperature, low muscle tone, acid reflux, developmental delays, scoliosis, and sleep apnea. The current average lifespan for patients living with FD is around 15 years, with most deaths caused by lung complications or autonomic dysfunction. Although supportive treatments are available, there is currently no cure for familial dysautonomia (2).

On the molecular level, FD is caused by intron splicing errors which decrease the production of IKAP, a protein necessary for aiding the expression of other genes needed for the development and function of the sensory nervous system and autonomic nervous system (the part of the brain responsible for unconscious bodily functions) (2) .The mutation that causes Familial Dysautonomia (FD) is a substitution of cytosine for thymine in the splice site of intron

20 in the IKBKAP gene, which codes for the IKAP protein. This mutation causes improper removal of intron 20, which results in the removal of intron 19, exon 20 and intron 20 simultaneously (9). Because exon 20 is removed from the IKAP transcript, a stop codon is created in exon 21 so that the protein that is created is lacking all the amino acids that would have been coded for in exons 21-37 (6).

In spring of 2000, Dr. Berish Rubin was asked by Rabbi Yoseph Eckstein of Dor Yeshorim to create a genetic test for Familial Dysautonomia, as FD is mostly seen in the Ashkenazi Jewish community. Three months later, with the help of Dr. Sylvia Anderson (the director of his lab), Dr. Rubin was able to find the mutation that caused FD and within weeks it was incorporated into the Dor Yeshorim testing program. Additionally, Dr. Rubin was able to help patients with FD by discovering that tocotrienols, a type of vitamin E, increases the production of the IKAP protein. These tocotrienols are a much better alternative to the prescription drugs previously used- which only targeted specific aspects of the autonomic nervous system, such as blood pressure (3).

The discovery of introns was a paradigm shift in the study of genetics and molecular biology. Because of this discovery, scientists now better understand the complexity of genetics and how a small amount of genes can express the millions of proteins found in our bodies. Additionally, the discovery of introns was able to help scientists like Dr. Berish Rubin understand and prevent genetic diseases like Familial Dysautonomia With continued research, scientists will be able to use the study of introns to help understand other genetic diseases and to work towards preventing them from occurring.

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# THE ROAD MORE TRAVELLED

Avigail P. Deutsch

They march in a steady line across Ann's counter, and she frantically checks the status of the delivery of ant repellant, yet again. Her mother-in-law is coming tomorrow morning, and her kitchen must be critter-free by then. Down the block, David starts worrying that his daughter's gift won't come in time.

Her birthday is tomorrow and he can't miss it again. David and Ann are not the only ones waiting. In a neighboring town, Jane regrets procrastinating her project so late; what if her supplies aren't delivered before the science fair tomorrow? Others are waiting with Ann, David, and Jane, too. Three miles away, Joe sets out with all the precious packages in his truck and with hundreds of addresses in four different towns. The pressure is on to deliver every package within the next 12 hours, and the question is how?

This scenario resembles the Traveling Salesman Problem (TSP), a common problem in computer science. The TSP seeks to find the most efficient route for a theoretical salesman to take to visit specific cities in the shortest amount of time, or on the smallest budget ("Travelling Salesman Problem"). Computer programmers aim to solve this problem with optimization algorithms which are problem-solving operations that find the best solution out of numerous solutions (Liu). In the case of Joe the delivery man, an optimization algorithm would help him find the best route to deliver his packages out of the many possibilities. Ironically, the best optimization algorithm for this issue was inspired by ants like those on Ann's counter.

In 1992, an Italian PhD student named Marco Dorigo realized he could model an algorithm after the way that ants discover their food ("Ant Colony Optimization Algorithms."). Ant colonies work together to find the shortest route to the food source through a system of positive feedback and probability. In the beginning, individual ants travel randomly to find food, laying a trail of scent hormones called pheromones to mark their paths (Li). Once enough pheromone trails have been laid, ants begin choosing paths based on probability. Paths with higher concentrations of pheromones are more likely to lead to the food efficiently, and therefore the probability of an ant choosing a particular path increases with the pheromone concentration (Dorigo). These hormones evaporate over time, so unused trails dissipate while popularly used trails become stronger, which causes more ants to choose that path. As more ants find the food source and follow the path back to the nest, the pheromone trails leading to the source become more intense. Over time, the longer paths to the food become less used and fade completely in order to save time and energy, while the remaining routes merge into the shortest one (Li). Figure one shows a simplified depiction

of an ant colony as it organizes itself to find the shortest route from the nest, N, to the food, F, over time. The pheromone trails become thicker as the routes consolidate.

This highly effective natural process is what inspired Marco Dorigo and other computer programmers to create the Ant Colony Optimization (ACO) Algorithm. The ACO Algorithm utilizes computer generated ants, called agents, that travel through a graphed simulation of the problem, such as the TSP. These ants lay artificial "pheromones", meaning that they leave bits of data as they travel, for the other ants to sense. Like the natural hormones, the artificial pheromones expire after a certain amount of time. It is important for the hormones to evaporate so that a less optimal path is not reached as the final solution. If the hormones wouldn't evaporate, then the path that the first ant travels on will have a significantly high probability for the following ants to choose it, which might cause it to become the most traveled, but not necessarily the fastest route. When the pheromones evaporate, all the paths start with fairly equal probabilities, so the best path becomes the most populated. Once the shortest route has been established, the program is terminated, or ended (Dorigo). A simple form of this algorithm is shown reaching termination in figure two. The pheromone trails fade as the longer paths are mostly abandoned.

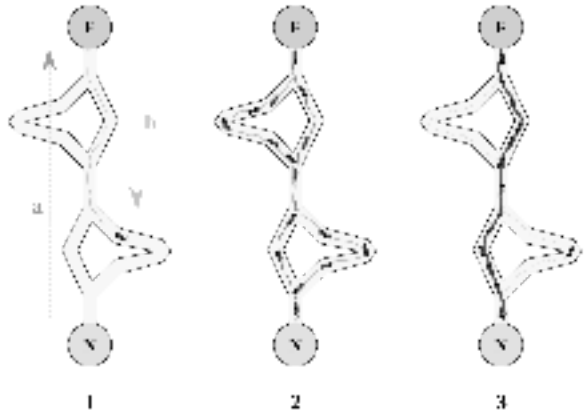
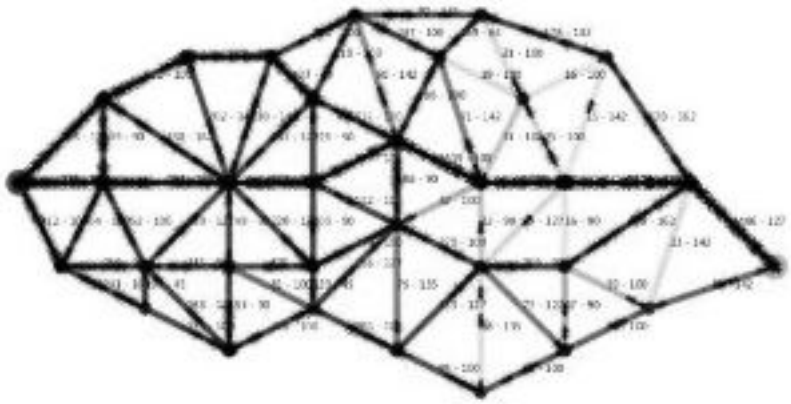



Figure 1: Ants Optimizing the Route to the Food Source



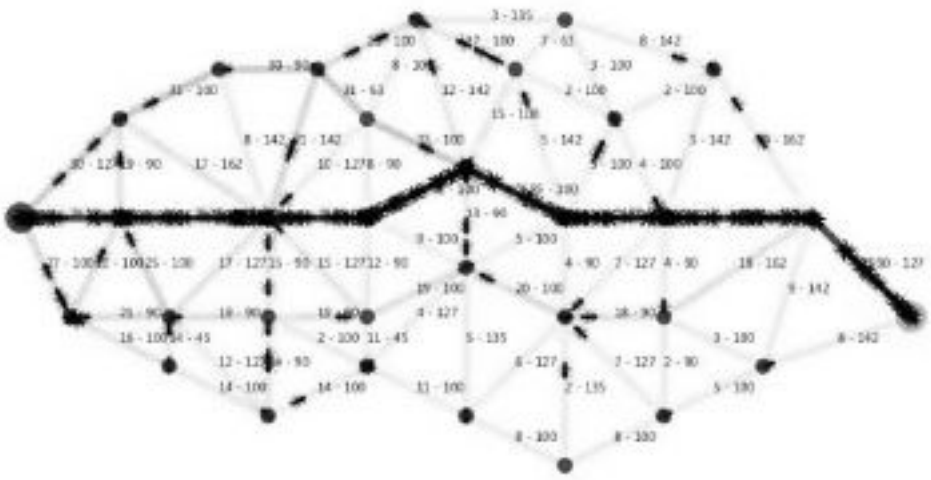


Figure 2: ACO Algorithm in Action

More sophisticated versions of the ACO algorithm mentioned above can be adapted for many commercial applications. This includes obvious applications similar to the TSP, like delivery and bus routes. So thanks to the ants, Ann, David, and Jane all received their packages on time, as did all their neighbors and friends. Joe even finished his route early enough to pick his kids up from school. But ACO Algorithms are applied more obscurely too. Scientists can use the algorithm to determine the best sequence of chemical synthesis. If there are 10 reactions necessary to create a desired chemical, there might be $8^{10}$ possible orders of reactions, so an ACO Algorithm can find the most effective process to synthesize the chemical. Additionally, ant-inspired algorithms can simplify job scheduling and space planning, and is even used to create a blending tool for digital art programs (Krishnaiyer). These algorithms are also used to plan water delivery and plumbing systems (Zecchin).

The concept of applying natural ant behaviors to complex human problems might seem original and modern. However, Shlomo HaMelech gave this advice almost three thousand years ago. In Mishlei 6:6, the wise king writes "Go to the ant, you lazy one; see her ways and become wise". This verse can be interpreted in many ways, and perhaps ACO algorithms is another way to apply it. Hashem created the world in His Infinite Wisdom and therefore every single one of his creations play an important role, and every word of His Torah is still relevant today. As Jews, we believe that nothing was created without a purpose, not a letter in the Torah, and not even the smallest insect, and that everything can be used to enhance our serving of Him. Everything in the world can teach a lesson; one just need to open his eyes to see. Maybe ants can teach society more than just computer algorithms. Maybe we can learn to work together to continue expanding our understanding of the world for the benefit of everyone in it.

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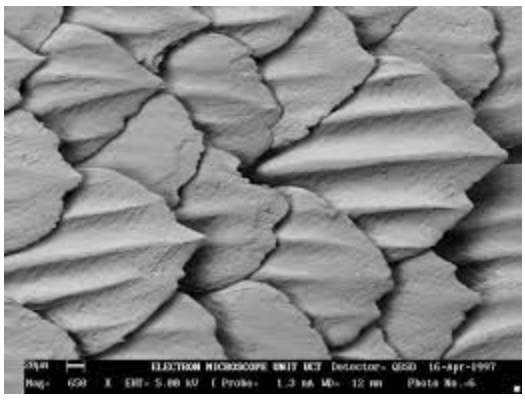
# SWIM LIKE A SHARK

Esther Guelfguat

In 2009, Speedo, a swimsuit company, faced a major cross road. Speedo needed to create a more technologically advanced swim gear since their previous product had been banned by the Olympics committee. The Olympics were fast approaching, and the company was desperate to upgrade their merchandise to most benefit their athletes.

A team of 19 individuals who specialized in hydrodynamics, kinesis, biomechanics and fluid dynamics, set out on this daunting task in the Aqualab. After four years, 55,000 hours, the group produced the "Fast skin 3 System" in which the body of the swimmer was compressed three times the capability of the previous gear. Upon wearing this new swim suit, the athlete was able to use less oxygen while being propelled much further. Subsequently, such gear was banned from the Olympics ever since (Morrison). Surprisingly, the material used to create this innovation was inspired by none other than the skin of sharks.

Shark skin has been an area of great interest to both scientists and engineers, such as those from Speedo. Embedded in a bendable epidermis are hard tooth-like structures called denticles. The sharks benefit from having this particular epidermal structure in numerous ways. The denticles allow for bends and changes in shape which propel the shark further (Wen). Due to the denticles found in the shark's skin, the drag that is common in swimming activities does not exist in its movement (Southall). Although sharks use their teeth to consume food, these denticles increase the type of food the shark can consume. This allows the shark to have an increased growing potential (Southall). Additionally, this particular skin type enables the shark to navigate the water smoothly (Lauder).

