LABYRINTH 2017:

THE SCIENCE JOURNAL OF MANHATTAN HIGH SCHOOL FOR GIRLS

Mrs. Tsivia Yanofsky, *Menaheles*
Mrs. Estee Stefansky, Principal, General Studies
Mrs. Brenda From, Chair, Department of Science

TABLE OF CONTENTS

LABYRINTH 2017: FOREWORD

Mrs. Brenda From

Every great idea in science is an offspring of the creativity, curiosity, and tenacity of the collaboration of minds of all the scientists, past and present. And behind every great male mind, is the greater mind of a woman. Every great idea is embedded in the historical and social fabric of its time. This is part of the story we aim to tell.

The ambition of every educator is to instill in her students a passion for her discipline, an appreciation for independent inquiry and to imbue them with the tools to accomplish this task. The need is especially acute when it comes to the field of science. Our knowledge of science is expanding at an exponential rate, and we are charged with the responsibility of empowering our students with the skills necessary to critically evaluate and assimilate novel information that is guaranteed to appear on the horizon. Publication of Manhattan High School for Girls annual science journal, *LAB*yrinth, was designed to impress upon our students that formal classroom education is but a prelude to a lifetime of independent learning. This project was designed to prepare the student to become an astute and aware citizen of tomorrow's technological and scientifically advanced society.

A stated goal of the National Science Education Standards is that all students should achieve scientific literacy—the ability to read and understand articles about science, the nature of science and the scientific enterprise, and to engage in both oral conversation and written communication about the validity of conclusions and the role that science plays in society and personal life. Critical reading, synthesis and integration of information, and writing all play an important role in science literacy. When students are skilled in reading and writing in science, they are prepared to learn and think critically about concepts in depth.

Entries to this year's edition draw from two sources: the tenth grade Chemistry research project and two of the various competitions to which our students subscribe, the Jerusalem Science Contest and the DNA Day Essay Contest sponsored by the American Society for Human Genetics. In fulfillment of the Chemistry research project, students had to select a modern female scientist and write about her life and her work. Where two students wrote about the same scientist, each with their own strengths, I asked them to collaborate and combine the two into a unified whole. In that case, both students are attributed. In fulfillment of the requirements for this year's Jerusalem Science Contest, students had to prepare an independent study of the intersection of Astronomy and Judaic themes. For the DNA Day Essay Contest, students described how novel therapies and approaches might be utilized to treat genetic diseases. Students learned to how to construct productive searches, test the veracity of their findings through a critical reading of sources, unravel the knotty strands of evidentiary clues, understand the relevance of the science information, and evaluate new information via analytical comparison with their current state of knowledge. Quite a task, but they proved up to it.

Science has always depended upon dissemination of findings by effectively communicating and sharing ideas in the written forum in a manner that is both concise and lucid. The first scientific journals appeared in 1665 in England and France. Since that time, journals have served as the primary means of communication in the sciences. Currently, an estimated 70,000 scientific and technical journals are published throughout the world. I am sure you will agree with me that the students performed magnificently and we are unabashedly proud to offer *LAB*yrinth 2017 as our latest contribution.

I owe a huge debt of gratitude to Mrs. Tsivia Yanofsky, *Menaheles*, and Mrs. Estee Stefansky, Principal of General Studies, for upholding the highest standards of educational excellence at our school, Mrs. Chani Kanowitz, Director of Technology, for her assistance with layout and preparation for printing, Digital Media elective students Chayala Kazarnofsky and Shoshana Farber for the cover design, and most of all to our supportive parent body for entrusting us with the immense responsibility of educating their most precious daughters. *Kol Ha'Kavod.*

מה רבו מעשיך ה׳ כלם בחכמה עשית מלאה הארץ קניניך.

תהילים (104:24)

WHERE ARE WE? MAY-BRITT MOSER

Odelya Barsky

Imagine yourself sitting on a cruise ship, in the middle of the Pacific Ocean. As you sit on the deck and enjoy the fresh, cool air, a question crosses your mind. "Where am I?" you wonder. Have you ever wondered where you are? How does our body know where we are? How can our brains process the difference between home, school, and the middle of the ocean? Thanks to May-Britt Moser, now we know.

May-Britt Moser grew up on a small farm on the coast in the town of Fosnavåg, Norway. Her mother was a doctor, and her father a carpenter. May-Britt Moser always wanted to be like her mother and 'save the world', but decided if she couldn't be a doctor when she was older, she'd be a veterinarian. She had a keen interest in the animals, and constantly wondered what causes them to behave the way they do. Due to her fascination with the animals, May-Britt Moser had little interest in her school work growing up, and didn't do particularly well either. In high school, she took an interest in both mathematics as well as physics, but wasn't exactly the top student then, either.

High school was uneventful, and then she decided to attend University of Oslo, where she pursued psychology. Along the way, she met Edvard Moser, who would later become her husband. They continued to study psychology, as well as mathematics and neurobiology. They even published a paper, "The interactional effects of personality and gender in small groups: A missing perspective in research," in the *International Journal of Small Group Research* (3). Her paper was liked so much that May-Britt Moser was encouraged to go on the path of social psychology, but she and Edvard were fascinated by neuropsychology. However, this posed a challenge, as there were no neuroscience courses being offered. They looked to Carl Erik Grenness, a behavioral analysis teacher, to guide them. He led them to Terje Sagvolden, who advised them to study brain-behavior relationships instead. This had always been something May-Britt Moser had been interested in and was eager to pursue because she grew up with animals, and constantly wondered why they acted the way they did. Soon after, they began studying in the lab of Terje Sagvolden, where they studied hyperactivity in rats and behavior for two years. During this time, May-Britt and Edvard got engaged and continued to work together (2).

In 2005, May-Britt Moser and her husband discovered what would later win them the Nobel Prize: grid cells. The discovery of these cells came after long, complicated and costly work. Their work in the lab of Terje Sagvolden had led them to a man name Per Anderson, who headed a neuroscience group. However, his group was full and they needed to really impress him to gain entry and do a masters' thesis in his lab. He challenged them to build a water maze, and if they succeeded, he would allow them. Luckily for them, Edvard's brother worked at a facility where he could help buy them a tank. This water maze was for the rats to swim around in and for May-Britt and Edvard Moser to be able to test their proprioception. Once they built the maze, they put in the rats and conducted tests. May-Britt

Moser had to make lesions in the hippocampus to find Long Term Potentiation (LTP), responsible for 'long term memory' between nerve cells in the entorhinal cortex of the brain, a hub in a widespread network associated with memory and navigation. LTP is when the nerves send out a certain signal, called an Excitatory Post Synaptic Potential (EPSP). These signals are repeated in quick patterns, and this results in long-term potentiation because now that the brain has gotten the same pulses multiple times in a row, it is easier to retain and recall this information. The first step was finding out where they could make lesions, without destroying too many cells so that the rats can still receive these vital signals in order to learn. They figured out that they could make lesions in the ventral (lower) part , but not the dorsal (upper) part, because then the rats would have no memory due to the loss of ability to send the signals necessary for long-term potentiation (See Figure 1).

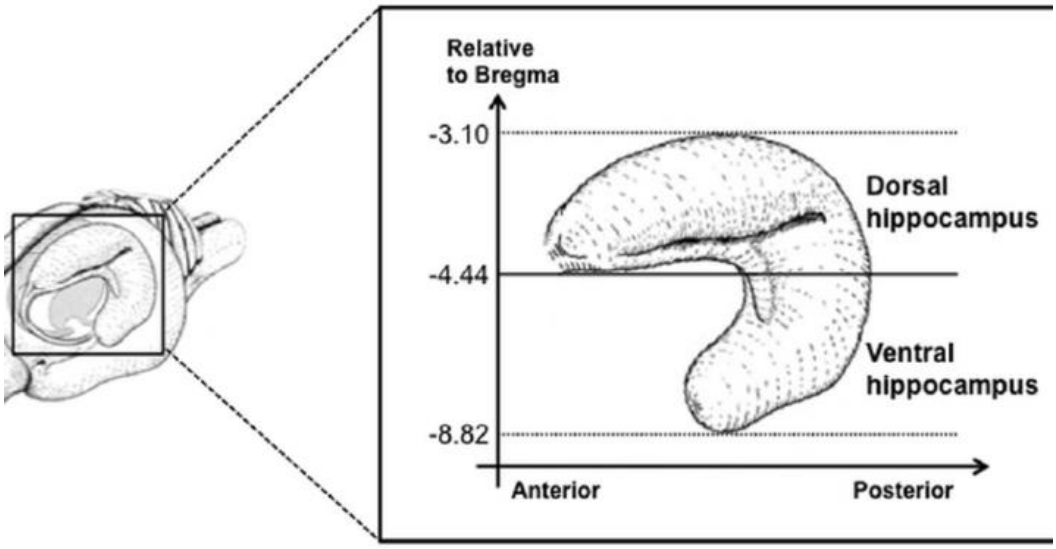


Figure 1: The dorsal and ventral parts of a mouse's hippocampus. (6)

This raised the question of what the ventral part is responsible for, if not memory. This became part of the research that they were doing, and helped them finally get funding for their PhDs. After they both received grants, they were introduced to John O'Keefe, who had just recently discovered place cells, and invited to do work with him in University College London (2). Place cells are hippocampal cells that fire specifically when the animal is at a certain location (3). When discovering the place cells, they made lesions to an area of the hippocampus that should have resulted in no spatial signals, but they were strangely still receiving them (1).

The obvious conclusion was that there was something else near the hippocampus that was also responsible for special coding and awareness. This led them to make lesions in the entorhinal cortex, where they then discovered grid cells. Grid cells are located near the hippocampus (where the place cells are) in the entorhinal cortex, and are also responsible for proprioceptive awareness (*see figure 2 below)*. In simpler terms, they are responsible for our brains and our bodies knowing where we are in space and recognizing our surroundings. They differ from place cells in that they don't fire specific

patterns at different places; rather they record the paces on a 'map' of the environment, hence the name grid cells.

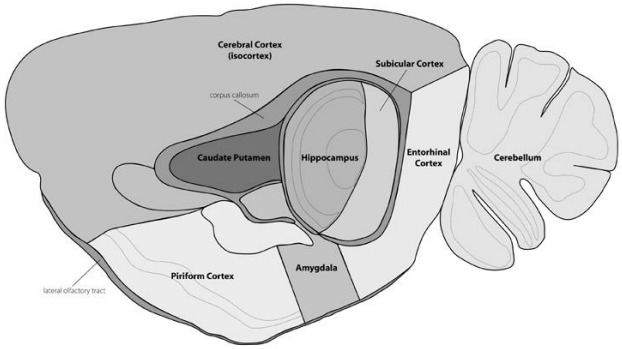


Figure 2: The entorhinal cortex, where the grid cells are located. (7)

After discovering grid cells in 2005, they won the Nobel Prize in 2014, along with many other prestigious awards (2). Some of these include- David Koetser Award for Brain Research, Perl/UNC Neuroscience Prize, 'Best female leader', and the Louisa Gross Horwitz Prize for Biology or Biochemistry. In fact, May-Britt Moser was so excited to accept the Nobel Prize, that she wore a gown designed after the neurons she and her colleagues found (See Figure 3). May-Britt and Edvard Moser are now cofounders of the Kavli Institute of Neuroscience and continue to pioneer in the field of neuroscience research (5). Their discovery was a major breakthrough in the scientific community because until now, it was unknown what part of our brain is responsible for our spatial awareness. This discovery is extremely important, especially to the scientists who work with neurodegenerative diseases, because if they know where some of the brain's functions stem from it can help them work on a way to fix them (4). Hopefully this new information can be utilized in discovering treatments, and maybe even cures, for neurological diseases.

Figure 3: May-Britt Moser's dress for the Nobel Prize Ceremony.

WORKS CITED

1. Moser, M.B., "Discovering Grid Cells." *Kavli Institute for Systems Neuroscience*. NTNU, Web. 20 Apr. 2017.
2. Moser, M.B. "May-Britt Moser - Biographical." *Nobelprize.org*. Science History Publications/USA, 2014. Web. 20 April 2017.
3. Moser, May Britt, Edvard I. Moser, and Charlotte B. Alme. "Place cells in the hippocampus: Eleven maps for eleven rooms." *Proceeds of the National Academy of Sciences of the United States of America*. HighWire Press, 8 Dec. 2014. Web. 14 May 2017.
4. Moser, May Britt. "Edvard and May-Britt Moser." *Edvard and May-Britt Moser | The Kavli Foundation*. Kavli Foundation, Web. 14 May 2017. (Source 4)
5. Rogers, Kara. "May-Britt Moser." *Encyclopædia Britannica*. Encyclopædia Britannica, inc., 04 Jan. 2017. Web. 14 May 2017.
6. Christensen, T., Bisgaard, C.F., Nielsen, H.B., Wiborg, O."Transcriptome differentiation along the dorso–ventral axis in laser-Captured microdissected rat hippocampal granular cell layer." *Neuroscience*, Oct. 2010, doi:10.7717/peerj.1072/supp-7.
7. "GENSAT Project at Rockefeller University." *GENSAT Brain Atlas*. N.p., 21 Aug. 2016. Web. 21 May 2017.
8. Hall, R.H. "Long Term Potentiation." *Missouri Institute of Science & Technology*, 1998, <web.mst.edu/~rhall/neuroscience/05_simple_learning/ltp.pdf> Accessed 21 May 2017.

MAKING SENSE OF SCENTS: LINDA BUCK

Lea Book & Dina Kalman

How many smells can humans detect? Have you ever smelled something and it reminded you of a certain time or place, but when you asked someone else to smell the same thing, their response was totally different? There's a particular way that the brain translates smells, and even though there is a science to show why someone will have derived their response to a certain scent, individual brains are one-of-a-kind, so each smell presentation is distinctive.

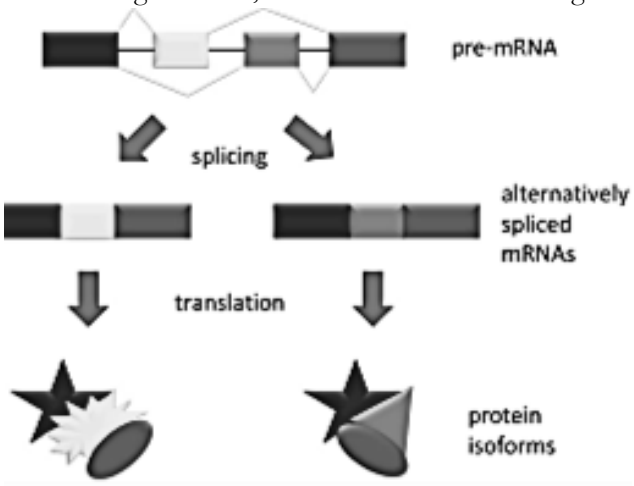
For instance, when one of the author's parents got divorced, she asked her father for a t-shirt of his, so that she may have his scent with her whenever she missed him. To her nose, the t-shirt smell reminded her of her father, but someone else who smelled the shirt would not have the same response.

Our sense of smell can even affect productivity in office environments. Certain smells have been proven to increase alertness, resulting in higher productivity. One study found that when lemon oil was diffused, productivity among subjects increased by 54%. In nursing homes and emergency rooms, lavender fragrances have been used to calm residents and worried visitors (9). Linda Buck together with Richard Axel were awarded the Nobel Prize in Physiology or Medicine in 2004 for their studies of how smells are distinguished in the nose and deciphered by the brain.

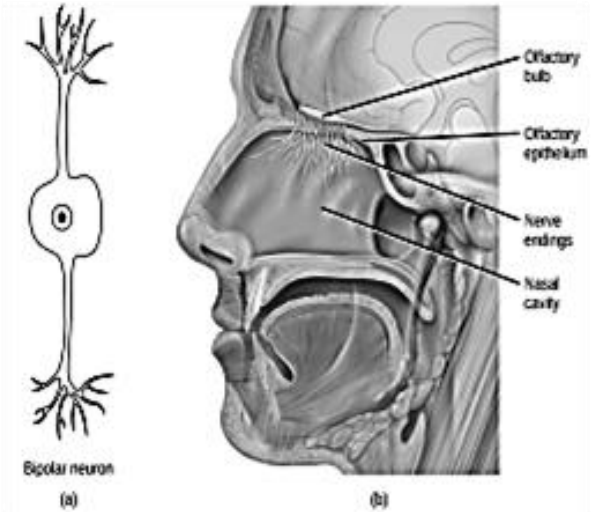
Very little was known about Buck's topic of research when she decided to become an olfactory scientist. At the University of Washington, where Dr. Buck received her undergraduate education, she majored in psychology, with the goal to become a psychotherapist (3). Even as a child, Buck wanted to have a career in which she assisted people, and her parents had always told her to aim for more. Buck ultimately found her calling when she took a course in immunology, which she found captivating, and from that class decided to become a biologist (4).

After an initial start in immunology research, Buck was influenced by David Hubel, who founded studies of the visual system with Torsten Wiesel, for which they won a Nobel Prize in 1981, to turn her attention towards neurobiology. In 1980, she studied molecular techniques from Jim Roberts in Columbia and even learned about neural development from neuroscientists Tom Jessell and Jane Dodd during that time (4). She later joined Richard Axel and Eric Kandel with molecular studies of the nervous system of *Aplysia*, a sea snail. This was the prototype organism that Kandel had used in numerous studies of his on learning and memory, for which he won a Nobel Prize in 2000. Eric Kandel's group explained to her how to isolate giant *Aplysia* neurons that had been assigned names and could be classified by their locations.

Within a relatively brief time, Buck began to reveal genes that were differentially expressed in *Aplysia* neurons. While analyzing a neuropeptide gene expressed in neuron R15 which codes for hormones that produce neuronal responses with slow onset and long duration, Buck determined that the gene was also expressed in some other neurons, but that its initial transcript was alternatively spliced in different neurons to give various polyproteins (see Figure 1). The two polyproteins could generate two different sequences of peptides in different neurons, suggesting a way to present physiological or behavioral programs with somewhat overlapping components (4).While working on the neuropeptide gene, Buck confronted numerous technical complications that developed her understanding of molecular biology and sharpened her skills (3).

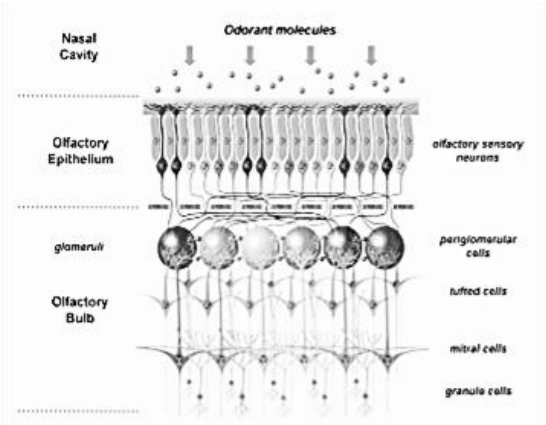


Near the end of her *Aplysia* project, Buck read a paper that, by her own statement, changed her life. The 1985 paper by Solomon Snyder's study group at Johns Hopkins University, addressed the likely mechanisms that might underlie odor detection (4). Olfactory transduction is when odorants (odor molecules) attach to odor receptors on the surface of the olfactory neuron and then are translated into nerve impulses. The impulses travel through the olfactory bulb which is a receptor that sends projections to the olfactory epithelium (see Figure 2). The olfactory epithelium is right below the brain and right above the olfactory bulb. The olfactory bulb has many types of olfactory epitheliums, which are each nerves that are sensitive to a certain odor molecule.



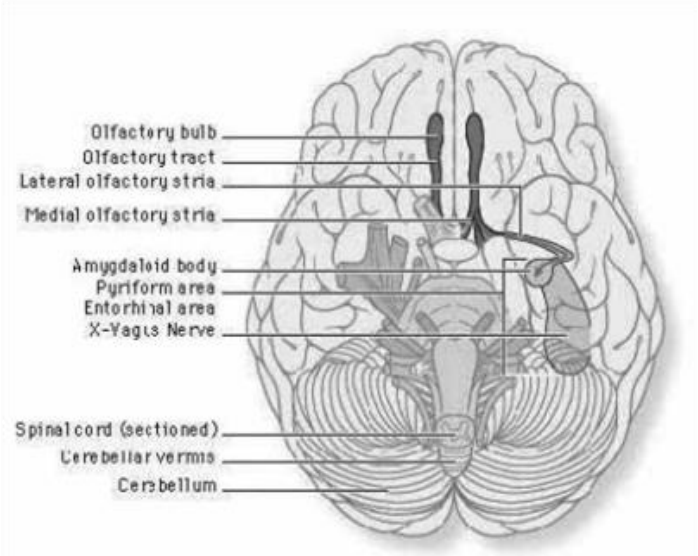
For example, when one smells benzene (a volatile organic compound with a ring-like chemical structure), the odor molecules enter the nose and bind to membrane surface receptors, which in turn activate all other molecules that are sensitive to benzene to move to one location in the olfactory bulb called the glomeruli. The glomeruli are a destination point for various olfactory cells that are sensitive to the same odor molecule. All of these benzene activated receptors synapse onto a cell which is known as the mitral or tufted cell (see Figure 3).

The glomeruli are a destination point for various olfactory cells that are sensitive to the same odor molecule. All of these benzene activated receptors synapse onto a cell which is known as the mitral or tufted cell (see Figure 3). The impulses from the mitral/ tufted interneuron cells enter the brain and enable the brain to perceive the odor (6). Dr. Buck had never contemplated the process before and was intrigued. In 1988, Dr. Buck set out to map the olfactory process — the sense of smell — at the molecular level, tracing the development of perceived odors through the cells of the nose to those of the brain.



Linda Buck and her colleague Richard Axel have completed many experiments in order to get to their current clarity on the olfactory system. One of their experiments was to grow olfactory receptors in vitro (a controlled experimental environment of a petri dish rather than in their natural setting within the organism). Buck bombarded the olfactory receptors with panels of odors and measured their response, which allowed her to characterize their molecular receptive range. She exposed these olfactory receptors to 73 distinct odor molecules. This led to the identification of 18 previously unknown odor-receptor pairs, adding to the 22 already known (1). An additional finding of the study was that if an allele variant conferred hypersensitivity, this hypersensitivity (reaction or intolerance) tended to be universal for all of the odorants bound to that receptor. This is also surprising because it implies that the recognition part of the receptor is not the most crucial part for functional variation (2).

Operating with the genes of a rat, Buck classified a family of genes that code for more than 100 odor receptors (ORs) (4). This work proved that the rat has a multigene family—a group of genes which were originally copies of the same gene but evolved by mutation to become different from each other—that codes for in excess of one hundred various odorant receptors, all linked, but each one unique (3). Dr. Buck's course of study is a unique, individual topic, yet also built around the established brain receptors. Following her fundamental discoveries of the means by which odors are identified by the nose, Buck set out to discover how these signals are observed and classified. It



was an astounding time for Dr. Buck. That same year, Buck became an investigator of the Howard Hughes Medical Institute, which has promoted her work ever since, and she met Roger Brent, a fellow scientist, who became her enduring companion (3).