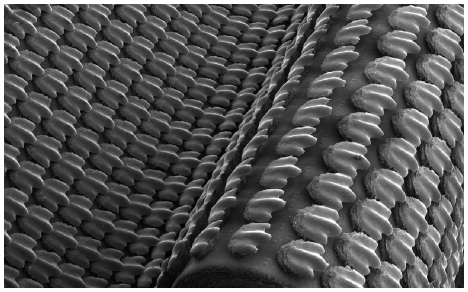


Shark Skin Denticles
Courtesy of http://ocean.si.edu/ocean-photos/biomimicry-shark-denticles
Smithsonian National Museum of Natural History

As is widely understood, sharks are sly hunters. Because they are on the top of the food chain, all the smaller fish are consumed by this species. The tooth-like denticles of the shark's skin enable it to swim with great speed without being audible to the prey (Smithsonian Ocean Team). This allows the shark to consume more food, thereby increasing in its size. Upon observation, scientists found that young dogfish, a type of shark, used their denticles for maneuvering the food source and for eventual consumption. However, adult sharks had denticles that did not extend as far as those of the younger sharks. This is perhaps due to the fact that larger sharks are no longer a prey to crabs and other animals that would otherwise

eat the young sharks (Southall). All of these inherent benefits of shark skin have created much interest it recreating this material.

Just like Speedo, other manufacturers, have been trying to mimic the structure of the shark's skin in order to provide the same benefits to their clients (Smithsonian Ocean Team). Because of the complex organization of shark skin, it was difficult to recreate a material that was both hard and soft. However, George Lauder, an ichthyologist at Harvard University, and his team successfully synthesized the first artificial shark skin from a 3D printer. The process entailed using a micro-CT scanner to scan a piece of shark skin. They then made a 3D model that went through the 3D printer. After completion, the result was a "plastic polymer material with soft base covered in hard denticle-like structures." George Lauder explained that it is best if the artificial skin is rough and has a "sandpaper" feel because that is what will cause an increase in speed. Through 3D printing and controlling water flow, scientists were able to create the best type of artificial skin. By changing the spacing between the denticles or overlapping them, scientists were able to test which form of organization will produce the best results (Thompson).



Biomimetic Shark Skin
Courtesy of http://jeb.biologists.org/content/217/10/1656
Journal of Experimental Biology

In the lab, this team found intriguing results. Upon testing, they discovered that the synthetic skin reduced energy input by 5.9% and increased speed by 6.6% (Thompson). In a similar project, the man-made skin had a maximum decrease in drag of 8.7% at slower water flow but increased drag at higher speeds (Wen). The relatively low improvement can be attributed to a finding of a different experiment in which it was clear that biomimetic skins are only productive under certain movement patterns (Lauder). Although this component of the artificial shark skins is still under investigation, much improvement has been found in other areas. In one experiment, swimmers who wore the synthetic skins experienced an increased kinetics to 6.6% and required less energy investment (Wen). Similarly, in a different experiment the artificial skins were able to move at a speed within the range of an average shark (Lauder 8). Although there has been significant improvements in the synthetic skins, continued research is being conducted to create a more direct copy of shark skin in order for all of its characteristics to be incorporated in the artificial ones.

Man-made shark skin has been used in other areas besides for swim gear. Often times the bottom of ships are lined with algae and barnacles. Previously, these materials have been removed with the help of toxic agents which have a negative impact on the environment. However, by lining the ship with shark skin, these settlements will not stick to the ship and their removal will not have any harmful side effects. In 2005, German researchers made a mimic of sharkskin to suit this purpose and found that it reduced the accumulation of algae by 67%. A similar material, named Sharklet, was made by Anthony Brennan in 2008. Sharklet reduces algae settlements by 85% and has been applied in hospital settings. Bacteria is often transmitted quickly and easily from person to person, so by covering public surfaces with Sharklet, the amount of circulating bacteria will decrease. Scientists hope to incorporate denticle structures on the

wings of airplanes in order to reduce drag thereby using energy efficiently. Additionally, they hope to use mimic shark skin as a coating for underwater robots to increase their speed and reduce the necessary energy input (Thompson).

It is comforting to know that solutions to modern day problems are already in existence in the natural world. It is up to us to open our eyes to the *chachma* and design with which the *Borei* created the world. Every living thing has a purpose; *Dovid HaMelech* was shown that lesson. It is up to us to preserve the biodiversity inherent in the natural world and not abuse the precious gifts that Hashem has given us.

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# BRILLIANT BIRD BRAINS

Leora Lehrfield

As a four-year-old, I laughed at *The Fox and the Hound*'s comical woodpecker Boomer as he struggles to catch an elusive tree-dwelling worm, but I never wondered how he endures millions of sharp blows against a tree every day. I never wondered how researchers could use the unique structure of the woodpecker's head as a template for protection gear for human usage.

However, numerous zoologists have studied the anatomy of the woodpecker's skull to understand how the bird avoids brain damage while rapping a tree. Their studies have inspired improved protection for people and objects subject to high levels of shock every day.

Researchers were specifically interested in woodpeckers because of the way their brains remain intact despite the exceedingly high levels of shock, measured in G-force (g), they endure. A woodpecker drums a tree about 500-600 times a day, 20 times per second, and bears a shock of about 1200 g (1200 times the force of gravity) with each peck (6, 8). Several studies have been conducted to identify and analyze the anatomical structures of the woodpecker that enables it to peck fiercely and continuously without suffering brain damage (Figure 1).

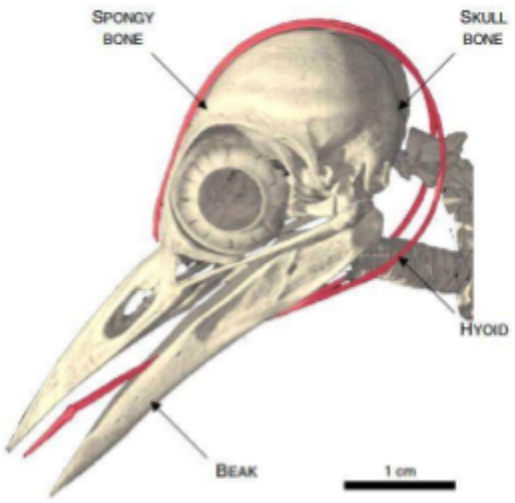


*Figure 1: A woodpecker's head*

To examine the specialized structure of the bird's head, natural scientists Oda, Sakamoto, and Sakano dissected a woodpecker and a grey bunting, a non-pecking bird, to compare their mechanical differences (6). The results showed that the woodpecker's hyoid, the bone that supports the tongue, passed through the neck and wrapped around the skull, whereas the grey bunting's hyoid did not even reach the end of the neck (Figure 2) (6). Aside from acting as a seatbelt for the brain, the hyoid bone gently presses against the woodpecker's jugular veins, reducing blood blow out of the brain and

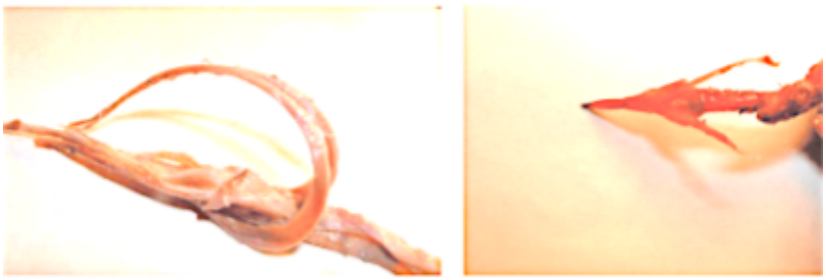

*Figure 2: the hyoid bone of a woodpecker (L) and a grey bunting (R)*

creating a backflow of blood to the brain (Figure 3). With more blood filling the space between the skull and the brain, the brain has less room to move and a smaller chance of banging against the skull.

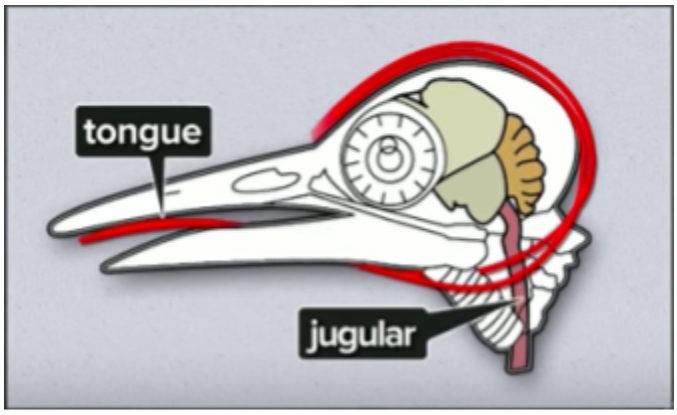

*Figure 3: the hyoid bone, which supports the tongue, compresses the jugular veins*

Once the role of the woodpecker's hyoid bone in escaping brain injury was discovered, neurologists and sports directors scrambled to create a similar structure to help athletes avoid brain injury. In 2016, 91 percent of college football players were diagnosed with the degenerative brain disease CTE, or chronic traumatic encephalopathy (1). When football players collide with each other with a force of 200 g, their helmets do not protect their brains from jolting within the skull and banging against it, referred to as "sloshing." A human brain can tolerate up to 100 g before suffering a concussion, an injury to the brain often caused by a blow to the head.

*Figure 4: Concussion-preventing collars*

Aiming to reduce the number and severity of brain injuries, neurologist Dr. Julian Bailes and director of sports medicine for Cincinnati Children's Hospital Dr. Gregory D. Myer each devised collars that functions in humans like the hyoid bone does in woodpeckers. Dr. Bailes worked with the Canadian hockey equipment company Bauer to design the NeuroShield, and Dr. Myer with the US company Q30 Innovations to design the Q-Collar (Figure 4) (5,7). These collars gently press against the jugular veins, reducing blood flow from the brain thereby increasing the amount of blood in the cranium. The ample blood volume cushions the brain against the skull, reducing the frequency and impact of sloshing. When Dr. Bailes tested the NeuroShield and Dr. Myer tested the Q-Collar, athletes who did not wear a collar experienced significantly more changes in the brain than those who wore one of the collars (Figure 5) (2).

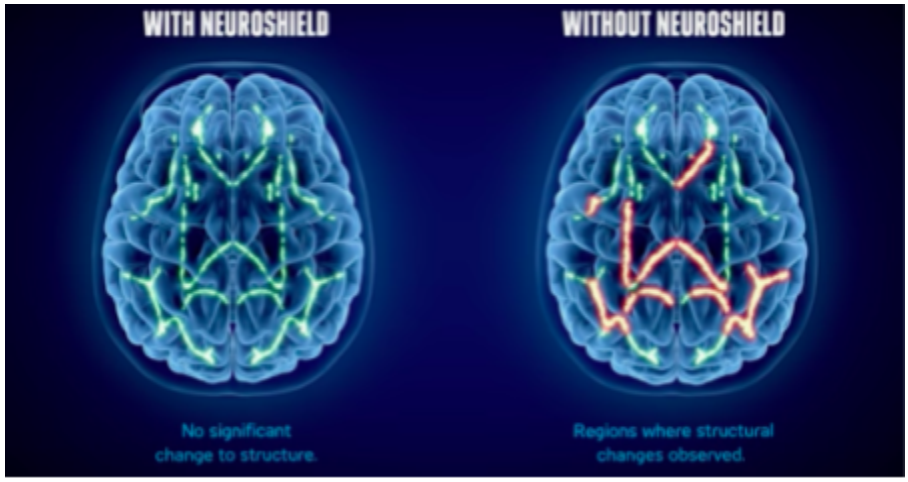

*Figure 5: Changes in the brains of athletes with and without the Neuroshield (green indicates no change after hockey game, red indicates change)*

Another structural characteristic in woodpeckers that researchers found to be critical in prevention of brain damage was the spongy bone in the beak and at the front of the skull. Spongy bone, or cancellous bone, is a web of tiny columns of bone tissue called trabeculae. The layers of trabeculae forming the cancellous bone absorbs shock waves in the woodpecker's beak and skull, reducing the impact that reaches the brain (3). The purpose of helmets is to act like spongy bone and absorb most of the shock before it reaches the brain. Unfortunately, most helmets fail to absorb enough shock to prevent concussions. Anirudha Surabhi, an industrial design student, used the woodpecker's spongy bone as a model for a bike helmet. After experimenting with 150 materials, he found that cardboard was most absorbent. The cardboard in Surabhi's Kranium bike helmet protects the head against shock like the porous bone does in a woodpecker's skull (Figure 6) (3).