The unprecedented scope and diversity of the family of rat genes classified told of the ability of mammals to recognize a vast collection of diverse chemicals as having distinct odors (3). Humans can identify or encode more than 10,000 different smells through these receptors (8). Buck would ultimately name genes responsible for 1,000 ORs in the mouse nose, and 350 in the human. Buck published her findings on the formation of olfactory impressions in the outer layer of neural tissue of the brain in 2001, concluding a decade of scientific achievement at Harvard (see Figure 4) (4). In her years at Harvard, Buck's group additionally investigated the chromosomal organization of OR genes and launched the investigation of the mechanism of taste (1). While still in college, her thesis advisor at the University of Texas Medical Center in Dallas, Ellen Vitetta, demanded perfection and exactness in analysis, habits that Buck considered valuable to learn as a student (4). In 2004, her hard work paid off, and the pioneering work she did on the mechanism of smell was praised with the Nobel Prize in Medicine.

Although Dr. Buck shares the 2004 Nobel Prize in Medicine with Richard Axel, which is an honorable achievement, Buck has recanted two papers published in 2005 and 2006. One in the *Proceedings of the National Academy of Sciences* (PNAS) and one in *Science*. The retractions came two and a half years after Buck withdrew a 2001 Nature paper co-authored with Zhihua Zou, a postdoctoral scholar in her then-Harvard lab. The article "Odor maps in the olfactory cortex," by Zhihua Zou, Fusheng Li, and Linda B. Buck reported how nerves that transmit information about scents connect from the nose to the olfactory bulb, where they are processed. They published that some cortical neurons (nerve cells that make up the cortex of the brain) express Arc, a gene needed to consolidate memories, in response to a mix of two odorants but not either odorant alone. Her laboratory had then been incapable of duplicating this conclusion. Buck regretted any confusion that has resulted from the publication of these papers, saying "It's disappointing of course. The important thing is to correct the literature." This means that Buck felt bound by her ethical and moral duty to disseminate correct science (5). Harvard University acknowledged her achievement with a spontaneous Doctor of Science degree in 2015. As Dr. Buck announced her findings, the response in the scientific community was unanimous; she was showered with every significant honor in American science (4).

The Jewish community in particular appreciates the significance of the sense of smell. The *ketoret* in the *Beit HaMikdash* and the *b'samim* during *Havdalah* both rely on the sense of smell to heighten our spirituality and our *neshamot*. With the withdrawal of *Shabbat* and the coming of another prosaic work week, our *neshama yeteira* departs, leaving behind a melancholy soul. The odoriferous smell of the *b'samim* soothes and consoles the soul at its most delicate position of the week (7). Just as when the author's parents got divorced and she had her father's t-shirt to smell whenever she wanted him, the fragrance of the *b'samim* lets us keep the scent of Shabbat with us all week. Exploring the olfactory system sheds light on the *niflaos haBoreh*. We often take senses such as our sense of smell for granted.

However, upon contemplating the true depth of science, we can gain new-found inspiration paired with an appreciation for Hashem's fascinating creations.

Linda Buck researched how odors are detected in the nose and interpreted in the brain. There's a certain way that the brain processes smells, but each brain is different, which makes each detection unique. Even as a girl, Buck wanted to have a profession in which she helped the greater public, and she has. As a female Nobel Prize winner who has collaborated with multiple scientists, analyzed problems, and even criticized her own work, Linda Buck has shown that "nothing in the world is worth having or worth doing unless it means effort" (Theodore Roosevelt).

WORKS CITED

1. Corey Binns, How We Smell, Live Science, May 22, 2006.
2. Lavi Secundo, Kobi Snitz, Kineret Weissler, Liron Pinchover, Yehuda Shoenfeld, Ron Loewenthal, Nancy Agmon-Levin, Idan Frumin, Dana Bar-Zvi, Sagit Shushan, Noam Sobel, Individual olfactory perception reveals meaningful nonolfactory genetic information, Proceedings of the National Academy of Sciences, 2015.
3. "Linda B. Buck - Biographical". Nobelprize.org. Nobel Media AB 2014. 3 April. 2017. Web. 9 March. 2017. <http://www.nobelprize.org/nobel_prizes/medicine/laureates/2004/buck-bio.html
4. "Linda Buck, Ph.D. Biography- Academy of Achievement." Academy of Achievement. 19 December. 2016. Web. 9 March 2017. <http://www.achievement.org/achiever/linda-buck/>.
5. Oransky, Ivan. "Nobelist Linda Buck retracts two studies on olfactory networks — and the news is embargoed." Retractionwatch.com Ed. Alison McCook. N.P., 3 Sept. 2010. Web. 9 March. 2017. <http://retractionwatch.com/2010/09/23/nobelist-linda-buck-retracts-two-studies-on-olfactory-networks-and-the-news-is-embargoed/>.
6. Ronald Sahyouni. Olfaction - Structure and Function. *YouTube*. Khan Academy, Oct. 24 2013.
7. Silberberg, Naftali. "The Incense (Besamim) and Havdalah Candle." chabad.org. 21 August. 2016. Web. 2 April. 2017. <http://www.chabad.org/library/article_cdo/aid/610826/jewish/The-Incense-Besamim-and-Havdalah-Candle.htm>.
8. Wilson, Jennifer Fisher. "The nose knows: how the olfactory influences conduct: researchers start to uncover how the sense of smell is involved in complex behaviors. (Research)." The Scientist, 10 December. 2001, p. 22+. Academic OneFile, go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nysl_me_queensb&v=2.1&id=GALE%7CA81106024&it=r&asid=0227b3ef39c9cca2cea5c30c1fb295a4. Accessed 2 Apr. 2017.
9. 5 Ways Your Sense of Smell Influences Your Everyday Life. *Ambius*. Ed. Sean Heffernan Development. N.P., Mar. 27 2013.
10. Figure 1- <https://www.bing.com/images/search?view=detailV2&ccid=1Cnhs2cx&id=825DC179F188D0D2213327AEE42D3A5666560978&thid=OIP.1Cnhs2cxkupdP-VF5nTlAQEsDW&q=Describe+mRNA+Splicing&simid=608043422105275986&selectedIndex=1&ajaxhist=0>.
11. Figure 2- Boundless. Reception and Transduction, May, 26 2016.
12. Figure 3- Dyad. How Do We Identify Specific Odors? *Monell Center*. Monell Chemical Senses Center, 2008.
13. Figure 4- <https://www.bing.com/images/search?view=detailV2&ccid=LRq1tm2v&id=A9D21DF0A12FBF3516AE5F2CE3C474A21E5DBE0F&thid=OIP.LRq1tm2v9Isr5pLPqYAwFQEsD4&q=olfactory+impressions+in+the+outer+layer+of+the+brain&simid=607995795210046382&selectedindex=6&mode=overlay&first=1>.

AMAZING GRACE: GRACE HOPPER

Avigail P. Deutsch

If Admiral Grace Hopper had been told that a student in 2017 would be writing a paper about her life on a computer, she would not have been surprised. Yet 73 years ago, Grace Hopper had just begun working as one of the first computer programmers on one of the very first computers. Built in 1944, Mark I had the very large dimensions of 5'x 8'x 8', was able to store 72 words, and perform three additions per second (1). At the time, computers were essentially giant calculators.

Even Howard Aiken, inventor of Mark I believed the function of a computer was nothing more than "makin' numbers" (2). But Grace Hopper believed that the future of computers relied on the existence of a coding language that can be understood by regular people, not just mathematicians and computer experts. She envisioned children of the future doing homework on computers and that one day the computer would be used by many people in their regular lives (1). Time has shown just how prescient and true her predictions were.

Grace Murray Hopper was born on December 9, 1906 in New York, New York. She was always a curious and inquisitive child, and was fascinated with electronic devices. At the age of seven, she took apart several alarm clocks throughout her house to find out how they work. Eventually, she was limited to experiment with one alarm clock after her mother found out, but her fascination with technology never left her (3).

Hopper received her MA and PhD from Yale University, and began teaching mathematics in Vassar College (1, 2, 7). It was there that Hopper's ability to articulate mathematical and scientific concepts in simple English terms became well known (7). However, during WWII, Hopper became dissatisfied with the life she was living and enrolled in the Naval Reserve at the age of 36 (2, 7). She was assigned to work with Harvard's Mark I where she worked with its creator, Howard Aiken (1, 2, 4, 7). Aiken encouraged her to write the first operating manual for Mark I, which began her lifetime hobby of writing about her own life and the struggles and triumphs of early computers (2).

Contrary to popular belief, Grace Hopper did not invent COBOL (Common Business Oriented Language), a coding language. Rather, she was part of a team that developed it. It was built upon her development of FLOW-MATIC, which allowed data to be called using English terms (6). This turned the previously linear, mathematical computer codes into a simple, user-friendly language almost like English, which was the basis for COBOL (5). COBOL was, and still is popular because it can process variables and different data. This means that multiple pieces of information can be inserted into the program to be called and manipulated at a later point.

This can be seen in Image 1, below, which is a fake code explaining to the computer how to hire an accountant. Several variables are set with English names, such as Accountant and Salary. In this segment of code, the variable Accountant is called and set to true, as well as other variables. When all the variables are true, the program is instructed to deduct from the value of the previously set variable Salary. Because of COBOL, these variables can be easily changed throughout the program, and are easy to follow.

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7--
       PROCEDURE DIVISION.
           SET ACCOUNTANT TO TRUE
           SET INEXPERIENCED TO TRUE
           SET WANTS-TO-STAYPUT TO TRUE

           EVALUATE TRUE       ALSO TRUE          ALSO TRUE
              WHEN  ACCOUNTANT ALSO EXPERIENCED  ALSO WILLING-TO-TRAVEL
                 MOVE 2000 TO SALARY
              WHEN  ACCOUNTANT ALSO INEXPERIENCED ALSO WANTS-TO-STAYPUT
                 MOVE 1000 TO SALARY
              WHEN COMPUTER-SCIENTIST ALSO ANY    ALSO ANY
                 MOVE 3000 TO SALARY
              WHEN SYSTEMS-ANALYST ALSO EXPERIENCED ALSO ANY
                 MOVE 4000 TO SALARY
              WHEN ANY              ALSO EXPERIENCED ALSO ANY
                 MOVE 500 TO SALARY
           END-EVALUATE