*Figure 6: Surabhi's Kranium cardboard bike helmet*

Technology companies are also inspired by the protective structure of woodpeckers' heads. Researchers of Berkeley, University of California, Sang-Hee Yoon and Sungmin Park, used the woodpecker's shock-absorbers as models for a shock-absorbing system in microelectronics (9). To imitate the spongy bone of the woodpecker's beak, Yoon and Park built a metal cylinder tightly packed with tiny glass beads. A layer of rubber in the cylinder acts like the bird's hyoid bone, a layer of aluminum as its skull. Yoon and Park placed the metal cylinders into a bullet and shot it at an aluminum wall using an airgun. The shock-absorbing systems they built withstood 60,000 g (9). When these metal cylinders were inserted into micromachined electronics, the electronics were protected from 60,000 g of mechanical shock. Various companies are now researching this woodpecker-inspired system to protect their machinery against shock. The shock-absorbing system could be used to protect black boxes from the shock of plane crashes, cars from the shock of car crashes, and spacecraft from the shock of collisions with micrometeorites and space debris (4). Protection in planes, cars, and spacecraft ultimately leads to protection for humans.

As our understanding of nature progresses, researchers explore ways they can use their findings to make our world a safer place. As Jews, it is especially important to guard our bodies from harm as we are commanded in the מצוה of "וְנִשְׁמַרְתֶּם מְאד לְנַפְשֹׁתֵיכֶם" (Deuternomny 4:15). Hashem created protective structures for plants and animals and allows scientists to use His ingenious designs so that we can fulfill the מצוה of "וְנִשְׁמַרְתֶּם מְאֹד לְנַפְשֹׁתֵיכֶם." One of the ways scientists have adapted the perfect characteristics of nature for human use is by mimicking the hyoid bone and spongy bone of woodpeckers' heads for our own protection. Although Boomer the woodpecker never caught the worm, he did catch the attention of several scientists who used his head-banging to solve their head-scratcher.

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# HEALTH BENEFITS OF NATURE

Lele Book

With the ever increasing release of new technologies, children have been spending a lot more time with their heads facing down towards glowing screens. There is a new disorder, not yet recognized by psychologists, called Nature Deficit Disorder, when children lack the benefits of nature.

Richard Louv is the author of *Last Child in the Woods: Saving our Children From Nature- Deficit Disorder,* which discusses the benefits of the great outdoors for children. He says that it can help stop depression and just ensure a much healthier lifestyle. In his book, there is an interview with a child who says that children like to spend more time indoors than outdoors because that's where all the screens and technology is. The great outdoors has a lot of benefits for the healthy development of a child. There is not one way to "use" the outdoors and this allows for a child's imagination to run wild and force them to be creative. As children play outdoors, they assume responsibility for their surroundings, being careful not to step on living creatures or ruin their habitats. This responsibility and caution can be transferred into the indoors and their life of interacting with others and their belongings (Danielle Cohen). Studies have shown that exposure to the outdoors makes people less tense and relieves stress that sometimes builds up indoors. When people are crammed together inside, it is normal and natural for there to be tension and aggression. Scientists call this 'chronic mental fatigue.' The natural world can be a cure and can release aggression, causing people to be calmer and nicer (Frances E. Kuo and William C. Sullivan, Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Environment and Behavior. Vol. 33 No. 3, May 2001. 343-367).

The reason that the topic about nature stuck out to me is because I live in the suburbs, surrounded by nature, and am constantly exposed to it. I was interested in delving deeper into why I am lucky to live in the suburbs and what children in NYC are lacking and should take advantage of when they can.

A nationwide poll from The Nature Conservancy says that only about 10 percent of children are spending time outdoors each day. This poll was done over the summer of 2011 and 602 kids between the ages of 13-18 were asked why they do not spend more time in nature. 80% said that the outdoors is buggy and too hot, 62% claimed they had no mode of transportation to get get near nature and 61% said they do not live anywhere near a place of nature. However, another 66% said that they enjoy nature because they personally had a good experience with nature. This shows that kids need to develop an appreciation for nature and then they will spend more time enjoying the benefits. The problem seems to be that there are way too many distractions indoors, that it doesn't even enter their minds to go

outdoors and they don't care to. It is interesting to note, that these children who do not spend time in nature for whatever reason, are more obese and do not get enough exercise. Many kids said that they do not even get enough time with nature in school, so the Nature Conservancy began to develop programs in schools to expose children to the beauty of nature. The LEAF program, was implemented into high schools to have the teens get involved in conservation projects and get them interested in environmental issues. Children happen to be interested in the planet and the world around them and would love to help "save the planet." These programs which exist around the world are a great opportunity to expose school kids to the environment, get them to appreciate it and make a difference (The Nature Conservancy).

Nature has been a key to human survival since the beginning of man, proving that one cannot live without it. One can be exposed to nature by looking at a picture hanging in an office of a beautiful landscape, by being in a room with a vase of roses, or, actually being surrounded by nature on a hike in the wilderness. A study researched the three types of interactions of humans and nature. Type one being indirect, type two being incidental, and type three being intentional. All types of interactions have positive health benefits for humans. The research in this study concludes with six benefits, including psychological well-being, positive effects on mental processes, increased self-esteem and reduced anxiety. The majority of the research focused on physiological benefits rather than physical benefits. Specifically for children, a study was done where schools did outdoor activities in order to analyze the social and mental health of a child exposed to nature. Through these activities, both parents and teachers were able to see an increase in the psychological well being in the students. The second benefit is positively improved cognitive abilities. Cognitive benefits are also very important for children. The severity of ADD in children was seen to significantly decrease when they were exposed to nature. Another study also seems to say that children that moved into new homes surrounded by more land and nature had an improvement in cognitive functioning. It may not be the only reason, however, it is one of them.

The third benefit is the most obvious, nature has a positive benefit on the physical well-being and functioning of a person causing reduced headaches, reduced blood pressure, and faster healing etc. Exposure to nature also has social benefits for a person. It can have a positive social effect on an individual or a whole community with reduced crime rates, reduced violence and a stronger support system. A study was done when teachers and principals were interviewed and asked what they think the social benefits of nature are for children. They answered with characteristics such as empowerment and better social engagement. The fifth benefit that comes from interaction with nature is the increased inspiration for individuals that are religious. The beauty of nature strengthens their belief in the force behind it all. The last benefit that was found by this study is the tangible benefit from nature. Nature provides a source of food which in turn benefits the economy. The study seems to say that adults who are exposed to nature as a child end up appreciating it more as they grow up. There are many US adults who live in urban areas but are involved

in different environmental programs due to the fact that they grew up exposed to nature and have a strong appreciation towards it (Lucy E. Keniger, Kevin J. Gaston, Katherine N. Irvine and Richard A. Fuller).

All in all, it seems that there are many types of benefits for both adults and children when exposed to nature. Those who reside in NYC are lucky to have Central Park as a free opportunity to enjoy nature and its benefits. It is up to parents and teachers to expose children to the wonderful beauty of what lies in front of them and get them outside.

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# WHAT'S ON YOUR PLATE?

Nechoma Flohr

The average American consumes about 200 lbs of meat annually (Business Insider). This seemingly harmless statistic, is in reality the source and reason for many issues facing the global community today. The images of happy, harmless farms that companies market as their source of meat, are not only inaccurate but deceptive.

A more realistic depiction would not be blissful cows grazing in seas of endless pasture, rather it would be animals crowded like sardines in a feedlot, knee deep in manure and mud. Aside for the many health and ethical issues surrounding the meat industry, animal agriculture is directly and indirectly one of the main causes of major environmental issues such as land degradation, ocean dead zones and climate change; it is also a major source resource depletion because of its extensive land, water and fossil fuel usage.

Most beef consumed in the US originally comes from cattle grazed in the Midwest and Southwestern United States. Rangeland degradation, is one of the chief problems associated with the overgrazing of cattle. The Bureau of Land Management (BLM) alone manages 155 million acres of rangeland used to graze animals, and although government agencies such as this one try to control grazing and prevent overgrazing by limiting the number of permits they distribute (etc), it is difficult to enforce policies when those who may potentially violate them are thousands of miles away (Bureau of Land Management). The results of rangeland degradation have been extremely detrimental and even devastating. Overgrazing can lead to the partial or complete degradation of land and soil. This leaves lands more susceptible to erosion and eventually may leave them arable and desertlike, this is called desertification. However, land degradation does not only result from overgrazing, but it also occurs when grazing animals trample and paw through vegetation and soil, destroying vegetation and breaking up topsoil (USFWS). In especially severe cases livestock can completely destroy soil crusts, which then interferes with the nitrogen cycle and water infiltration (USFWS). The shocking difference between overgrazed and non grazed land can be seen in fig. 1. Additionally, livestock disturbance has been linked to lessened stream condition in Western United States. Some of

these areas are home to endangered salmonid species, and have witnessed a decline in their numbers due to livestock disturbance (Goss, Roper).

From rangelands cattle are moved to a feedlot, where they "primed" to become beef. Feedlots, also know as Concentrated Animal Feeding Operations (CAFOs) (Fig 2), are perhaps the most environmentally detrimental part of beef production, as this part of the process is inadvertently a main cause of climate change and ocean dead zones. Globally, enough cereal crops are planted to end world hunger, but unfortunately food insecurity is still a significant problem. So where is it that all this grain goes to? The answer is that most of it is used to feed animals used for human consumption. In the US alone 409 million acres of land are used to plant crops, mostly corn used to feed cattle and other farm animals; the results of this are massive fossil fuel inputs, and extensive pesticide and fertilizer usage (USDA). Cattle require 7 kg of grain to produce 1 kg of beef, therefore farmers are at a disadvantage if they do not produce as much crop yield as they possibly can, and thus use stunning amounts of fertilizer and pesticides to grow their crops (Horrigan, Lawrence, Walker).

Annually US farmers use about 20 million tons of fertilizer and an additional close to one million tons of pesticides to grow crops, it is further estimated that less than one percent of pesticides reach their targets and that the rest becomes runoff (Horrigan, Lawrence, Walker). Agricultural runoff has become the cause for major ocean dead zones, such as the dead zone in the Gulf of Mexico. Dead zones are created when nutrient rich fertilizers enter waterways and create nutrient rich conditions perfect for algae growth. Algae blooms then occur, and leave waters hypoxic because the algae use up too much of the oxygen in the body of water. Following algae blooms and hypoxic conditions, are fishkills, in which large numbers of fish (along with water vegetation) die off at a rapid rate. This creates further damage when fishermen are left without a source of income on account of fishkills. Furthermore, the EPA estimates that agricultural practices are responsible for 70% of polluted US waterways (Horrigan, Lawrence, Walker).

Along with the issues indirectly linked to feedlots mentioned in the above paragraph, there are many problems that are more closely related to them as well. The average US farm uses approximately 3 kcal of fossil fuels to produce 1 kcal of food energy (Horrigan, Lawrence, Walker). Additionally, the average cow produces 70-120 kg of methane annually, and livestock production alone accounts for 35% of total methane emissions; this is especially concerning considering the fact that methane has 25-100 times the heat retaining power of CO2 (Horrigan, Lawrence, Walker). Meat

production is an extremely fossil fuel intensive industry and because of its greenhouse gas emissions is one of the main drivers of climate change.

Greenhouse gases have tremendous heat retaining capacities, and when they are released in excess into the atmosphere create a greenhouse effect in which they trap heat in the atmosphere causing global temperatures to rise. In every step of the meat production process from planting grain, to shipping meat to grocery stores, an enormous amount of fossil fuel inputs are involved. Nearly one million metric tons of carbon dioxide are emitted annually in the process of shipping food to consumers and grain to cattle (Horrigan, Lawrence, Walker). This number does not include emissions from farm machinery, and only applies to the US, it is also a number that continues to grow with no sign of diminishing. Moreover, animal agriculture is responsible for 13% of all greenhouse gas emission. Though this number may not seem like a very high percentage, it is higher than that of all combined transportation emissions (FOA).

In addition to fossil fuel emissions, agriculture accounts for two-thirds of water use worldwide (Horrigan, Lawrence, Walker). In the US agriculture accounts for 80-90% of water consumption (USDA). This percentage is more astonishing still, considering that a large percentage, if not most of agriculture is responsible for growing feed crops for livestock. Furthermore, in the US 34-76 trillion gallons of water are consumed annually by the animal agriculture sector (United States Geological Service, BioScience).

As the global population continues to grow, and as countries become more developed, meat consumption is becoming increasingly less sustainable, and more potentially harmful. Already the negative results of meat production are causing significant harm to the planet, and it is predictable that its harm will only continue to grow in size and influence. But it is not impossible to stop or mitigate these effects, indeed it can be relatively simple to do so. Currently land planted in cereal grains produces 2–10 times as much protein for human consumption as land devoted to beef production (Horrigan, Lawrence, Walker), and the most obvious although difficult, and perhaps unlikely decision for people to make, would be to stop eating meat and other animal products. But even lessening meat consumption can have a critical impact on the environment. Other more sustainable options are to eat beef from pasture raised cattle, rather than from those raised in feedlots; or to buy locally sourced beef to reduce greenhouse emissions and fossil fuel inputs. The planet is very much at a crossroads now, and it is worthwhile for people to consider if their steak is worth the harm that is served along with it.

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(Image)

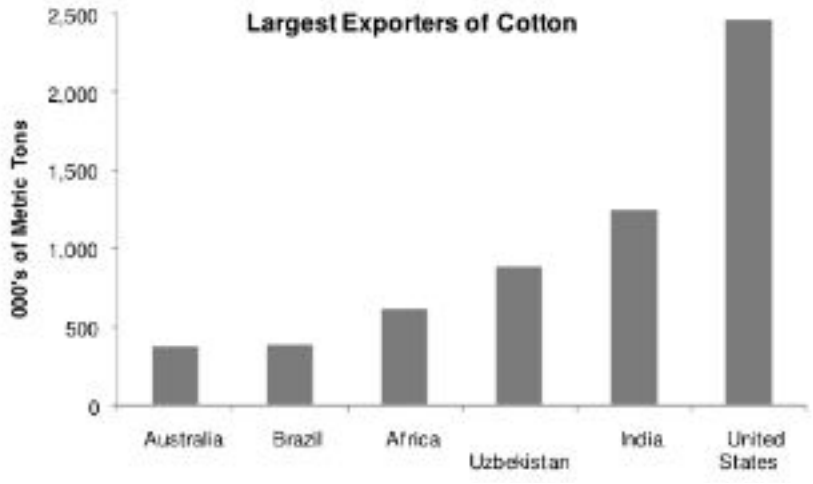
# SUSTAINABLE STYLING

Dina Kalman

Are your endless purchases of clothes damaging our earth? Although we usually don't link nitrogen and carbon dioxide pollution with the cotton t-shirts that are hanging in our closets, our clothes do play a significant role in the environmental damage that is caused by conventional cotton agriculture.

We live in a consumerist society where the average household spends about 2,000 dollars per year on apparel (5). Much of the clothes we buy are made from cotton. A large amount of the cotton exported is produced through conventional cotton agriculture. Conventional agriculture damages our environment through the use of pesticides and fertilizers that damage our environment. An alternative to conventional cotton agriculture is organic cotton agriculture.

*Figure 1*

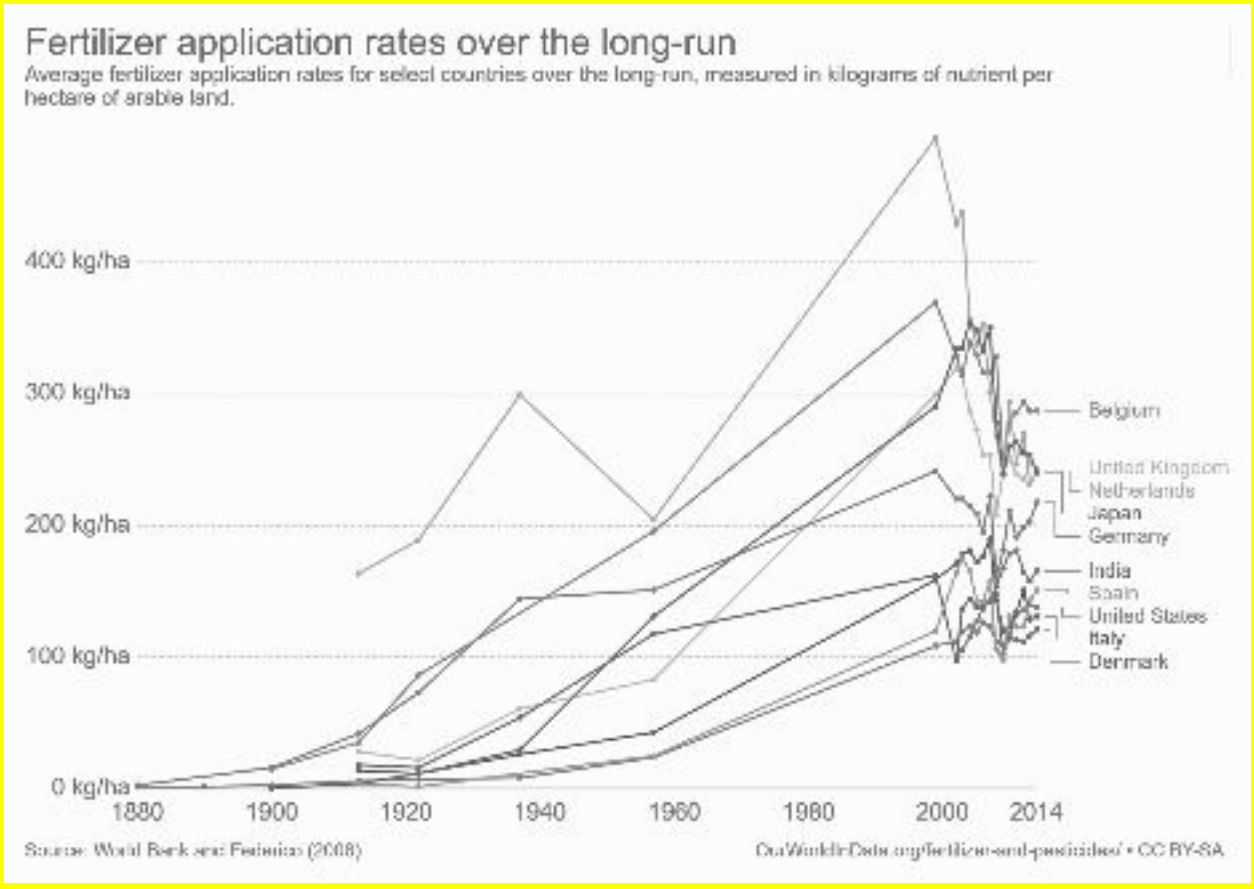



Pesticides, a major component of conventional cotton agriculture, threatens the health of animals. Nearly one-third of a pound of chemical pesticides and fertilizers are used by farmers in the United States for every pound of cotton harvested. Additionally, 25% of the pesticides in the United States are used for growing cotton. The U.S. Environmental Protection Agency classified many of the chemicals used in pesticides as some of the most toxic chemicals. Although only 2.4% of the world's arable, or fertile, land is used for cotton, it accounts for 24% of the world's insecticide consumption and 11% of the global pesticides market, making it the most pesticide-intensive crop grown on Earth (3).

The movement of pesticide chemicals through the ecosystem and trophic levels harm wildlife. These chemicals often contaminate groundwater and surface water, polluting drinking water for animals. As the chemicals move up the trophic levels, the concentration of consumed toxins increases, resulting in bioaccumulation. Furthermore, in 1995 runoff contaminated with pesticide chemicals from cotton fields caused nearly 240,000 fish to die when it brought the

harmful chemicals into the bodies of water they lived in (3). Minimizing the use of pesticides would decrease environmental damage caused by the chemicals in the pesticides.

Fertilizers are a major component of conventional agriculture. Figure 2 below depicts kilograms of fertilizer used per hectare of arable land throughout the world. Some of the most used fertilizers in conventional cotton agriculture are nitrogen fertilizers. Nitrogen-based fertilizers, whose use is predicted to almost triple by 2050, are the primary source of nitrogen pollution (6). Nitrogen is a greenhouse gas that pollutes the environment, affecting all organisms.




The release of nitrogen through fertilizers can be measured through a nitrogen balance, calculated by nitrogen intake minus the nitrogen removed with the crops. A positive nitrogen balance occurs when an ample amount of nitrogen is released into the environment during cotton growth (2). With the global increase of nitrogen-based fertilizer usage, the nitrogen balance and nitrogen pollution are growing.

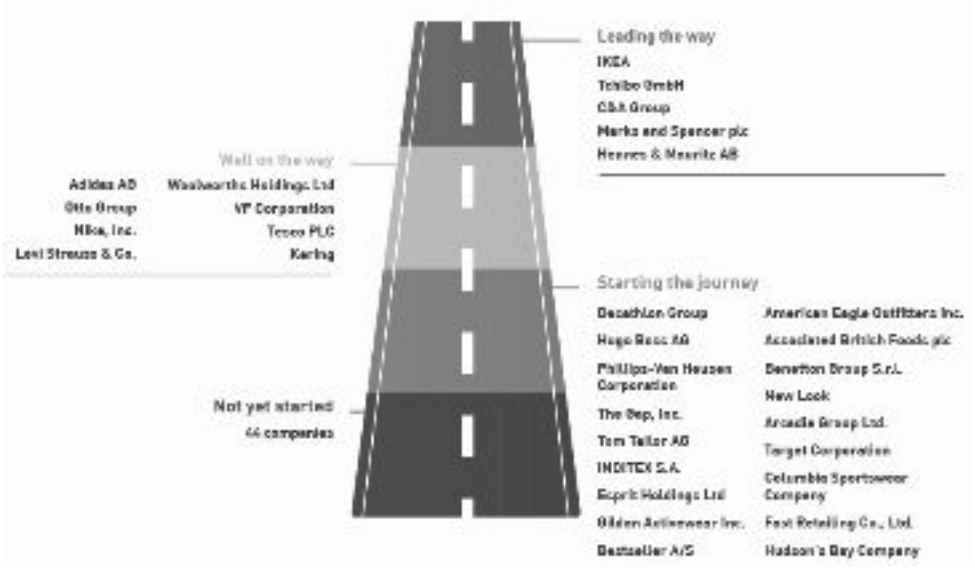
The efficient management of nitrogen through organic agriculture reduces the amount of nitrogen released into the environment. Conventional agriculture increases the concentration of nitrogen the atmosphere and water. In conventional agriculture, denitrification in the soil reduces nitrates and nitrites to $N_2$, increasing the concentration of atmospheric nitrogen, while leaching increases the concentration of nitrogen into water by draining nitrogen from the soil into bodies of water. In 2006, environmentalist Kramer conducted a 9-year trial to study leaching and

denitrification from conventional and organic agricultural systems receiving the same amount of nitrogen. He found that in conventional plots, the annual nitrate leaching was 4.4–5.6 times higher than in organic plots (2). Microbial denitrification (loss of nitrogen) intensified with the inputs of nitrogen in conventional fertilizers. This study reveals that conventional fertilization provides more denitrifier bacteria, increasing the environmental damage (2).

Organic cotton agriculture uses cropping techniques, biological control, and natural pesticides rather than chemically dependent pesticides to rid weeds and pests. One method of reducing atmospheric nitrogen is by intercropping among cotton fields. For example, farmers can plant cover crops that absorb and fixate atmospheric nitrogen ($N_2$) into ammonia ($N_3$), reducing the amount of $N_2$ in the environment (2). Organic farmers in India intercrop cotton with pigeon peas and make insecticidal sprays from chili, garlic and neem tree to eliminate insects (3). Organic agriculture also uses the method of crop rotation, polyculture and intercropping to increase soil fertility and reduce the amount of weeds (2). Through crop rotation, pests that are only able to consume the first crop die out when the new crop is planted. Intercropping decreases the amount of a singular plant and increases biological diversity of crop plants and prevents the pests of one plant from multiplying.Through these methods, organic farmers maintain ecological balance while eliminating undesired weeds and pests.

Organic agriculture decreases carbon dioxide (a greenhouse gas pollutant) emission into the environment. As a result of the increase in the amount of organic matter in the soil under organic agricultural management, the organic soil has a higher ability to store carbon.

Organic farming is founded on the principle of working with rather than against nature. Organic farming decreases the amount of Nitrogen and Carbon Dioxide released into the environment. Today, more than 18 countries worldwide grow organic cotton (3). In 1998, approximately 10,000 acres of organic cotton were grown in California and Texas (3). Through implementing organic cotton agriculture we can minimize the amount of damage that is caused by conventional cotton agriculture.