           DISPLAY 'SALARY = ' SALARY
           STOP RUN.
```

Additionally, COBOL can compute using decimal arithmetic which eliminates numbers, through rounding. However, as opposed to rounding where the value changes, with decimal arithmetic the value remains the same, but is easier to visually process and read. Image 2 to the left, shows a regular math problem of 1.005+1.005=2.100. The column next to it shows the same computation in decimal arithmetic form, where the computer rounds .005 to .01. However, the computer keeps track of the original value of the number, so the sum remains 2.01, and not 2.02, as would be expected. This programming language also produces an easily understood output (5). This worked well with Hopper's invention of a compiler. The compiler is a program that processes the source code (such as a COBOL program) and breaks it down into simpler machine commands. This allows the same source code to be used by multiple machines (6).

1.005	1.01
1.005	1.01
2.010	2.01

Decimal Arithmetic

Throughout her life, Grace Hopper strongly disapproved the excuse of "we've always done it this way". To prove her point, the clock in her office ran counter-clockwise so her colleagues would see that new ways could be adapted to in one is open to new ideas. She was an adventurous and proud woman and although she seemed frail and elderly in her advanced years, she remained independent and energetic (3). Hopper was an incredibly passionate woman, and in her later years enjoyed transmitting that passion to her audiences. She spoke to all kinds of people, but her favorite audiences were young women. No doubt, she inspired more women to enter the ever-expanding technological fields as professionals, or even as a hobby (6). In fact, the Grace Hopper Program is a unique educational coding course for women inspired by and in honor of this remarkable woman.

One of Hopper's dreams was to live to the year 2000. As she said, the New Year's parties on January 1, 2000 would put previous parties to shame. Additionally, it was believed that the 2 in the thousands place would cause a worldwide crash of all computers. (Obviously, the quick measures that were

enacted prevented that catastrophe). But she also explained that she wanted to show all those who doubted her how far computers had advanced. Although she lived to see many of her predictions for the technological world come true, this dream was not materialized. Grace Hopper died on January 1, 1992 and was buried in Arlington (8).

Admiral Grace Hopper changed the way technology advanced, and created the modern, technological society we live in. Her early work with compilers and programming paved the way for the multitudes of advancements that are so prevalent today. But most inspiring about Hopper was the way she followed her passion and dedicated her life to improvement. She didn't believe in quitting, and was forced to retire from the Navy twice due to her age (1). She was one of the first computer programmers and among the only females in the computer science industry when it began. Yet, she believed in herself, in her colleagues, and in progress, which is what eventually allowed her to progress. Grace Hopper became one of the only female rear admirals in history, allowed for computers to become so much more than giant calculators, and truly deserves the nickname which has been bestowed upon her; "Amazing Grace".

WORKS CITED:

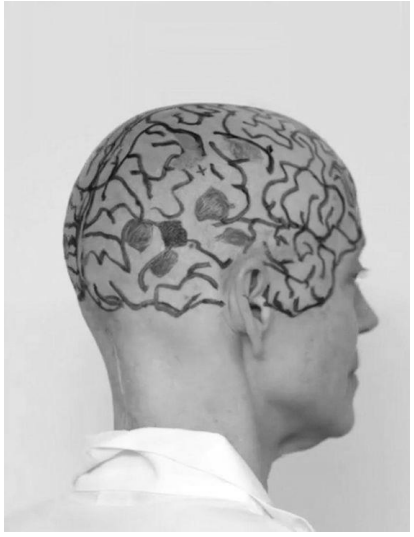
1. "About Grace Hopper." *CHIPS Articles: About Grace Hopper*. Ed. Sharon Anderson. CHIPS , 27 June 2011. Web. 14 Mar. 2017. <http://www.doncio.navy.mil/chips/ArticleDetails.aspx?ID=2265>.
2. Babb, Colin E. "Grace Hopper and Information-Age Invention." *Grace Hopper and Information-Age Invention*. Naval Science and Technology Future Force, 16 June 2014. Web. 14 Mar. 2017. <http://futureforce.navylive.dodlive.mil/2014/06/grace-hopper-and-information-age-invention/>.
3. Bass, Brad. "Hopper's vision keeps technology in perspective." *Government Computer News*, 19 June 1987, p. 31. *Academic OneFile*, i.ezproxy.nypl.org/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nypl&v=2.1&id=GALE%7CA5141489&it=r&asid=ce5544f0c6bd08f32d818617b4cc8ceb. Accessed 20 Apr. 2017. (9)
4. Dickason, Elizabeth. "Looking Back: Grace Murray Hopper's Younger Years." *CHIPS Articles: Looking Back: Grace Murray Hopper's Younger Years*. CHIPS, 27 June 2011. Web. 15 May 2017. <http://www.doncio.navy.mil/Chips/ArticleDetails.aspx?ID=2388>.
5. Glass, Robert L. "Cobol - a contradiction and an enigma." *Communications of the ACM*, Sept. 1997, p. 11+. *Academic OneFile*, Accessed 19 Apr. 2017. (8)
6. Headrick, Dan. "Presidential medal of freedom awarded to pioneering women in computer science." *Research-Technology Management*, Mar.-Apr. 2017, p. 5+. *Academic OneFile*, Accessed 19 Apr. 2017.
7. Markoff, John. "Rear Adm. Grace M. Hopper Dies; Innovator in Computers Was 85." *New York Times*. N.p., 03 Jan. 1992. Web. 19 Apr. 2017.
8. Sammet, Jean E. "Farewell to Grace Hopper - end of an era!" *Communications of the ACM*, Apr. 1992, p. 128+. *Academic OneFile*, i.ezproxy.nypl.org/login?url=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=nypl&v=2.1&id=GALE%7CA12068464&it=r&asid=b2d3c11e83077aa6c1c01e8ad7cb89ee. Accessed 20 Apr. 2017.
9. Image 1: http://lh3.ggpht.com/_sQvdFWqMlMg/S0Q1as7Q8yI/AAAAAAAABwY/TBeONeWKs3Y/Image63%5B1%5D_thumb%5B1%5D.png?imgmax=800
10. Image 2 based on: http://go.galegroup.com.i.ezproxy.nypl.org/ps/retrieve.do?tabID=T002&resultListType=RESULT_LIST&searchResultsType=SingleTab&searchType=BasicSearchForm&currentPosition=6&docId=GALE%7CA20378493&docType=Article&sort=Relevance&contentSegment=&prodId=AONE&contentSet=GALE%7CA20378493&searchId=R2&userGroupName=nypl&inPS=true

PUTTING ON A HAPPY FACE: NANCY KANWISHER

Nechama Flohr

At the sound of the bell, twenty rambunctious five year olds burst through the classroom door. The mothers waiting outside ran to greet their children. There was one, however, that held back. She scanned the room quickly, looking for the red ribbon she pinned to her daughter's hair as she dressed her that morning. There it is she noted with a sigh of relief; but the little girl's face was a mystery to her. What kind of mother could she be to be blind to her own child's face?

Our brains are largely a mystery to us. Although there have been countless discoveries that opened up our eyes to how our brains work, the more we learn about the human brain, the more we find out how little we actually know. One such scientist who is responsible for making boundless progress in the area of cognitive science is Nancy Kanwisher. Nancy Kanwisher was born in Massachusetts in 1958. She received her bachelors of science from MIT in 1980, and her Ph.D. in 1986 (also from MIT). She joined MIT's Brain and Cognitive Sciences department as a faculty member in 1997, previously she taught at Harvard and UCLA (2,3). As a professor at MIT, Dr. Kanwisher is known for her creative way of teaching. To teach her students where specific brain regions are, she had a graduate student shave off all her hair (during a class) and draw a "map" of her brain on her head, highlighting parts to show the different areas of her brain used for different functions. She previously had her brain scanned to guarantee the accuracy of the drawing (see below).



When a brain damage patient goes to a hospital their treatment options are often forced to remain within the boundaries of research done on other brain damage patients. Doctors also don't have the "before data" of their brain before the brain damage. Dr. Kanwisher wanted to get this "before data" of a functional brain, and use it teach her students. To do this she used Transcranial Magnetic Stimulation (TMS), a process in which magnetic fields are used to stimulate nerve cells in the brain. In one of her classes with the help of a grad student, a coil stick was placed on her head with a magnetic current running through it. This current affected neural activity in the region under the coil. Depending on the placement of the coil, fingers and feet involuntarily move.

Much of Dr. Kanwisher's research was done on prosopagnosia. Prosopagnosia, also known as "face blindness," is a condition in which a person is unable to recognize faces, even their own face in the mirror. All other similar cognitive functions, such as recognizing places and names remain intact, but faces are entirely unrecognizable. The term "Prosopagnosia" was coined by Joachim Bodamer, a German neurologist in 1947. There are two kinds of prosopagnosia, acquired and developmental prosopagnosia. Acquired Prosopagnosia is "acquired" through neurological trauma or illness. There is significantly more information known about this kind of prosopagnosia than developmental prosopagnosia, which we know very little about. However, there has been an increased awareness of developmental prosopagnosia in recent years. A few childhood cases have been reported, but many adults are not aware of their condition until they are much older. A few studies have attempted to find a cure for prosopagnosia with little or no success. In 1988 two scientists studied an eight year old with acquired prosopagnosia from anesthetic complications when the she was three. For eighteen months the subject (KD) underwent four training programs, all of which did not improve KD's face processing skills. In the 1990's scientists attempted to improve facial recognition skills in four adults with acquired prosopagnosia. They underwent training programs in which they tried to recognize the faces of famous people with similar occupations and other similar training. There was a slight improvement in their processing skills which were not maintained a few months later. More recent studies have made small improvements, but only for developmental prosopagnosia. (5)

Nancy Kanwisher uses fMRI (functional MRI) to study the brain. FMRI works by using a strong magnetic field and radio waves to pick up increased blood flow, detecting areas with heightened neural activity (1). It had been known for decades that people with damage to the back end of their right hemisphere, sometimes lost the ability to recognize faces. This was one of the reasons Kanwisher came to believe there is a specialized facial recognition area of our brain. She used fMRI to find out if this was really the case. Dr. Kanwisher used fMRI on herself to test if there was an area of the brain responsible for facial recognition. She found that a part of her brain looked like it had a higher response to faces than it did to objects. This process was repeated dozens of times showing the same results. But this still did not prove that there is a specialized facial recognition area of every brain; it could simply mean there was something unique with her brain. So Kanwisher and her colleagues tested loads of people and they all seemed to have a face processing region in similar parts of their brain (figure to the left).

Now the question was, perhaps this area responds to all body parts? But through fMRI Dr. Kanwisher found neural activity to be much stronger when subjects were shown images of faces, than if they were shown images of other body parts, such as hands, or if they were shown an image of an animal, or a cartoon image. While these finds are no doubt

amazing they still did not prove this region is *necessary* for the brain to recognize faces. The only way to prove it is indeed necessary would be to "mess" with that part of the brain. And while this can be done with animals such as mice, animals' brains are vastly different than ours and using animals would probably not prove much.

At this time Dr. Kanwisher and her team found out about a hospital patient with epilepsy. His doctor attached electrodes to the surface of his brain to locate the source of his seizures in hopes of stopping them. As it happened, the electrodes were put near the area of his brain believed to be for facial recognition. With his permission the electrodes were electrically stimulated on the supposed facial recognition area of his brain. For the second that the stimulation took place he was unable to recognize his doctor's face. This finally proved this area of the brain is indeed necessary for facial recognition (6, 7, 8).