Programs such as the Better Cotton Initiative (BCI) provide information and advice about sourcing more sustainable cotton. After analyzing the market performance of 75 of the largest cotton consuming companies, Environmental agencies such as WWF, Solidaridad and PAN UK wrote

a report to help companies transform the cotton market to sustainability. International retailers such as C&A, M&S, H&M and Ikea have made an effort to sustainably grown cotton by integrating organic agricultural methods to their cotton growth. Refer to Figure 3 above for a list of companies that sustainably grow cotton.

Not only should we consider buying clothes from companies that limit their ecological footprint by using organic agricultural methods to grow cotton, but, we should make an effort to reduce the amount of cheap, low quality, "disposable clothing" we tend to buy whose prices do not include the cost of the environmental damage that comes from it's manufacturing. The production of all clothing causes some level of environmental damage through greenhouse gas emission etc. By being aware of the environmentally friendly practices that we can implement into our daily lives we hope to sustain the animals and resources in our environment in order for our children to enjoy and benefit from them the way that we do.

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# BARKING UP THE WRONG TREE

Chana Gelbtuch

In Buena Park California, on May 22, 2005 at 12:30 am, a Hispanic man approached two other Hispanic men, pulled out a gun and demanded their wallets and the key to one victim's Volkswagen Jetta (2). At the same time, a man named James Ochoa was sitting with his family, flipping through the channels of his television (3).

Little did this he know that this incident, which seemed completely unrelated to his life, would cost him a year behind bars. At 6:00 am, the next morning, James Ochoa was arrested on his front lawn in pajamas (2). As the police fastened handcuffs around his wrists, Ochoa asked, "So you're gonna put me in jail because of a dog?" (3). To much of his and others' astonishment, the answer was yes.

The science originally used to convict James Ochoa was scent tracking dogs, typically employed by the police force. Scents that bloodhounds trace are typically collected in one of four ways. The most traditional method is having the dog smell the sample directly, risking destruction of the evidence. Another method is transferring the scent to a pad, by wiping a sterile pad on the surface of the sample and giving it to the dog to smell. This also poses risks for the destruction of DNA evidence or fingerprints. The third method is called absorption, placing a sterile pad on the surface of the scent sample for an unspecified period of time and using that pad as the dog's scent sample. This method also has the potential to contaminate evidence. The most recent method, which is used by the FBI and police agencies, is called scent transfer unit or STU-100. The STU-100 is a forensic vacuum, which using its airflow system, transfers the scent to a sterile pad without contacting the sample, thus circumventing problems of evidence destruction (1).

Once the sample is collected, the dogs smell the sample, with the scent then traveling through the dog's nasal cavity and reaching its olfactory sensors. Signals are then sent to the brain's olfactory bulb, where smells are analyzed, and an "odor image" is formed. Odor images are extremely precise and are considered to be even more intricate than a photograph. The dog uses this odor image to track the scent trail (5). Dogs are able to track scents in three stages. First, when looking for a track, they go faster, sniffing within short intervals. Next, once they have discovered a track, they go slower, trying to sense a direction. They discover the track and its direction by following the track that contains increasing concentrations of the scent (4). They have a higher ability to do this than humans because they have forty times more olfactory sensors or scent receptors than humans do (5). Once they know the track and direction, they go even faster, again sniffing within short intervals (4).

In a study trying to detect the reliability of these bloodhounds, a group of experienced handlers had a ninety-six percent success rate with no false identifications and a group of beginner handlers had a fifty- three percent success rate with one false identification, showing that the experience of the handler is key to the technique's accuracy (1).

This science was applied in Ochoa's case. The bloodhound in this case, named "Trace", led the police to Ochoa's house, following the scent of the baseball cap of the perpetrator, which was collected as evidence by the police. As a result of this, Detective Frank Nunes arrested Ochoa, claiming, "These dogs are 100 percent accurate . . . and the dog mapped a perfect track to your house without us saying a word" (3).

However, there were many issues in assuming Ochoa's guilt based solely on the science of scent tracking dogs. Firstly, the very same officers that had swarmed the crime scene previously, were the officers that surrounded Ochoa's house, their scent possibly leading Trace to Ochoa's front doorstep. Also, it was later discovered that Trace had passed Ochoa's house twice before identifying it. According to police logs, it took over an hour for Trace to reach Ochoa's house, when it was only a 50 yard run, meaning that Trace had to have passed the house at least twice within that time frame and distance (3).

Although this science is often used in the police force and FBI, not much research has gone into calculating an error rate. The notion of Ochoa's guilt had holes that would be inexplicable if one would consider the scent tracking dog science to be infallible. The DNA on all of the pieces of evidence collected from the car that was recovered, like the empty wallets, steering wheel cover, and clothing and BB gun of the perpetrator, exhibited an unknown male profile and did not match James Ochoa's DNA. Additionally, after searching Ochoa's house, the police found nothing linking him to the crime (3).

Despite all of this, if found guilty by a jury, Ochoa was threatened with a 25 year, to life sentence. Instead, he accepted a plea deal, giving him a 2 year sentence (3). In October 2006, a man named Jaymes T. McCollum entered county jail as a result of unrelated carjacking charges. After his DNA was entered into CODIS, an officer named Pete Montez realized that it matched the unknown male profile of the DNA from the evidence collected by James Ochoa's case. McCollum pled guilty of the 2005 carjacking that Ochoa had been jailed for. The Orange County District Attorney was informed of this, and after serving one year in prison, James Ochoa was exonerated (2).

Scent tracking dogs can be extremely useful in achieving justice. Despite that, this method of criminal investigation caused a gross injustice to occur. The justice system's overconfidence in this science clouded their judgement and caused an innocent man and his family great suffering. If the police force would have recognized that scent tracking dogs cannot always be completely reliable, and if there had been a legitimate error rate for this science to prove such, the injustice that was inflicted on James Ochoa could have been prevented. If more research goes into determining an error rate for scent tracking dogs, further incidents like James Ochoa's can be stopped.

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# GILLS RUNS ON DUNKIN: A DUNKIN DONUTS ROBBERY

Goldie Goldberger

"America Runs on Dunkin," is a slogan we are all familiar with which sarcastically connotes that we need coffee in order to function. It appears, that Terrel Gills took this very literally. Gills was convicted in August of 2015 of robbery in the first degree, as well as possession of a weapon in the third degree.

Although Gills' physical appearance did not match the eyewitness description, the presence of his DNA at the crime scene was enough to send him to jail. We would like to believe that science is fact and that it can't be argued with, but in reality mistakes are made and science doesn't always tell the true story.

It appears to be that the DNA match was enough to jail Mr. Gills. According to the surveillance footage a man wearing a crimson and yellow hat, jumped over the counter at a Dunkin Donuts in Queens and took all the money in the cash register; An investigator claimed that based on the video it seemed that the criminal was about 5'6, and so is Gills. Despite that this claim wasn't deemed correct, it was overlooked when the DNA found on the touch screen matched Gills'. Forensicists swabbed the touch screen and ran it through the database and the results were a positive match for Terrell's DNA. This information was enough to jail Mr. Gills. After 19 months in jail, Gills was finally found not guilty when initial police reports came to light. In the reports, the cashier working at Dunkin, Imtiad Ahmed, described the intruder as a 6 feet tall man. When the defense hired a forensics expert, it was found that according to the video the robber had to be about 5'10 with a two inch margin of error (6). This information proved Gills' innocence and sent him home.

Although justice finally prevailed and Gills was sent home, the quick assumption that the DNA was 100% accurate left a man in jail for almost two years. The investigators should have taken into consideration that the evidence recovered from the screen was not directly from Terrel. This is known as Locard's Principle where there are several exchanges of DNA throughout our lives and that we may pick up and leave traces of other people's DNA. Edmond Locard was a French doctor and criminologist that came up with the concept of exchanging DNA. It's not accurate to deem someone guilty simply due to a small trace of DNA according to Locard's principle. FST, a forensic statistical tool could be used to give a more accurate result regarding DNA but was banned from use in a legal battle. This was a tool where the software would calculate the likelihood that a suspect's genetic material is present in a complicated mixture, but this software was a copyright and can't be used (3). Before accusing Gills guilty, the judge should have been very aware that DNA evidence has been proven to not be completely accurate (5) according to the National Academy of Sciences these results, "are not necessarily repeatable from examiner to examiner." When fingerprints are involved, it's easier to identify fingerprint matches when there is a high quality fingerprint, but at a crime scene, no

criminal is careful to leave crisp fingerprints for the investigators which makes it very difficult to get a clear match says Dr. Anil Jain from Michigan State University.

*It's clear to see how many fingerprints appear on touch screens and how it would be difficult to single out one's print or DNA (7).*

The judge in Mr. Gills' case relied purely on the results the computer gave. The New York Court of Appeals clearly state that, "we will not indulge in the science fiction that DNA evidence is merely machine generated," (4). This proves the inaccuracy of computers and how we can't simply rely on the results it feeds us. There is plenty of advancement in evidence relating to fingers such as fingerprints, NIST (National Institute of Standards and Technology) along with Michigan State University improved the field of fingerprint analysis by creating an algorithm that determines if the fingerprint is good enough for the database. Within this study they use "training examples," this is when they take fingerprint experts and have them analyze several prints and rate them from one to five, and then use this information to train the algorithm. With a larger database of accurate fingerprints, it will be much easier to run tests and get accurate results. Additionally, algorithms are not subjective. A large issue with fingerprint analysis is biased detectives. "Empirical research supports the effects of bias in some forensic disciplines; for example, in fingerprinting, the same forensic experts may arrive at different conclusions when identical evidence is presented within different extraneous contexts," (1). This problem of human opinion clouding judgment calls will be irrelevant if we use algorithms to find matches.

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# DNA - DO NOT ASSUME

Elisheva Hollander

When police arrived at the ravaged mansion of millionaire investor, Raveesh Kumra, outside of San Jose, California in November 2013, they found what was left of Kumra: blindfolded, bound, suffocated and gagged with packaging tape.

Forensics teams swabbed his body and found DNA under his fingernails, belonging to an unknown person. The DNA sample was inserted into a DNA database, and a hit came up. The DNA belonged to a man by the name of Lukis Anderson (1).

Lukis Anderson had no idea why he was sitting in a California jail, waiting to be tried for a crime he was certain he didn't commit. Anderson's DNA that had been detected under Kumra's fingernails, was enough to place Anderson at the crime scene. He presented a compelling alibi, insisting on his innocence. His defense attorneys argued that he could not have possibly committed the crime, because he was being treated at the Santa Clara Valley Medical Center at the time of Kurma's murder. Anderson was sent to the hospital after passing out drunk in San Jose, with blood alcohol levels way past the legal limit.

Despite the alibi, the mystery of the discovery of Anderson's DNA on Kurma's body persisted . In 2013, an article in the *San Francisco Chronicle*, proclaimed that the paramedics who treated Anderson for his intoxication were the same people who replied to the crime scene at Kurma's home just a few hours later. The traces of Anderson's DNA had been transferred through these paramedics, by way of their clothing or equipment, and inadvertently deposited under Kurma's fingernails (2). This transference theory was still under investigation when prosecutors accused Anderson of murder. This shows that very real injustices that can happen when we put too much trust in DNA forensic technologies (1).

A valuable tool for law enforcement is DNA forensics. It's mostly beneficial when it justifies evidence indicating a suspect, or to conclude if any two people's samples match. When the government gets into the business of collecting millions of DNA profiles to pursue hits as the prime basis for prosecutions, much more responsibility to the public is authorized. People have allowed the myth of DNA reliability to weaken our suspicions of the government's prosecutorial power for far too long, certainly leading to untold injustices (1).

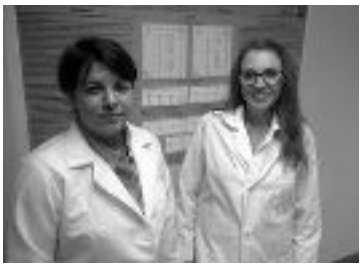
Prosecutors were compelled to acknowledge that there must have been some alternative explanation, because Anderson's alibi was strong. They recognized the obvious that it was impossible for Anderson to be in two places at once. Because of that dot of his DNA found under Kumra's fingernails, he was alarmingly close to being sent to death row. That one piece of evidence that was acquired from a technology with recognized limitations, and one that is

vulnerable to human error, might have wrongly led to a killing at the hands of the state (1). "Anderson is fortunate that he was at the hospital," the California Innocence Project contemplated in a blog post. "If he had not been so intoxicated or remained at the hospital, Anderson could have very well have been another wrongful conviction" (2).

(https://www.mercurynews.com/2013/06/03/murder-charges-dropped-in-lurid-monte-sereno-case-amid-questions-about-dna-test/)

Cynthia M. Cale, a human-biology graduate student, says that the case of Mr. Anderson further indicates that the way DNA evidence is evaluated and explained by law enforcement officials must be reviewed as technology advances. In an article for the weekly science journal, *Nature*, Cale addresses that in fact it is, "relatively straightforward for an innocent person's DNA to be inadvertently transferred to surfaces that he or she has never come into contact with."

In order to prove this point, Cale and her team engaged in an experiment to show that DNA can so easily be transferred from one thing to another. She and her team instructed people to shake hands for about two minutes, then directed each of them to handle a separate knife. The researchers discovered that in 85% of the cases, the DNA of the person who never touched the knife was transferred to the knife and detected. The DNA analysis in one-fifth of the samples classified the secondary person as either the prime or only contributor of DNA to the weapon. Cale says, "At the very least, the results highlight again that samples at crime scenes must be gathered with great care". She adds that even "apparently rigorous evidence such as DNA profiles can be interpreted in multiple ways, some of which will be incorrect." A forensic policy analyst at the Innocence Project named Kareem Belt, acknowledges and notes that with the raised awareness of newer DNA kits, the chance for secondary, even tertiary transfer, becomes much more of a feasibility. This is because more DNA is being identified (2).



(https://www.forensicmag.com/article/2015/11/secondary-transfer-new-phenomenon-touch-dna)

The forensic science of DNA is far from unerring, despite how often it is interpreted in the media and courts. Police and prosecutors commonly talk about touch DNA  "genetic profiles of suspects and offenders that have been

generated in a laboratory from just a handful of skin cells left behind in a fingerprint". Research performed at the University of Indianapolis in Indiana, emphasized how inaccurate this type of evidence can be. There is a large possibility that an innocent person's DNA can be carelessly transferred to surfaces they never had contact with, researchers found. This can place people at crime scenes they never visited or connect them to firearms they never touched, like Mr. Anderson. Furthermore, a transfer like this can weaken the statistics generated from DNA evidence, thereby rendering firm genetic evidence almost inconsequential (3).

Now we must review how DNA evidence is evaluated, described and examined. Forensic scientists, DNA analysts, judges and lawyers must know and understand the possibility for mistakes. The term touch DNA refers to "biological material found on an object that is the result of direct contact". The DNA could have been accumulated by secondary transfer, making it difficult for forensic scientists to know if the DNA was through direct transfer. Legal experts have mostly dismissed contamination from secondary DNA transfer as being uncommon outside laboratory conditions, although it is known to happen. They seemed to support this, for experiments were done in real conditions. They then confirmed that secondary DNA transfer would not have such a large effect on the translation of the genetic profile. Due to the power of modern forensic techniques to pull a DNA profile from a blot of cells, secondary DNA transfer is not a purely theoretical risk anymore (3).

As a result of DNA amplification kits becoming more sensitive than they were in the past, the kind of samples being analysed have increased. There is no longer a need for investigators to label and request analysis of body fluids, like blood and saliva. All they have to do is swab surfaces for invisible cells left behind, then ask labs to create a DNA profile from them. The current kits can produce a complete genetic profile of a suspect, from as small as 100 picograms of DNA. In court, these small things are not generally explained, and instead, the jury is told there is the slightest chance that the evidence collected from the crime scene didn't come from the defendant, for he was at the crime scene. What usually happens is that the jurors just presume that the defendant must have been there, which is not great (3).

From these experiments and in general, we learn that any type of sample found at a crime scene must be collected with extreme caution. Even a DNA profile, which is precise evidence, can be interpreted in numerous ways, some of which will be wrong (3). Our efforts to filter out potential mistakes must advance as the technology to generate these profiles advances as well (2). There is alot that can be learned from this interesting case of Mr. Lukis Anderson.

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# GOOD THINGS IN SMALL PACKAGES

Rachel Berenshteyn

Nanotechnology is an emerging scientific field that is making an impact on a wide array of applications. Nanomaterials—materials which are fully or partially of nanoscale dimensions, or are produced by nanotechnology (for example, nanoparticles)—are already being used by the fashion, aviation, and medical industries, to name a few (See Figure 1).

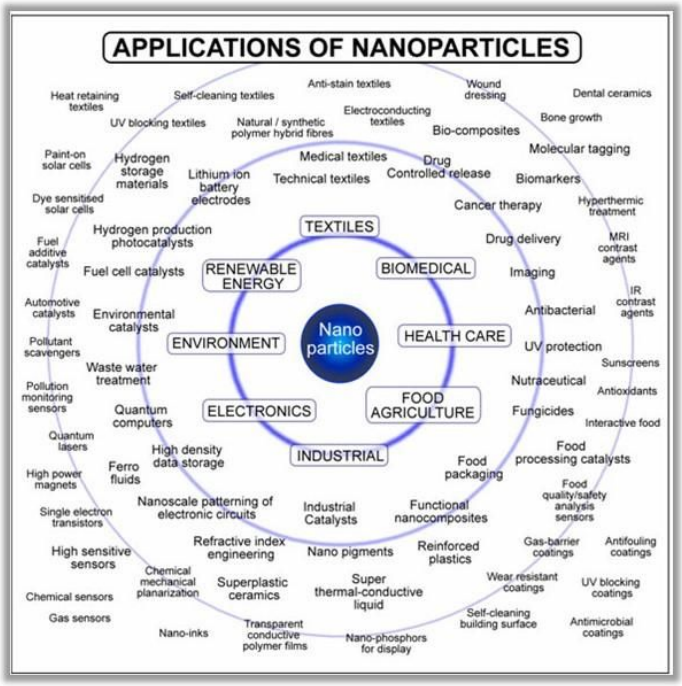



Figure 1

They are predicted to become increasingly pervasive in our lives as more research is done into their unique properties. Nanotechnology has the potential to fix important issues plaguing our society, such as pollution and illness. Understanding the science behind the production and application of such nanomaterials is vital for their continued improvement and for ensuring the safety of their use.

In particular, the nanobiology field is booming with research projects which aim to find medicinal uses for nanomaterials in regenerative medicine– the replacement or repair of diseased body tissue through *in vitro* and *in vivo* pathways. In a paper published in the *Journal of Cellular and Molecular Medicine,* Pooja Arora and her fellow researchers discuss the different applications of nanomaterials in regenerative medicine. Existing or newly designed nanomaterials are used to construct three dimensional scaffolding which can then be populated with stem cells to be used in bone tissue repair and implants. Scientists are closing in on the ability to regenerate bones, organ and muscle tissue, and even retinas. Originally, stem cells alone were used for such regenerative procedures, but that proved to be difficult in many cases. This is because the cells need a scaffold material to support and assist them in their growth so that when harvested, they are properly suited for the body into which they will be injected. Additionally, due to excessive complications with the process of harvesting stem cells for *in vitro* regeneration, the success rate for *in vitro* procedures is low (1).

Nanobiology researchers are working keenly to find alternative nanomaterials, such as specialized nanofibers and particles, to help with (stem-cell-based) biological

regeneration. Another nanomaterial used for these purposes is iron oxide nanoparticles. These magnetic particles are popularly used in regenerative stem-cell research because they easily enter the cell and circulate through the cytoplasm without interfering with the normal cell processes. These magnetic nanoparticles make the cells to which they are attached visible in an MRI machine, allowing for the tracking of *in vivo* stem cells, to assure that they are traveling properly through the body and attaching to the proper locations.

In order to effectively support and increase tissue growth during a regenerative treatment, molecules need to be directed to specific areas. For this, yet another nanomaterial is used—nanocarriers. Nanocarriers, which are synthesized through the combination of assorted polymers with hydrogels, are able to access hard-to-reach locations such as tight junctions and capillaries (1). These nano-carrying particles can also change their pH levels, temperature, and size, because of the polymers of which they are comprised. These "surface modification (1) properties" make nanocarriers useful in regenerative treatments, like with bone regeneration and osteoblast adhesion, where functionalized hydroxyapatite[1] nanoparticles are used. Additionally, nanosensors such as nanodots and carbon nanotubes are employed in regenerative procedures to sense any biological or chemical reactions within their surroundings when doing *in vitro* cell/tissue regeneration. These methods are still undergoing research and development.

In the arena of tissue engineering and regeneration, the standard surfaces of the biomaterials used are being improved through nanomaterials as well. This increases the yield of regenerated tissue, as the new nanoscale surface has certain key features that resemble those of a natural tissue's surface, improving tissue-cell reactions. Therefore, nano-structured materials have been designed for this purpose. For instance, nanostructured titanium has been designed to be used on implant surfaces. When used in bone-regeneration procedures, bone-cell response improves, as does the rate of calcium deposition (1). This leads to a more successful integration of the regenerated bone tissue with the bones around it. It can therefore be effectively argued that nanomaterials, especially when they are designed for their specific purposes, greatly improve the efficacy and success rate of tissue and bone regeneration procedures. Nanoparticle scaffolds—porous, three-dimensional structures that simulate the structure of the tissue that is being repaired, are another nanomaterial that could be used in regenerative procedures (see figure 2). Nanofibers, for instance, can

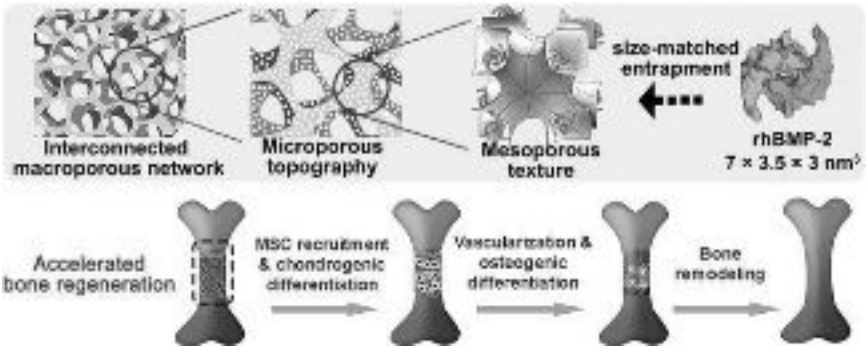
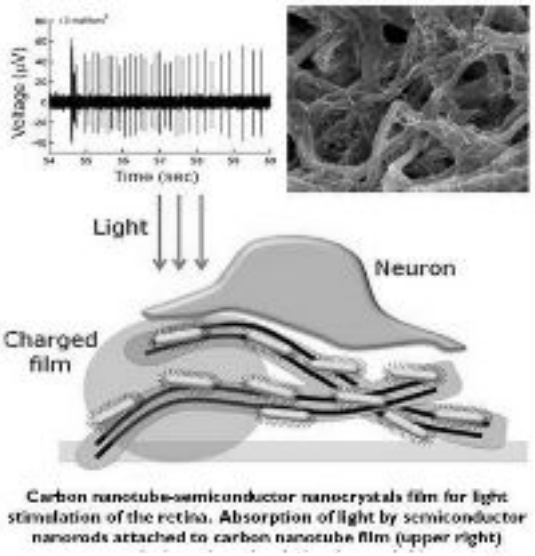



Figure 2- Yi, H., Rehman, F. U., Zhao, C., Liu, B., & He, N. (2016). Recent advances in nano scaffolds for bone repair. *Bone Research, 4*(1). doi:10.1038/boneres.2016.50 (**b**) Tri-modal macro/micro/nano-porous scaffold loaded with rhBMP-2 for accelerated bone regeneration.

[1] Hydroxyapatite is the main inorganic component of biological bone and tooth enamel.

be used to build scaffolds that support tissue regeneration. Because of their large surface area, they function as replacements of the tissues' natural extracellular matrix. Nanofibers also assist the ingrowth of cells into the matrix and successfully transport nutrients between the scaffold and its environment.

Implants also greatly benefit from nanomaterial applications. For example, nanocrystalline coatings can increase the duration of artificial joint implants. Nanobiology researchers are currently working on developing methods which would use nanomaterials to assist with active implantation[2] as well. A recent low-level implant procedure involves the implantation of a prosthetic retina made of a light-reactive nanofilm composed of semiconductor nanorods and carbon nanotubes (2) (See figures 4-5). This method is still largely in its initial stages.



Carbon nanotube-semiconductor nanocrystals film for light stimulation of the retina. Absorption of light by semiconductor nanorods attached to carbon nanotube film (upper right)

Figure 4- Canadian Friends of the Hebrew University of Jerusalem. Wireless Nanorod-Nanotube Film Enables Light Stimulation Of Blind Retina; Breakthrough Could Lead To Artificial Retinas For Visually

The paper concludes by saying that nanoregenerative medicine is a field which is still largely in its theoretical stage, and a field with lots of developmental potential, especially in regard to techniques for treating serious injuries and degenerative diseases. It praises the development of multi-functional nanomaterials and their applications, saying that this will lead to the improvement of our society's general health. It says that we can expect a future where nanodevices are frequently implanted in humans to repair damaged or abnormal cells.