When Nancy Kanwisher was conducting her research on Prosopagnosia, she found other areas of our brains responsible for highly specialized compartments, each for solving a specific problem. These areas all have the same approximate location in everyone's brain. For example she found a part of the brain for processing color, for processing landscapes, visual motion and body parts. It was previously know that there are specialized compartments in our brains, but Kanwisher's experiments showed just how many there are.

Her colleague, Rebecca Saxe found a region of the brain for when we think about what other people are thinking. The discovery of this area may be essential for progress in autism research. As far as scientists can tell, thinking about other people's thoughts is the core deficit of autism. Studying this area will very probably help autism research. Right now we know very little about autism. There are no theories about autism, and there is no way of telling if someone is autistic by looking at their genes or images of their brain. All we have is the clinical criteria for a diagnosis. Together with other scientists Nancy Kanwisher hopes to change this.

Kanwisher uses brain imaging to study what mental functions are preserved, what functions are impaired and which ones might be better than in a typical brain. She is studying the physical structure of the brains, size and structure; along with testing to see which regions activate when people do specific things. By doing this Dr. Kanwisher hopes to find a specific characterization and subtypes of autism; one of the biggest problems with current research in autism is that there are lots of different kinds of autism, and we don't know what they are. If Dr. Kanwisher is able to find out what they are this will be major progress for autism research, and for those with autism (9).

There had been an ongoing debate in the scientific community since the discovery of language center of the brain, called Broca's Area. (fig. 2 to the left) Questions arose on whether regions in Broca's Area are engaged solely in sentence processing, or if they are engaged in other functions as well (such as arithmetic, and in processing words and sounds). One of the arguments scientists who believed these regions are engaged in other activities too, was that previous studies did not show a stronger response when the

brain was processing language than when it was processing, for example, arithmetic. However, increased neural activity often does not show in a group analysis, although it is easily seen in individual subjects. Together with other scientists Kanwisher wanted to prove that these regions were responsible for only sentence processing. They presented evidence, (through the use of fMRI) of greater activity in the frontal regions of the brain when processing sentences than when processing words and sound. This showed that there are at least *some* regions in Broca's Area that respond more strongly to sentences than other language. (10)

Many people justify the huge expenditures of neuroscience research with the hopes that it will find a cure for brain disorders such as Alzheimer's disease, autism, epilepsy, ALS, and others. However, there is an even more compelling reason for neuroscience research. In *Breishit Perek 2 Pasuck 8, Hashem* blew the soul of life into the notsrils of *Adam* the and he became a living being. According to Artscroll Stone Edition, *Onkelos* translates this to be a "speaking spirit." A rational soul that is uniquely human has the ability to form intelligent speech and that is the defining factor which separates man from animal. We have seen that the brain is deeply involved in the power of speech, complex thought and cognitive awareness. Our brains are what makes us human and allow us to fully experience uniquely human endeavors, such as contemplation of the divine, self-awareness, empathy, creativity, mathematical reasoning….. (7). To paraphrase Nancy Kanwisher, what more noble quest than that can be found?

WORKS CITED

1. "What is fMRI?" What Is FMRI? - Center for Functional MRI - UC San Diego. N.p., n.d. Web. 21 May 2017.
2. "Kanwisher Lab." Kanwisher lab || people. N.p., n.d. Web. 21 May 2017.
3. "MIT Admissions." Q&A with Prof. Nancy Kanwisher '80 (CPW Preview!). N.p., n.d. Web. 21 May 2017.
4. Kanwisher , Nancy . "Nancy'sBrainTalks." The Neuroanatomy Lesson | Nancy'sBrainTalks. N.p., n.d. Web. 21 May 2017.
5. Bate, Sarah, Rachel Bennetts, Joseph A. Mole, James A. Ainge, Nicola J. Gregory, Anna K. Bobak, and Amanda Bussunt. "Rehabilitation of face-processing skills in an adolescent with prosopagnosia: Evaluation of an online perceptual training programme." Neuropsychological Rehabilitation 25.5 (2014): 733-62. Academic search premier . Web. 21 May 2017.
6. Bate, Dr. Sarah . "Information About Prosopagnosia." Prosopagnosia Research - About Prosopagnosia. Bournemouth University , n.d. Web. 21 May 2017.
7. Kanwisher, Nancy. "A neural portrait of the human mind." Nancy Kanwisher: A neural portrait of the human mind | TED Talk | TED.com. TED, n.d. Web. 21 May 2017.
8. Kanwisher , Nancy . "Nancy'sBrainTalks." Home | Nancy'sBrainTalks. MIT, n.d. Web. 21 May 2017.
9. Mittechtv. "Meet Nancy Kanwisher." YouTube. YouTube, 18 Jan. 2012. Web. 21 May 2017.
10. Fedorenko, Evelina, and Nancy Kanwisher. "Some Regions within Broca's Area Do Respond More Strongly to Sentences than to Linguistically Degraded Stimuli: A Comment on Rogalsky and Hickok ()." Journal of Cognitive Neuroscience 23.10 (2011): 2632-635. Web. 21 May 2017.

THE EVEREADY BUNNY: HENRIETTA LAKS

Esther Guelfguat

In the mid-1900s, long before the institution of consent forms and HIPPA laws, a woman by the name of Henrietta Lacks was diagnosed with cervical cancer (6). This seemingly small incident on the surface does not seem very impacting. However, the day that a small sampling of cells was taken from her would transform biological research and ultimately raise an uproar in future years.

The story begins with an African American woman, named Henrietta Lacks, see figure 1, below. Lacks was a tobacco farmer in Maryland and mother of four children when one day she felt unwell. She then proceeded to the nearest hospital that catered to African Americans, John Hopkins Hospital. After being admitted, a portion of her cells was handed over to Dr. George Gey to be examined. For the past 30 years he, along with his wife Margaret, had worked on culturing cancerous cells outside the human body without success. In fact Dr. Gey considered himself "the world's most famous vulture, feeding on human specimens almost constantly"(6).That simple act of handing over Lack's cells to Dr. George Gey was the beginning of the HeLa cell saga.

The process of culturing tumor cells is quite difficult and the percentage of success is extremely low. Many cells can't reproduce because of genetic, phenotypic insufficiencies or lack of nutrition. Additionally, many times there is a defilement of a specimen by other cells such as endothelial cells, which make up the lining of blood vessels. When testing such a solution, these cells can respond to cancerous cell division. This will skew the results of the research and therefore, cannot be used. The art of finding the exact balance that will yield more cells is still a topic of research today (3).

Contrary to normal expectations, Lacks's cells kept growing, even doubling. These cells were nicknamed HeLa, making up the initials of their ancestor. Dr. Gey discovered that the HeLa cells would grow until there was no more culture medium. This was a tremendous revelation in the science world since now potentially harmful experiments could be done safely on HeLa cells instead of humans. Instantly, Dr. Gey informed all his fellow scientists about what he called "his precious babies". Upon their request he shared with them a sampling. Meanwhile, Lacks remained bed

stricken in the hospital unbeknownst to the fact that her cells were being cultured and shared with others (6).

Soon HeLa cell's use in the laboratory spread throughout the country and then the globe. Their uniqueness included the fact that HeLa cells grow exceedingly fast, so results can be procured at a higher rate. Additionally, they are not expensive since they were accessible everywhere. Since all the science labs spanning the globe used the same cells, same culture medium and same equipment for their experiments this served as a control and a basis for comparison. It would not even matter if the trial failed since there is an endless supply at a very cheap cost (6).

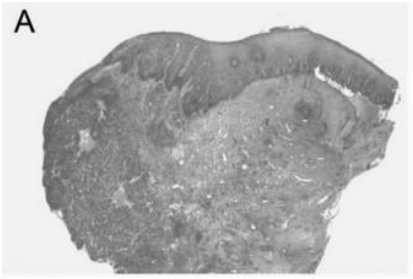


Figure 2 - A sampling of the biopsy taken from Lacks

After Lacks's death, preparations were made for the building of a HeLa cell factory in Tuskegee, Alabama, in which 20,000 vials of cells would be produced each week. Soon the experiments began to come out with revolutionary findings. First, scientists cut the HeLa cell in half in order to prove that cells can live without a nucleus. They used this finding to create new methods for feeding material into cells without destroying them. The National Foundation for Infantile Paralysis was investigating the Salk vaccine for polio, it tested it on HeLa cells and thereafter the vaccine was proven to be effective saving many lives. Similarly, the effects of steroids, chemotherapy drugs and vitamins and environmental stress were tested on HeLa cells (6).

Throughout the years many cell lines and experiments have been contaminated with HeLa cells since they were used worldwide. For example, in 1974 the USSR sent America five human cell lines which they claimed were of human descent combined with animal viruses. All these cell lines were found to be contaminated with HeLa cells. This revelation led to skepticism in the science world as to whether or not other studies have been compromised. Therefore, new methods of discerning contamination have been developed. For example, Short Tandem Repeat Profiling is used in molecular biology in order to compare two samples of DNA and make sure that no undesired strand is found. The difficulty lies in the fact that this methodology is not yet universally used, so contamination may still be lurking in the background. Due to the increased awareness of cell contamination, more and more steps are being taken to prevent it from happening (2).

One may wonder if the fact that Lacks was an African American was the cause of such violation of privacy. Upon being diagnosed, Lacks did not question her doctor's verdict since she was illiterate and had never learned science before. In fact, due to lack of education, Lacks was very reluctant to go to John Hopkins Hospital all together and only proceeded to go once the situation was very dangerous. Her doctor documented that she was not treated any differently than white patients (6). However, in a historical survey done by the National Medical Association it has been found that in most hospitals blacks were not deemed normal, so dangerous and experimental studies were done on them without their knowledge. For example, the infamous Tuskegee experiment, conducted by the National Institute

of Health, lasted from 1930 to 1970. Under the guise of receiving free health care by the US government, five hundred rural, poor and illiterate blacks who were infected with a communicable disease, were left untreated so that the natural progression of the disease could be charted. Despite the ready availability of penicillin, many of these men died horrible deaths. Even in the early 20th century, textbooks and journals were full of racist and discriminatory connotations of African Americans. During this time medicine was distributed exclusively to elite. Interestingly, John Hopkins Hospital, where Lacks was treated, was considered the spear-head and guide of all medical schools for 70 years. When it initially opened there were segregated classes, hospitals and medical staff. It was only in the 1960's when the American government announced that such discrimination is illegal (1).

Although Lacks's saga is now history, its repercussions are still felt today. HeLa cells are the drive for bioethical questions and patient privacy laws (7). The controversy became especially evident when the European Molecular Biology Laboratory issued the entire genome of the HeLa cells without consent of Lacks's family (5). Currently, the family is requesting privacy on the matter while the courts of law are investigating the matter. In truth, like her cells, which keep going and going like the Eveready battery bunny, the past is much alive.

WORKS CITED

1. Bryd, Michael W.,Clayton, Linda A."Race,Medicine and Health Care in the United States: A Historical Survey".Journal of the National Medical Association. March 2001.
2. Hutchins, Grover M., Lucey, Brendan P., Nelson-Rees, Walter A.Henrietta Lacks, HeLa Cells, and Cell Culture Contamination.Arch Pathol Lab Med.Vol 133.September 2009.
3. Montagna, Daniela." In Vitro Expansion of Tumor Cells Deriving from Different Types of Human Tumor Cells". Medical Sciences. 26 March 2014.
4. Skloot, Rebecca. "An Obsession with Culture". University of Pittsburgh.March 2001.https://www.pittmag.pitt.edu/mar2001/culture.html.
5. Skloot, Rebecca."The Immortal Life of Henrietta Lacks, The Sequel ".The New York Times.23March,2013.http://www.nytimes.com/2013/03/24/opinion/sunday/the-immortal-life-of-henrietta-lacks-the-sequel.html
6. Skloot,Rebecca.The Immortal Life of Henrietta Lacks".Crown Publishers,2010. New York
7. Venzke, Debra. "The Lasting Legacy of Henrietta Lacks".The University of Iowa".7 October,2013.https://now.uiowa.edu/2013/10/lasting-legacy-henrietta-lacks

Figure 1- http://ictr.johnshopkins.edu/consulting/consulting-services/research-participant-and-community-partnerships-core/community-resources/the-henrietta-lacks-memorial-lecture/henrietta-lacks/

Figure 2- http://www.archivesofpathology.org/doi/pdf/10.1043%2F1543-2165-133.9.1463?code=coap-site

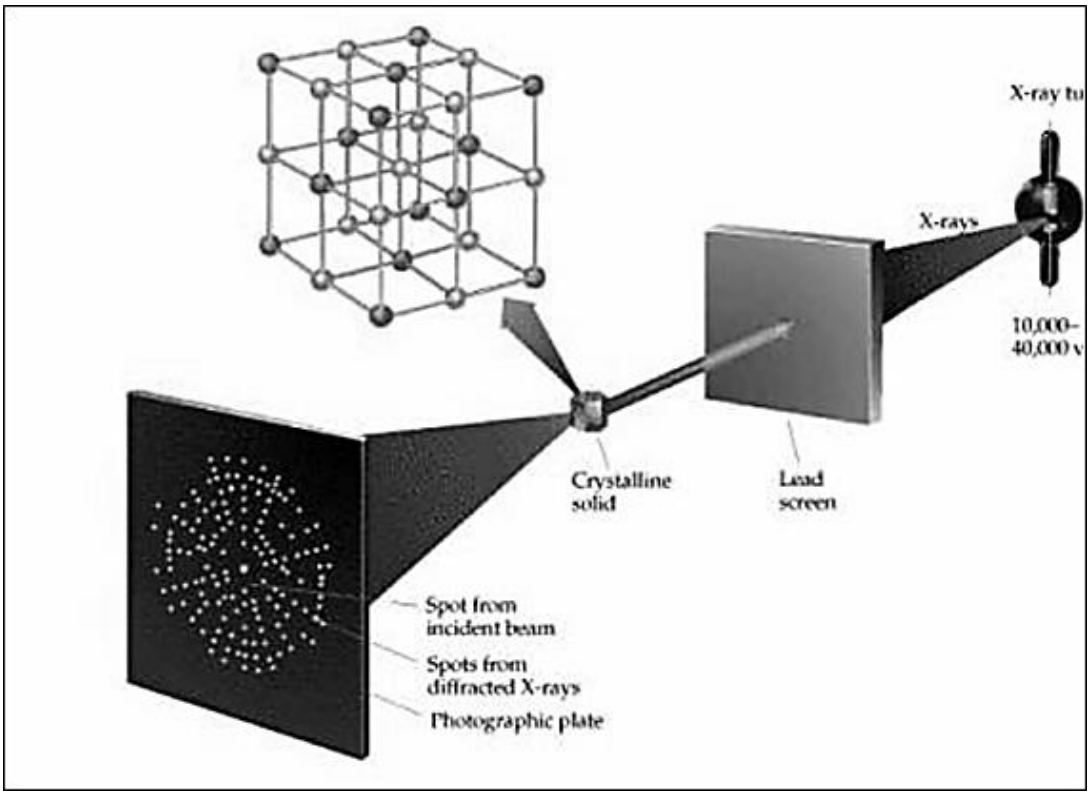
X MARKS THE SPOT: ROSALIND FRANKLIN

Daniella Kestenbaum

Discovering something so important, yet never receiving the proper credit, Rosalind Franklin, was a chemist most famous for her contribution to science known as Photo 51. Franklin's "Photo 51" led to the discovery of the DNA double helix. However, Franklin never received acknowledgement for her work during her lifetime and was never aware her model of DNA precipitated the discovery of the double helix. Her work proved to be very instrumental in the understanding of DNA and continues to be relevant today, long after she has passed away.

Rosalind Franklin was born on July 25, 1920 in London, England to a prominent Jewish family. She attended St. Paul's School for Girls, where she showed a great love for math and science. She then attended Newnham College at Cambridge University where she majored in physical chemistry (8). Franklin received her BA in 1941, and was awarded a scholarship for an additional year of research. She spent this year in the laboratory of R. G. W. Norrish, who was a major contributor to the photochemistry field (8). She then worked for a coal research company where she studied the structure of carbons and coals. From 1947-1950, she worked at a Paris laboratory where she learned techniques for X-ray crystallography. In 1950, she received a scholarship to work at King's College in London where she worked as a researcher in John Randall's laboratory. Franklin worked there with a new graduate named Raymond Gosling to investigate DNA. Together, Gosling and Franklin discovered that there were two forms of DNA, wet and dry, which produced very different pictures in Franklin's x-ray diffraction photos of DNA (2).

Rosalind Franklin began using x-ray crystallography which is a way of viewing the three-dimensional atomic and molecular structures of crystalline atoms. Being able to view the structure of atoms or molecules opened up the doors for scientists to understand the makeup and the properties of atoms and to understand the differences between elements and structures. In X-ray crystallography the crystals cause x-rays to diffract into different, specific areas based upon the structure of the crystal. When an x-ray beam is directed at crystals, geometric images and patterns get reflected on photographic sheets that lie behind the crystals. Different crystals produce different patterns and understanding these differences gave scientists a way of analyzing the structures of the matter being viewed (1) (See graphic below).

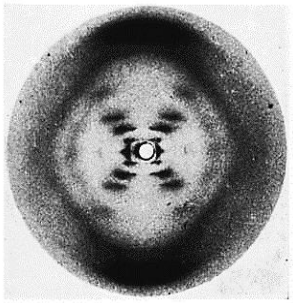


Franklin was advised by Randall, the lab chief, to use x-ray crystallography to begin investigating DNA, which she did. At the same time, Maurice Wilkins was working at that lab, also studying DNA, but he was away when she was given this assignment. When he returned, he thought she was an assistant and did not realize that they were really colleagues. This misunderstanding would soon have unfortunate consequences for Franklin (3).

Franklin first began her study of DNA by removing DNA from a cell and converting it into crystal form so that it could be analyzed with x-ray crystallography (7). While doing this research along with Raymond Gosling, she also studied the DNA crystals in high humidity and noticed that their structures changed. This made her realize that there are two forms of DNA, a shorter dry A form and a longer wet B form (6). This helped clarify matters for scientists who had previously been confused by images they had seen of DNA since those images were a mixture of both types (5).

Simultaneously and unbeknownst to Franklin, Francis Crick and James Watson were working together on producing a DNA model. Later, in January of 1953, without Franklin's knowledge Wilkins showed Franklin's very clear x-ray diffraction photo of the DNA structure to Watson and Crick (Photo 51) (See figure to the right). The reason for Wilkins' betrayal of Franklin was reflective of the time period, as well as a miscommunication between Randall, the director of King's Medical Research Council with Wilkins. Franklin also worked in a laboratory at a time where women didn't usually work in science and were treated and viewed as second to men. Furthermore, Franklin was quick, intense, and direct,

but Wilkins was indirect, and slow. Also, Randall wrote a letter to Franklin, assigning her to work with DNA, without informing Wilkins and without informing Franklin of Wilkins' interest in DNA (3).



This iconic photo, with its distinctive X pattern, helped Watson and Crick discover the existence of the famous "double helix" structure of DNA. They also read a summary of Franklin's unpublished research which gave them more crucial information that they needed in determining the structure of DNA. However, years later, when Watson and Crick received the Nobel Prize for developing a DNA model, they never acknowledged their debt to Franklin's work. In fact, Crick later revealed that Franklin was two steps away from realizing the correct DNA structure in 1953.

Many people believe that Rosalind Franklin should have been nominated for the Nobel Prize, because it was her work that led to the discovery of the structure of DNA. However, a few years before Watson and Crick were nominated Franklin had already passed away. Due to the rule that only a living person can be awarded the Nobel Prize it wouldn't have been possible for Franklin to receive the award (4). If Franklin's x-ray diffraction photo of the DNA structure had not been shown to Watson and Crick she most likely would've been the one to receive the credit for discovering the double helix.

After Franklin's 1953 DNA discoveries of DNA's structure, Franklin transferred her fellowship to J. D. Bernal's crystallography laboratory at Birkbeck College, where she studied the structure of plant viruses, specifically tobacco mosaic virus (TMV) and polio. Working with future Nobel Prize winner Aaron Klug, Franklin used x-ray diffraction to photograph the viruses. She again made important discoveries, this time about these viruses. This work was also recognized when she was honored by the Royal Institute in 1956 and in 1958, she built large-scale models of the structure of the viruses for the Brussels World's Fair Science Exhibition (8).

Later that year, on April 16, Rosalind Franklin died at the age of 38 from ovarian cancer, likely caused by her frequent exposure to radiation as a result of her research (2). Franklin's untimely death prevented her from having the satisfaction of knowing the significance of her discoveries and research in DNA. Although, Franklin's contribution to DNA was never properly acknowledged during her lifetime, there is no doubt today that Rosalind Franklin's work is the reason for the discovery of the DNA double helix. Rosalind Franklin has left an everlasting mark with her many significant contributions that will always be essential to science.

WORKS CITED

1. "A fun and easy way to remember 'X-ray Crystallography' in Biology." October 9, 2013. Web. 14 May 2017. https://www.memrise.com/mem/2206739/x-ray-crystallography/
2. Bagley, Mary. "Rosalind Franklin: Biography & Discovery of DNA Structure." *LiveScience*. Purch, 19 Sept. 2013. Web. 14 May 2017. http://www.livescience.com/39804-rosalind-franklin.html
3. Elkin, Lynne Osman. "Rosalind Franklin and the Double Helix." *Physics Today*, vol. 56, no. 3, Mar. 2003, p. 42.
4. Fredholm, Lotta . " The Discovery of the Molecular Structure of DNA - The Double Helix." *Nobelprize.org*. 30 Sept. 20013. Web. 14 May 2017. https://www.nobelprize.org/educational/medicine/dna_double_helix/readmore.html
5. Gibbons, Michelle G. "Reassessing Discovery: Rosalind Franklin, Scientific Visualization, and the Structure of DNA." *Philosophy of Science*, vol. 79, no. 1, Jan. 2012, pp. 63-80.
6. "Photo 51." *Wikipedia*. Wikimedia Foundation, 06 May 2017. Web. 14 May 2017. https://en.wikipedia.org/wiki/Photo_51
7. Rapoport, Sarah. "Rosalind Franklin: Unsung Hero of the DNA Revolution." *History Teacher*, vol. 36, no. 1, Nov. 2002, p. 116.
8. "The Rosalind Franklin Papers: Biographical Information." *U.S. National Library of Medicine*. National Institutes of Health, n.d. Web. 14 May 2017. https://profiles.nlm.nih.gov/ps/retrieve/Narrative/KR/p-nid/183

WAZE FOR A CELL: AVIV REGEV

Chedvah Lamm

Crediting women in the science field is only a recent phenomenon. While Anton LaVoisier was publicly acknowledged as father of chemistry, his uncredited wife, Marie Anne Pierrette Paulze, was the true mastermind behind his accomplishments. Like many other women throughout history, Marie Paulze was never recognized for her contributions to science.

Marie Curie a scientist in the late 19th century, was one of the first publicly acknowledged women scientists in history (5). The science being studied today is very much to the credit of Marie Curie. Her legacy lives on as many women achieve success in the world of science.

One honorable modern scientist, Aviv Regev, has made incredible contributions to her field of study, computational biology (2). Aviv Regev is a computational biologist at the Broad Institute as well as a professor of biology at MIT (2). She is a Howard Hughes Medical Institute Early Career Scientist (HHMI) (3). At HHMI they give awarded researchers money, equipment, a lab, and a full salary to use for their main focus of study. Regev uses bioinformatics and experiments to discover how genes change themselves when affected by shifts in the environment (10). She received the NIH Director's Pioneer Award, the International Society for Computational Biology awarded her the Overton prize, and she was granted the Earl and Theresa Stadtman Scholar Award from the American Society of Biochemistry and Molecular Biology.

Aviv Regev was born in Israel in 1971 (11). She attended Tel Aviv University, where she received her M. Sc. and studied biology, computer science, and math. She went on to receive her PhD. in Computational Biology (2). Computational Biology is the utilization of mathematics, computer science, and statistics in the study of biology (7). Today, most scientific research is done based on the collecting and analyzing data, and using the result to make predictions which can then be tested experimentally in the

Figure 1 (8). In this painting of Anton LaVoisier and his wife Marie Anne Pierrette Paulze, LaVoisier gazes up at his wife as if asking for her approval as she stares confidently into the distance.

laboratory. Computational biology or bioinformatics uses these skills to study biology. This has been proven to be the most effective form of research. It can help identify genes that cause diseases and discover codes that make genes function or malfunction (8).