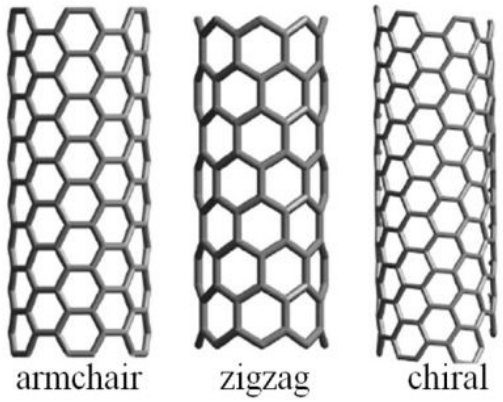


Figure 5- Choudhary, V., & Gupta, A. (2011, August 17). Polymer/Carbon Nanotube Nanocomposites. Retrieved February, 2018, from https://www.intechopen.com/books/carbon-nanotubes-polymer-nanocomposites/polymer-carbon-nanotube-nanocomposites

With the advent of such nanomaterial-based aids in regenerative medicine (and implantation development) in addition to other nanomaterial-containing medical products in the past decade, scientists speculate that many people will have regenerated body tissue or nano-based implants in the coming decades. It is important to note how this concerns the halachic Jewish community, as nanomaterial products are still largely unregulated, leaving ethical questions that ask if Jews are allowed to sell such treatments and products if their safety is not fully known. Another issue for the Torah-observant Jew that would come up in light of the regenerative treatments improved (and expanded) through the use of nanomaterials is the

[2] Active implants are implants that require a direct source of energy.

quandary of whether a Kohen who has regenerated tissue or bones in his body can serve in the Beis HaMikdash.

As Torah-observant Jews, it is our duty to understand the developments in our world, examine them through a Judaic lens, and ask ourselves if they conflict with Torah values. For example, numerous items such as sunscreens and beauty products are being produced with nanomaterials, and their ads claim that they are safe and effective. However, the fact of the matter is that these new products are highly unregulated and do not have concrete legal definitions, meaning that it is uncertain whether or not these products really do what they claim to, and do it safely. That being said, is a Jew ethically allowed to sell or promote nanomaterial-based products with unregulated claims and health-effects? Additionally, Halachic issues are liable to arise in response to the broadening presence of nanomaterials in our lives. In light of the "big future" ahead for nano-regenerative medical treatments, will a Kohen that has had a bone or organ tissue regenerated through nanomaterial-based treatments be allowed to serve in the Beis HaMikdash, or will he still be considered a Baal Müm?

The spirit of Judaism is greatly focused on being ethically upstanding. Although there are instances of ethical gray areas in non-Jewish legal discourses, they are different from those of Jewish community, because our ethics are firmly rooted in the Torah and not the current flavor of the month. It is up to us and our spiritual leaders to infer from our ancient texts what is ethical and what is not when new issues arise in our society. Take the issue regarding nanomaterial-based products, which have only recently come into play. Although neither the Torah, Mishna, nor Gemara discuss the ethics of Jews selling nanomaterial-based products, we can apply what our sages have taught us about the ethics of misinformation and public safety to the issue at hand.

There are two potential problems with consumer products (such as cosmetics) that contain nanomaterials, and they are brought to light in the University of Montana's informational packet, Ethical Aspects of Nanomaterials(3). The first problem is that many of these products have not been sufficiently tested (or haven't been tested at all) by the FDA. This means that we are still unsure of certain health risks that may result from exposure to nanomaterials. If left untested, consumers may only discover the safety issues after a decade or two of using the products, and that would mean that many had already developed a health issue because of it. The second issue is that since many of these products are barely regulated by the FDA, those being marketed may or may not actually be effective. In other words, even if the product is not unsafe, there's still no guarantee that it actually works. That being said, is a Jew ethically allowed to sell or promote nanomaterial-based products with unregulated claims and health-effects?

To address the first issue, the answer is no– a Jew may not sell a nanomaterial-based product (or any product, for that matter,) if he knows that it may negatively affect the consumers' health. This applies to a product that is even slightly dangerous. This can be explained through the following textual proof: the Torah says
"(4) וְנִשְׁמַרְתֶּם מְאֹד לְנַפְשֹׁתֵיכֶם"– you should make sure to protect your life very seriously. This is an instruction to take care of yourself and avoid health risks. The Torah also states "(5)וְאָהַבְתָּ לְרֵעֲךָ כָּמוֹךָ"– love (and treat) your fellow

Jew as you would yourself. Since you are commanded to care for your health, and to treat your fellow Jew as you would treat yourself, you can draw the conclusion that you have to look out for your fellow's health as well. At the very least, you may not cause any damage to his health. Therefore, you may draw the conclusion that selling an unsafe nanomaterial-based product goes against the ethics professed in the Torah, and should not be done by a Jew. Furthermore, note the *passuk* in Vayikra that says "(6) לִפְנֵי עִוֵּר לֹא תִתֵּן מִכְשֹׁל – " do not place a stumbling-block before a blind person (who does not necesarily have to be Jewish for this to apply). This phrase can be taken to mean that one should not cause a person to stumble or suffer because of their ignorance. By selling a potentially unsafe product, the Jewish salesman would be leading unknowing people to ultimately suffer from detrimental health effects. Although we do not know whether these nanomaterial-based products are indeed potentially hazardous, it is better to err on the side of caution, and assume that they are not fully safe. In light of this, it would be unethical for a Jewish salesman to sell such products to non-Jews and Jews alike.

With respect to the second issue presented, one can argue that if the product would not harm the consumer, a Jew who depends on selling that product to earn a living should be able to do so even if it doesn't necessarily work. It would be a nuisance, they'd say, but as long as the Jewish salesman doesn't guarantee perfect results, it would not be considered lying and he could therefore sell it. However, this train of thought is wrong. A case that was brought to the Maharalbach is discussed in Gerstenfeld's *Judaism, Environmentalism and the Environment* about a man who complains about his neighbor's use of millstones for his business because they ruin the man's walls. The ruling on that case was that a person is able to do work related to his occupation in his home so that he can make money, but could not sell his merchandise in his home because he is able to do that at the market, thereby reducing the noise (the public nuisance) in his neighborhood (7). This case shows us that although allowing a person to earn their *parnassa* is important, they are not allowed to earn their *parnassa* by doing something that is a public nuisance. Selling products that do not do what they claim to is a public nuisance, and therefore a Jew could not ethically sell such products, even if his *parnassa* relied on it.

In addition to such ethical quandaries, Halachic issues are bound to arise in response to the prevalence of nanomaterials in our lives, especially in the future. For instance, what of the matter of a physically imperfect Kohen who would want to serve in the third Beis HaMikdash? The Torah prohibits a Kohen from performing the ritual services in the Beis HaMikdash if he is a Baal Müm- if he contains a blemish- as it says "(8) כָּל־אִישׁ אֲשֶׁר־בּוֹ מוּם מִזֶּרַע אַהֲרֹן הַכֹּהֵן לֹא יִגַּשׁ לְהַקְרִיב אֶת־אִשֵּׁי ה מוּם בּוֹ אֵת לֶחֶם אֱלֹהָיו לֹא יִגָּשׁ לְהַקְרִיב." As a result, if a Kohen has (G-d forbid) lost part of a limb or bodily feature, he cannot serve in the Beis HaMikdash. Modern medicine, with its improvement of surgeries and recovery technology, has forced us to ask if this prohibition applies to a man who is missing an internal organ, while nanomaterial-based regenerative medicine is making us ask "what if that missing organ or limb was regenerated?"

In Mishne Torah, Rambam teaches us that "אין פוסל באדם אלא מומין שבגלוי"- a Kohen is only prohibited from serving in the Beis HaMikdash if his blemish is apparent. If his blemish is internal (for instance, if he is missing a portion of his liver,) then he is permitted to perform the ritual services in the Beis HaMikdash despite being considered a *tereifah*. The Sefer HaChinuch expounds on this by saying that a Kohen must look beautiful and complete at the time of his service because then "he will find favor and understanding regarding all that he does in the eyes of those who see him (10)." In light of this, a Kohen whose body contains regenerated bone or tissue may serve in the Beis HaMikdash as long as it is not outwardly visible. Therefore, when nano-regenerative medicine extends to the regeneration of entire limbs, it will be useful to know that, based on the logical application of the Sefer HaChinuch's and Rambam's answers, it is permissible for a Kohen to serve in the Beis Hamikdash if he has a regenerated limb as long as it is indistinguishable from an ordinary limb. Additionally, this would allow a formerly blind Kohen to serve in the Beis HaMikdash if he were to receive a retinal implant which would successfully restore his vision, as the retina would be wire-free, and therefore invisible to the regular observer. A counterargument to this may be that a Kohen, once missing a certain bodily tissue or feature, is considered forever blemished. This, however, would be refuted by the Gemara in the tractate of Bechoros, which says that although one may not sacrifice a temporarily-blemished animal on the altar, that animal may be sacrificed once the blemish heals (11). We may take this Gemara into consideration and say that the Talmud likens the Kohen to the sacrificial animal. Therefore, the Kohen would also not be regarded as "forever blemished," but rather as a Kohen fully capable of Temple service once his regenerative procedure proves successful. Because of the amazing research done with nanomaterials, Kohanim with previously untreatable blemishes (meaning those that were unable to fully heal naturally) would be able to serve in the Beis Hamikdash once these treatments are perfected.

Nanomaterials are swiftly entering our lives through their growing presence in cosmetics, regenerative medicine, and other fields. When used correctly, nanomaterials have the potential to greatly benefit whatever product or treatment they are being applied to. However, guidelines for their safety must be first be established. When the applications of nanomaterials in regenerative medicine become more developed, people with missing bone or body tissue will have the option to have it regenerated either *in vivo* or *in vitro,* and subsequently implanted. However, having regenerated bone or body tissue may still not be enough to remove a physically imperfect Kohen from the Baal Müm category. If, at the time when this question becomes relevant and is presented to the Halachic authorities, and they follow the logical path that I have presented and extend the Rambam's and Sefer HaChinuch's answers to apply to nanoregenerative medicine, a Kohen will be allowed to serve in the third Beis HaMikdash (*b'meheira b'yameinu*) if they appear to be physically perfect after the procedure. However, we will have to wait until that time to see what they decide.

In ten years from now, nanomaterial-based products should be more heavily regulated by the FDA (or a separate administrative group that is more familiar with nanotechnology) to ensure that everything on the market is safe to use and provides its promised results. Additionally, Jewish educators should establish the presence of Jewish ethics classes

in every school, where children will learn how to apply their Torah values to real-world situations. For instance, what to do in light of new scientific discoveries, or what to do when their job depends on promoting new, untested products. Rabbinic authorities should become educated in basic principles of nanotechnology and nanomaterials so that they can be properly equipped with the knowledge needed to address budding halachic issues that will arise with the ever-growing use of nanomaterials in our daily lives.

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4. Sefer Devarim, Perek 4, Passuk 15. וְנִשְׁמַרְתֶּם מְאֹד לְנַפְשֹׁתֵיכֶם כִּי לֹא רְאִיתֶם כָּל־תְּמוּנָה בְּיוֹם דִּבֶּר ה אֲלֵיכֶם בְּחֹרֵב מִתּוֹךְ הָאֵשׁ׃
5. Sefer Vayikra, Perek 19, Passuk 18. לֹא־תִקֹּם וְלֹא־תִטֹּר אֶת־בְּנֵי עַמֶּךָ וְאָהַבְתָּ לְרֵעֲךָ כָּמוֹךָ אֲנִי ה׃
6. Sefer Vayikra, Perek 19, Passuk 14. לֹא־תְקַלֵּל חֵרֵשׁ וְלִפְנֵי עִוֵּר לֹא תִתֵּן מִכְשֹׁל וְיָרֵאתָ מֵאֱלֹהֶיךָ אֲנִי ה׃
7. Gerstenfeld, M. (1999). *Judaism, Environmentalism and the Environment: mapping and analysis*. Jerusalem: The Jerusalem Institute for Israel Studies. Focusing on pages 121 and 122.
8. Sefer Vayikra, Parshas Vayikra, Perek 21, Passuk 21.
כָּל־אִישׁ אֲשֶׁר־בּוֹ מוּם מִזֶּרַע אַהֲרֹן הַכֹּהֵן לֹא יִגַּשׁ לְהַקְרִיב אֶת־אִשֵּׁי ה מוּם בּוֹ אֵת לֶחֶם אֱלֹהָיו לֹא יִגָּשׁ לְהַקְרִיב׃
9. Rambam, Mishne Torah, Sefer Avoda, Beis Hamikdash, Chapter 6, paragraph 7:
אין פוסל באדם אלא מומין שבגלוי אבל מומין שבחלל הגוף כגון שניטל כולייתו של אדם או טחול שלו או שניקבו מעיו אע"פ שנעשה טרפה עבודתו כשירה שנאמר שבר רגל או שבר יד מה אלו בגלוי אף כל בגלוי
10. Sefer HaChinuch, Mitzvah 275.
11. Talmud Bavli, Tractate Bechoros, 37b.

# PROMOTING GROWTH: TORAH VALUES ON THE EFFECTS OF NANOTUBES

Tamar Spoerri

Several studies have noted the potentially adverse effects of carbon nanotubes (CNTs), which are used increasingly in the manufacturing of numerous products from computers to strong spun fiber. Because of their marked prevalence in industry and consumer products in the last few decades, it is important to examine the health and safety hazards they present from a Torah perspective.

With this information, we will be able to assess the need to scale back or regulate the use of CNTs.

In a recent study published in the Royal Society of Chemistry's journal *Environmental Science: Nano*, researchers from Rice University discovered that single-walled carbon nanotubes (SWCNTs) dispersed in purified water increased the growth of wheatgrass, while SWCNTs dispersed in contaminated water exacerbated the pollutants' already-detrimental effects on plant growth. In the experiment, wheatgrass was planted in solutions of pure water or industrial solvent, then SWCNTs or multi-walled carbon nanotubes (MWCNTs), both purified or raw, were added to some of the samples. Samples that contained purified SWCNTs grew 13% larger than those in plain water, while samples that contained purified SWCNTs and industrial solvent grew at nearly half of the rate of those in plain water. MWCNTs and raw SWCNTs did not affect plant growth significantly.[3] Practically, this means SWCNTs pose a risk to plant life, but only when contaminants are present. In cases where no contaminants are present, the SWCNTs are possibly beneficial to plant growth and may lead to economic gain.

Additionally, an article published in the journal *Toxicological Sciences* assessed the toxicity of CNTs to humans. By examining the properties of CNTs, researchers predicted that once they enter the body, CNTs distribute quickly and cause severe harm to the lungs.[4] This is primarily caused by the high surface-area-to-volume ratio of nanoparticles, which provides a larger area for chemical reactions to occur, and ultimately increases the CNTs' toxicity.[5] Through oxidative stress in the cell, the tissue becomes inflamed,[6] possibly causing disease.[7] This shows CNTs pose a risk to human life.

[3] Lee et al. (2018). Effect of raw and purified carbon nanotubes and iron oxide nanoparticles on the growth of wheatgrass prepared from the cotyledons of common wheat (*triticum aestivum*). *Environ. Sci.: Nano, 5(1)*, 103-114. 10.1039/C7EN00680B

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These findings present a challenge to the widespread use of SWCNTs in consumer products and for industrial purposes, since SWCNTs may cause harm to both the environment and to humans. Considering the complexity and nuance of the issue, it would be difficult to merely reason about the morality of using SWCNTs. In order to properly address the problem, it is imperative to consult the Torah, which guides every element of our lives. Based on its teachings, we can find Jewish values which answer the questions presented by modern technology. The Torah addresses issues of potential harm to plants and humans from a number of angles, helping us understand the necessity of taking measures to minimize damage while still maximising the benefits of new discoveries.

The first issue is that of harming the natural world, to which the Torah takes a multi-faceted approach. From the verse, "If in your war against a city, you have to besiege it a long time in order to capture it, you must not destroy its trees," we see that baseless destruction of plant life is forbidden, because trees sustain humans and should be preserved for our long-term benefit, as the Ibn Ezra explains.[8] On the other hand, Rashi notes on this verse that trees are not participants in human conflicts and can't defend themselves, so people should spare them. They merit to exist not just to serve human purposes, whether for sustenance or fulfilling various commandments (e.g., the *lulav* and *esrog*, *bikkurim*), but for their own sake. Furthermore, the Ramban takes a similar approach in his comments on the rationale for *shiluach hakan*,[9] sending away the mother bird before taking her eggs. This commandment, he explains, addresses preventing the extinction of the species, independent of any concern of its effect on humans. This principle also applies to preventing the extinction of any species, including that of plants. The Torah values their existence, and does not just aim to maintain human ability to use plants in the long run.

From the above, one would think that harming plants is forbidden, but this is not the case. Needless destruction is indeed forbidden, though it is entirely permitted to destroy plants for the sake of economic need. This can be seen from multiple rulings of the Gemara which prioritize human interests.[10] However, before acting, one must also consider other Jewish values: that of responsibility of humans to protect nature[11] which is G-d's creation, and also the need to sustain nature for future human use. Ultimately, human interests are still of greater importance.[12]

Our last issue is whether a person is culpable for harmful effects which he did not directly cause. The Gemara mentions the case of one who bends grain, and a fire spreads to that area of bent grain and damages it. Ultimately, damage occurs because of the person's actions, yet it was unlikely that it would have happened based on the normal

[8] Deuteronomy 20:19
[9] Deuteronomy 22:7
[10] Bava Kamma 91b-92a, Shabbos 128b-129a, and Shabbos 140b as cited in Berman, S. The dynamic tension between nature and human needs. *Human Values and the Environment.*
[11] This responsibility is seen from multiple commentators' explanations on the verse, "The LORD God took the man and placed him in the garden of Eden, to till it and tend it" (Genesis 2:15).
[12] Berman, S.

movement of the fire. Still, he is held accountable for the damage in Heaven, though not in Bet Din.[13] This shows that one should try to avoid taking actions which may cause damage, even if that outcome is unlikely and not primarily due to their actions.

From examining situations in the Gemara, we can identify Jewish values which address potential consequences of SWCNTs filtering into the environment. First, we must assess whether the economic benefit from their use outweighs the risk it poses to plant growth. This is out of concern for preserving the environment, which the Torah values for its future use to humans and for nature's own sake. Second, we must ascertain that SWCNTs have a negligible chance of eventually harming people, because the health of humans is paramount. Third, even though SWCNTs only are harmful when contaminants are present, one should still avoid the small risk of contributing towards their harmful effects. In this way, one will follow G-d's Will by applying the values He provided for us in the Torah to our day-to-day decisions.

Ideally, reforms will be written in the near future which will ensure that these values are commonly put into practice. In ten years from now, governments will have introduced legislation and raised awareness regarding safe disposal of potentially toxic materials. Manufacturing companies will thoroughly research the effects of CNTs which leak into the environment to inform their decisions about how to use them, always considering the potential consequences of their actions. People will have gained awareness through government campaigns of the dangers of certain materials, in order to properly use them and safeguard the environment. With correct focus on implementing Torah-based measures to solve relevant societal issues, we will stay true to our faith and preserve the environment for future generations.

[13] Bava Kamma 56a

# HOW "KOSHER" IS NANOTECHNOLOGY?

Nev Sivan Yakubov

Nanotechnology is the science that deals with the manipulation of objects from one to one hundred nanometers. As more research is done in this field, scientists look for ways to introduce this new science into everyday living.

One area in which nanotechnology integration is being contemplated and even implemented is in the production of food. Xiaojia He and Huey-Min Hwang (2016), in their article "Nanotechnology in food science: Functionality, applicability, and safety assessment" identify that in the food industry, nanotechnology will mainly be used to enhance food security, extend storage life, improve flavor, and nutrient delivery, and detect pathogens, toxins and pesticides in food products. Benefits of these innovations, listed by He and Hwang, include introducing anti-microbial properties to food using silver nanoparticles, preventing fruit browning using nano-packaging, enhancing food color with nanoparticles and adding silicon oxide to powdered foods to prevent caking.

However, these benefits are not without risk. Because of the relative modernity of nanotechnology, much of its risks are unknown, including the distribution and availability of nanomaterials throughout the human body and the possible toxic effects they may have upon contact. He and Hwang cite a study in which over 93% of titanium dioxide in sugar-coated chewing gum is on the nanoscale. This increases the ease with which titanium dioxide can be swallowed by a person chewing the gum and subsequently can lead to the buildup of titanium dioxide in their system. Titanium dioxide is approved as a color additive to foods by the FDA (2017), however it must account for less than one percent of the weight of the food. The authors also mention allergies and the release of heavy metals as concerns of the integration of nanomaterials into the production of foodstuffs. They specifically present carbon nanoparticles as causative of allergic inflammation. They also report that zinc oxide, silver, and copper oxide are the most notorious metal-leaching nanomaterials. Another concern, of He and Hwang's, is unintentional leakage from nano-packaging. They state that aluminum and clay particles were both found to migrate from nano-packaging film into food stimulants. In a study cited by "Nanotechnology and its Applications in Food and Animal Science" (Mura, Carta, Roggero, Cheli, & Greppi, 2014), silver nanoparticles used in food packaging transferred to the food with a certain level of toxicity. Another risk mentioned by Mura et al. (2014) is the presence of organic moieties that can carry foreign substances into the blood and cause inflammation. They conclude (Mura et al. 2014) that governments should regulate the use of nanomaterials and encourage consumer awareness until more is known regarding the toxicity and negative effects of certain nanomaterials.

A dichotomy exists in the Torah regarding the implementation of new technologies. Manfred Gerstenfeld and Avraham Wyler (2006) tackle this concept in the introduction to their paper, "Technology and Jewish Life." They bring down two instances in the Torah where technology is being introduced: one good, and one bad. The first

instance they mention is brought down in this verse: "תּוּבַל קַיִן לֹטֵשׁ כָּל־חֹרֵשׁ נְחֹשֶׁת וּבַרְזֶל" (Genesis, 4:22) when, "Tubal-cain forged all implements of copper and iron." Rashi explains this verse to mean that Tubal-cain built weapons for professional murderers. This shows the potential evil that lies in technology. However, in speaking of Noah, the verse says, "זֶה יְנַחֲמֵנוּ מִמַּעֲשֵׂנוּ וּמֵעִצְּבוֹן יָדֵינוּ מִן־הָאֲדָמָה," "He will provide relief from our work and the toil of our hands on the earth" (Genesis, 5:29). Gerstenfeld and Wyler cite a midrash that says that Noah implemented farm tools to help aid in the work of the ground. This represents the other side of technology, that it can be used to improve people's lives. These two viewpoints must be considered when discussing technology of any kind, including nanotechnology. Nanotechnology advances in regards to food products can lead to both a rise in undetected food contaminants and increased health benefits.

With research of nanomaterials in food products rapidly developing, the implications of food-related nanotechnology in regards to Judaism cannot be ignored. Jews are commanded in the Torah "וְנִשְׁמַרְתֶּם מְאֹד לְנַפְשֹׁתֵיכֶם," (Deuteronomy 4:15) to "watch over your being very well." This has been interpreted as watching over the welfare of the body or to be cognizant of one's health. This could be taken to mean that Jews have a responsibility to be aware of the health risks that nanomaterials in food represent, and to safeguard themselves against them. This assumption produces more questions: How strictly must one's health be guarded? Can low levels of potentially toxic substances (such as silver oxide) be consumed in order to prevent a more prevalent danger (bacterial/microbial infestation)?

The obligation to eat kosher food is also an obvious concern of Judaism with the heightened research and usage of nanotechnology in food. Rabbi Eliyahu Ferrell (2013) addresses the size of nanomaterials in terms of kashrut. Normally, the laws of kashrut only emphasize substances which can be seen with the naked eye. Nanomaterials cannot be seen unaided by human eyes. Does this mean they do not need to adhere to the laws of kashrut? Rabbi Ferrell writes that it is possible that nanomaterials may need to follow the laws of kashrut because the effects of the nanomaterials (increased flavor, enhanced color, higher solubility etc.) can be detected with the naked senses.

Nanotechnology is a highly evolving field and the new opportunities it presents are met mostly with excitement. In this excitement it is likely that innovators can't wait to introduce nano-enhanced materials into common use. It seems wise however, from both a Jewish and scientific standpoint, to wait and see what new discoveries develop, especially regarding the safety of nanomaterials. As the field further develops, halakhic commentators will no doubt form opinions and practical applications of them, but as of now they are just theoretical.

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