Regev attempts to systemically describe all the cellular interactions at the system level and abstract out their essential qualities and express them in mathematical terms of equations and algorithms. Algorithms are like the Waze navigational software for getting to your destination; they are set of step by step instructions to solve a particular mathematical problem. She can then manipulate the variables in her equations to predict outcomes. These predicted outcomes can then be tested in the laboratory. Just as Waze uses feedback from actual motorists to refine their directions to better accommodate real road conditions, the results of her experiment are then be used to refine her algorithms so that they more closely approximate the real cellular world (17).

Dr. Regev was recruited by Harvard for a Bauer Fellowship where she worked creating algorithms for cell circuitry to uncover undiscovered circuits and pathways. Her algorithms are so universal that they are being used in labs all over the world today to solve issues in biology, in addition to the ones for which her algorithms were originally designed. She is testing her hypothetical circuits in the areas of Multiple Sclerosis and Rheumatoid Arthritis, in actual cells, to confirm that her hypotheses work (15).

In addition, Regev is trying to discover certain diseases and traits that are caused by different parts of the immune system. By doing this, she can work backwards and examine statistics or look at numbers and mechanics to understand how the disease reached that point. She can then treat the part of the immune system that caused the disease to occur. By examining what led to that result, she can trace back using the data and find a way to cure that disease (1).

In 2006, Regev set up her own lab in MIT and Broad Institute where she tested her algorithms in yeast cells and T-helper cells. Currently, she is directing a project in The Cell Observatory at the Broad Institute which will classify and chart every circuit in human cells (3). (See Figure 2 below).

As Director of the Klarman Cell Observatory at the Broad Institute, Aviv Regev works with Orit Rosenblatt-Rosen, Itay Tirosh, Benjamin Izar, Alex Shalek, and Levi Garraway. Together they use analysis of single cells to research cancer. They are currently studying how T cells affect cancer and how they react to the medication. T-helper cells enlarge the response of the immune system by perceiving antigens that are foreign in the body and they then cause other T-cells to turn on and proliferate (13). By studying each individual tumor cell, they can understand which method is most effective in eradicating these cells. They are trying to attack one cell at a time to fully obliterate the cancer more effectively.

The other lab headed by Levi Garraway has been researching Melanoma and the resistance to drugs, while the Regev lab has been studying single cells (12). These two labs are collaborating using their different fields of expertise to draw a conclusion and come up with useful results. The Garraway lab has influenced Regev's work in single-cell research, by providing information about the disease that they took them many years to develop.

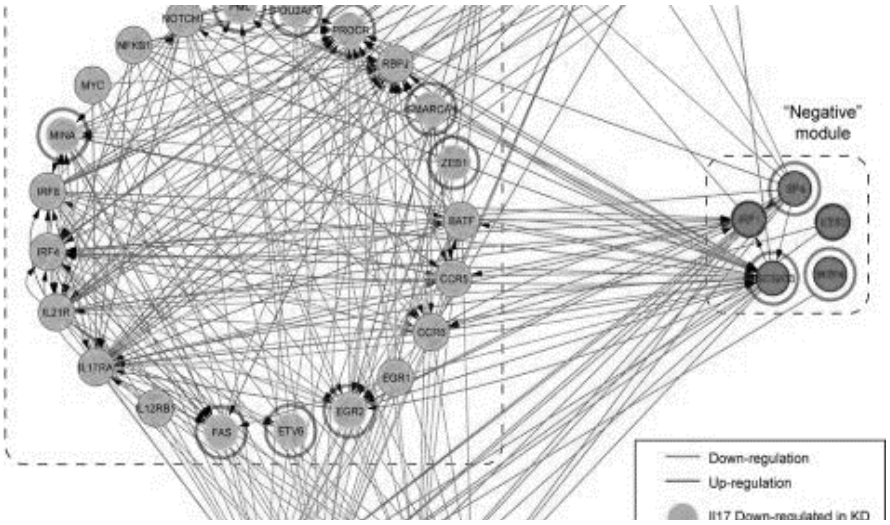


Figure 2 (4) The Th17 cell in the cell circuit changing from one cell to another has two groups, blue nodes that are positive regulators and red nodes that represent negative regulators. The negative regulators turn off the gene expression while the positive regulators turn on the gene expression. By turning on the gene expression the cell can change and cause transcription.

The Regev lab uses the information about the cells of a tumor and how they react to treatment, to further their study. They can eventually reach their goal in finding the most effective method to destroy the cancer cells. Through their work together they have created a potential treatment. The immunotherapy drug to treat melanoma harnesses the power of the body's own immune system to encourage T-cells to kill the cancer cells instead of a foreign force, for example chemotherapy or radiation that kill the cancerous cells directly (12). Today science is a combined effort of many scientists and teams working together cooperatively. During the times of Benjamin Franklin, scientists worked in isolation. This shows the change from science viewed as an isolated field to an open collaboration of people.

Although Aviv Regev is a very successful scientist she faces social challenges in the scientific field. Some issues that impact her life as a scientist can be in her own laboratory. This male-dominated field can be hard to navigate as a woman especially as the head of a lab. Women are still underestimated for their abilities and capabilities in science and many other work fields (14). Although there are some difficulties in this area she has managed to accomplish a lot even with these social pressures.

When Aviv Regev first entered the field of bioinformatics, the term was so new that it had only been coined about 20 years earlier. The information that was known about bioinformatics before Regev entered the field was that living structures take in information, process it, and bank it to be utilized at a later time (9). Today Aviv Regev has contributed to this field by disrupting these systems so that she can better understand bioinformatics. Through perturbing genes which causes autoimmune disorders like multiple sclerosis and inserting them into a mouse, Regev is able to study gene expression. Aviv Regev was able to understand the genes that were expressed by the T-cells in these systems (6).

Aviv Regev continues to study and experiment in computational biology. She is an accomplished woman still paving her path in scientific research. Regev has proven that women in science have exceptional talents and skills that would never be discovered if not for their entry to the world of science. Beginning with Marie Curie and continuing with Aviv Regev, hardworking talented women bring the world scientific advancements and knowledge as never seen before.

WORKS CITED

1. Nature Reviews Immunology. Vol. 11 Issue 12. Dec 2011. Amit, Ido Regev, Aviv Hacohen, Nir <http://web.a.ebscohost.com.i.ezproxy.nypl.org/ehost/detail/detail?vid=1&sid=c20bcfb9-7c2b-4d6c-8524-44dfc455e25e%40sessionmgr4008&hid=4209&bdata=JkF1dGhUeXBlPWNvb2tpZSxpcCx1cmwsY3BpZCZjdXN0aWQ9bnlwbCZzaXRlPWVob3N0LWxpdmU%3d#AN=67482955&db=aph>.
2. "Aviv Regev, Ph.D. Core Institute Member, Chair of the Faculty, Co-director of the Cell Circuits Program." *Broadinstitute.org*. Broad Institute, Nov. 2015. Web. 25 Feb. 2017. https://www.broadinstitute.org/bios/aviv-regev
3. "Aviv Regev, PhD." *www.hhmi.org*. Howard Hughes Medical Institute, 2014. Web. 7 Mar. 2017. http://www.hhmi.org/scientists/aviv-regev
4. Regev, Aviv. "Reconstruction of Dynamically Rewiring Circuits: From Population to Single Cells." *Http://www.hhmi.org*. Howard Hughes Medical Institute, 12 Apr. 2016. Web. 15 May 2017. <http://www.hhmi.org/research/reconstruction-dynamically-rewiring-circuits-population-single-cells>.
5. "Biographies of Women in Science." *Www.eiu.edu*. Ed. Eastern Illinois University. Eastern Illinois University, Web. 19 Apr. 2017. <http://www.eiu.edu/wism/about_biographies.php>.
6. Blum, Amy E. "Researcher Interview: Aviv Regev." *www.cancer.gov*. National Cancer Institute, 15 Aug. 2016. Web. 2 Mar. 2017. https://www.cancer.gov/about-nci/organization/ccg/blog/2016/aviv-regev-interview
7. Cornell University. "Computational Biology." *Bscb.cornell.edu*. Cornell University College of Agriculture and Life Sciences, Web. 4 Apr. 2017. <https://bscb.cornell.edu/about/computational-biology>.
8. David, Jacques Louis. *Antoine Laurent Lavoisier (1743–1794) and His Wife (Marie Anne Pierrette Paulze, 1758–1836)*. 1788. The Met, New York. *Http://www.metmuseum.org*. The Met. Web. 27 Apr. 2017. <http://www.metmuseum.org/art/collection/search/436106>
9. Hogeweg, Paulien. "The Roots of Bioinformatics in Theoretical Biology." *http://journals.plos.org*. PLOS Computational Biology, 31 Mar. 2011. Web. 16 Mar. 2017. http://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.100202
10. "3 MIT faculties named HHMI Early Career Scientists." *News.mit.edu*. Massachusetts Institute of Technology, 26 Mar. 2009. Web. 5 Mar. 2017. <http://news.mit.edu/2009/hhmi-early-0326>.
11. Regev, Aviv. "Curriculum Vitae of Each Applicant." *Personal.broadinstitute.org*, 8 Sept. 2010. Web. 20 Apr. 2017. <https://personal.broadinstitute.org/mgarber/cherry813.pdf>.
12. "Taking on melanoma, one cell at a time." *http://news.mit.edu*. Ed. News Office. Massachusetts Institute of Technology, 7 Apr. 2016. Web. 2 Mar. 2017. http://news.mit.edu/2016/melanoma-cancer-one-cell-time-personalized-medicine-0307
13. "T Cells." *Www.nationalmssociety.org*. Ed. National Multiple Sclerosis Society. National Multiple Sclerosis Society, Web. 19 Apr. 2017. <http://www.nationalmssociety.org/What-is-MS/Definition-of-MS/T-cells>.
14. "Top Issues and Solutions for Women Faculty in Science and Engineering." *Gender.stanford.edu*. Clayman Institute for Gender Research, Apr. 2006. Web. 15 Mar. 2017. <http://gender.stanford.edu/sites/default/files/TitleIXTopIssues.pdf>.
15. University of Utah. "10 ALGORITHMS THAT ARE CHANGING HEALTH CARE." *Http://healthsciences.utah.edu*. University of Utah, Web. 14 May 2017. <http://healthsciences.utah.edu/innovation/tenalgorithms/>.
16. Whitesides, George M. "The origins and the future of microfluidics." *Gmwgroup.harvard.edu*. Nature Publishing Group, 2006. Web. 5 Apr. 2017. <https://gmwgroup.harvard.edu/pubs/pdf/960.pdf>.
17. Regev, Aviv, and Ehud Shapiro. "Cells as Computation." *Nature* 419.6905 (2002): 10.1038/419343a. *PMC*. Web. 7 June 2017. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3842595/>

GROWING MORE RADIANT EACH DAY: MARIE CURIE

Rivka Lax

"Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less" (2). This was Marie Skłodowska-Curie's attitude which led her to greatly impact science and through that, the world. Marie Curie was raised in a time during which it was very challenging to be a woman in science.

In the nineteenth century, it was presumed that women were not physically, or mentally able to enter the workforce. There were no laws yet against the abuse of wives or children, in fact, if a woman ran away, her husband could legally track her down and return her as if she were an owned possession. There was even a popular book titled *"The Physiological Feeble-Mindedness of Women."* This inferior image of women portrayed at the time made it challenging for any woman to be taken seriously (4).

Marie Skłodowska was born in 1867 in Warsaw, the youngest of five children, to parents of French and Polish nationality. Both her parents were school teachers; she was said to have learned from her father who was a teacher of math and physics. At the young age of 11, her mother succumbed to tuberculosis (2). After graduating high school, Marie Curie was denied admission to either a Russian or Polish University because she was a woman. This caused her to have a mental breakdown for a year. As a result of her being rejected by the university, she worked for several years as a tutor and governess. She continued to study math, physics and chemistry on her own, during her free time. She had to work for many years as a governess to save up her money to travel to a different country to study at a foreign school which was open to women. Yet even there it was still uncommon to find women interested to study science. In 1891, she went to Paris and enrolled in the Sorbonne and became the first woman to teach there. Of the 2,000 students enrolled at the School of Sciences at the Sorbonne, only 23 were women. Marie Curie was one of only 2 pursuing a degree in science (3).

Later, she met a professor in the University's school of physics, Pierre Curie. She received her Master's degree in physics a year before her marriage to him. In 1894, Marie Curie also achieved another degree, this one in Mathematics. They married in July of 1895. With monies they received as wedding gifts, the Curies bought two bicycles and would ride together, their only form of relaxation in lives otherwise completely filled with their scientific work and studies(2). In 1896, Professor Henri Becquerel discovered radioactivity. He had known that the rays were able to pass through solid matter and caused air to conduct electricity (5). Marie Curie decided to investigate these uranium rays using an electrometer which was built by Pierre and his brother. Marie Curie identified a new way to discover elements by measuring their radioactivity.

As she continued to analyze various chemical compounds, Marie Curie discovered that the amount of radiation did not depend upon whatever compound she was studying but was only based upon the

amount of uranium or thorium it contained. From this, Marie Curie concluded that the ability to generate radiation had to be based on the actual composition of the atom. This was a revolutionary discovery and is viewed as her most important contribution to the development of physics. She went through the whole periodic table and found that only uranium and thorium gave off this radiation (5).

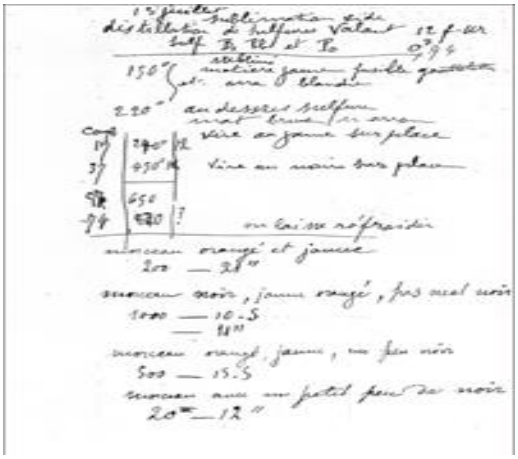


Figure 1 - First mention of polonium, "Po" in the laboratory notebook of Pierre and Marie Curie, 13 July 1898. https://www.iupac.org/publications/ci/2011/3301/5_adloff.html

Next, Marie Curie thought to study the actual ores which contain uranium and thorium. After getting samples from geological museums she found that of all the ores, pitchblende was four to five times more active than the amount of uranium it contained. It was her hypothesis that a new element that was considerably more active than uranium was present in small amounts in the ore. On 18 July 1898, Pierre and Marie Curie wrote to the *Comptes Rendus de l'Académie des Sciences*, "On a new radio-active substance contained in pitchblende. We believe that the substance we recovered from pitchblende contains a heretofore unknown element, similar to bismuth in its analytical properties. If the existence of this new metal is confirmed, we propose that it be named polonium in honor of the native land of one of us" (2). The symbol Po, written by Pierre Curie, appears in the notebook on 13 July (see Figure1)

The name polonium had a special significance because Poland had stopped appearing as a state since 1795 when it was divided between Prussia, Russia, and the Austrian Empire (1). It was also in this work that they used the term *radioactivity* for the first time. After another few months of work, the Curies informed the *l'Académie des Sciences*, on December 26, 1898, that they had identified an additional substance that behaved chemically almost like pure barium and suggested the name of *radium* for the new element.

In order to prove it was a new element, the Curies had to isolate a significant amount to be able to determine its atomic weight. To perform this, they would need tons of the costly pitchblende. It was known that at the Joachimsthal mine in Bohemia large slag-heaps had been left in the surrounding forests; Marie Curie thought there would be radium left in the residue. After testing a sample, she found the slag to be even more active than the original mineral. Her husband understood her determination to commit to her research, and he understood her intense need to isolate the new elements. He even persuaded the President of the Academy of Science of Vienna, Eduard Seuss, to obtain pitchblende from the Austrian government at no cost. This led to their access to several tons of pitchblende. He then went Baron Edmond Rothschild for donations to pay for the cost to transport this material (3).

At this point the Curies realized that they needed more room to continue their work. The principal of the school where Pierre worked gave them access to a large shed. They began working on separating and analyzing the pitchblende. The steps involved much physical work and required many tons of material. Marie Curie processed 20 kilos of material at a time and Pierre would measure the results after each step. First she cleared away the pine needles and then would boil it and stir it with a heavy iron rod. She started doing it herself and was very exhausted, "Sometimes I had to spend a whole day stirring a boiling mass with a heavy iron rod nearly as big as myself. I would be broken with fatigue at day's end," she wrote. Her husband saw her condition deteriorate and was worried for her health. He decided to raise money to hire an assistant for her to help with the physically demanding work (2).

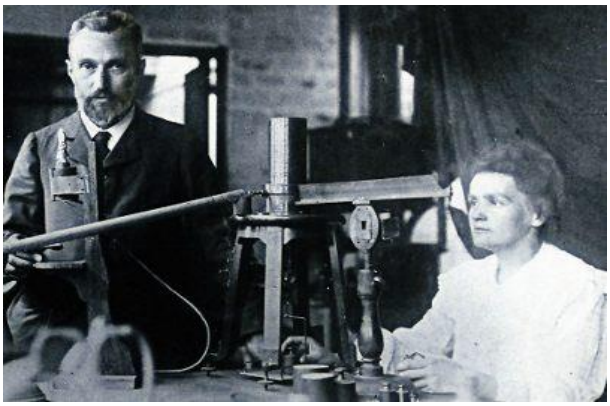


Figure 2- Marie and Pierre Curie in their laboratory https://www.famousscientists.org/marie-curie/

The floor of the shed they worked in was made of asphalt and it had a glass roof which did not provide complete protection against the rain. Although it felt like a hothouse in the summer, drafty and cold in the winter; in that shed the Curies reported that they spent the best and happiest years of their lives and devoted themselves to work long days (see Figure 2). Sometimes due to the weather they could not do their processing outdoors, they just opened the windows to let out the toxic gases (2).

Figure 3-Radium hands from 1940-1950's watches. (Photo licensed under Creative Commons, author: Mauswiesel, November 2011) https://www.nobelprize.org/educational/nobelprize_info/curie-edu.html

The only furniture they had were old worn wood tables upon which Marie Curie worked with her expensive radium fractions. Since they had no shelter to store their precious products they would arrange them on tables and boards. Marie Curie described the joy they felt when they came into the shed at night, seeing "from all sides the feebly luminous silhouettes" of the products of their work. The dangerous gases contained, among other things, radon, a radioactive gas which is still of concern today, since small amounts are emitted from certain building materials. The Curies had no idea of the harmful effects of the radiation on their health. "Pierre, who liked to say that radium, had a million times stronger radioactivity than uranium, often carried a sample in his waistcoat pocket to show his friends. Marie Curie liked to have a little radium salt by her bed that shone in the darkness." Henri Becquerel had by accident developed a burn in response to carrying a sample of radium salt in his vest pocket. After this incident occurred he went

to tell the Curies this dangerous effect of radium saying "I love it, but I owe it a grudge" (4). In fact the Curies left notebooks of their work from December 1897 to 1900 at the *Bibliothèque Nationale*. Anyone wishing to review them has to sign a certificate that they do so at their own risk. People will have to do this for a long time to come. In fact it takes 1,620 years before the activity of radium is reduced to a half(5).The harmful effects of radium were unknown to the extent that watch hands were painted in it so they would glow in the dark (*see Figure 3)*

Wilhelm Ostwald, a highly regarded German chemist, was one of the first to realize the importance of the Curies' research. He traveled from Berlin to Paris to see how they worked. When he arrived, neither Pierre nor Marie Curie was at home. He wrote: "At my earnest request, I was shown the laboratory where radium had been discovered shortly before ... It was a cross between a stable and a potato shed, and if I had not seen the worktable and items of chemical apparatus, I would have thought that I was been played a practical joke"(2).

The Curies made major contributions to the fields of chemistry and physics. Although the physicists believed Marie Curie Curie's discovery because they were working with the properties of rays, the chemists remained disbelieving until they had physical proof to weigh and measure. So once she delivered these isolated elements, her revelation of these new elements was undisputed. This achievement won her the Nobel Prize in Physics in 1903, making her the first woman to win the Nobel Prize. She won the Davy Medal in 1903 as well. Later on, in 1911, she won a second Nobel Prize in Chemistry after the realization of the significance of her discovery of polonium and radium to the field of chemistry (5). Due to prolonged exposure to radiation, Marie Curie died of aplastic anemia in 1934 at the age of 66 in Passy, Haute-Savoie, France, where she had gone to regain her strength (4). Marie Curie's determined attitude towards her research and science was what enabled her to contribute immeasurable discoveries to science. Albert Einstein says about her "Not only did she do outstanding work in her lifetime, and not only did she help humanity greatly by her work, but she invested all her work with the highest moral quality. All of this she accomplished with great strength, objectivity, and judgment. It is very rare to find all of these qualities in one individual" (4). Her accomplishments are not only recognized by the science community but by the world at large. The New York Times wrote on July 5, 1934, in her obituary "She not only conquered great secrets of science but the hearts of the people the world over" (4).

WORKS CITED

1. Adloff, J.P., K.H. Keller, and G. Stöcklin, eds. 1996. One hundred years after the discovery of radioactivity. Special issue of *Radiochimica Acta*. Chemistry International.
2. Curie, Eve. *Madame Curie. A Biography. Translated by Vincent Sheean. Illustr*. New York, Doubleday, Doran & Comp, 1937.
3. Goldsmith, Barbara. *Obsessive Genius: The Inner World of Marie Curie Curie*. New York, NY, W.W. Norton & Company, 2005.
4. "Marie Curie." Famous Scientists. famousscientists.org. 8 Sep. 2014. Web. 5/13/2017 <www.famousscientists.org/marie-curie/>.
5. "Marie Curie and Pierre Curie and the Discovery of Polonium and Radium." *Nobelprize.org.* Nobel Media AB 2014. Web. 5 Apr 2017. <http://www.nobelprize.org/nobel_prizes/themes/physics/curie/

SOME NERVE: RITA LEVI-MONTALCINI

Leora Lehrfield

A famous scientist once said, "Think of the future that awaits you and do not fear anything." This scientist could have told this to her twenty-year-old self when she was just entering the beautiful world of scientific study. Rita Levi-Montalcini had much to fear, having been born in 1909 Italy into a society that practiced gender discrimination at home, in the workplace, and especially in academia.

What was more, Italy was on the verge of experiencing a wave of Jewish persecution that barred Jews from holding many professions. Despite this, all Rita Levi-Montalcini thought about was her brilliant future, which pushed her hardships and fears to the side.

Ever since her childhood governess, whom she had grown quite close to, died of cancer, Levi-Montalcini was determined to study medicine and become a doctor (6). However, she was born into a Victorian-style home, and her father believed pursuing a profession was not a woman's duty. When she was twenty, Levi-Montalcini fought her first battle against discrimination and finally convinced her father to enroll her in the medical school of the University of Turin, where she studied biochemistry and cell physiology under Giuseppe Levi (2).

Levi-Montalcini continued to struggle against gender discrimination and even anti-Semitism, too, while she learned at the University, but was somewhat protected by Professor Levi (5). He was the one who encouraged her to study different cell types *in vitro*, which allowed her to later make the groundbreaking discoveries of the functions of nerve growth factor (NGF) (4). She graduated in 1936 with a degree in medicine and surgery, and then enrolled in a specialization of neurology and psychiatry (2).

Dr. Levi-Montalcini was still unsure whether she should pursue a medical profession or further her research in neurobiology. Italian law decided for her: *Manifesto per la Difesa della Razza,* ("the Manifest of Race"), passed in 1938, restricted Jews from academic or professional careers, forcing her to leave her studies of neurology in the university and to continue to study in private instead. Even as Italy's laws restricted the lives of its Jews, Levi-Montalcini defeated its attempts and was determined to further her neurological studies. During the early years of World War II, she studied neurobiology of chick embryos in her cramped, homemade bedroom laboratory in which she had only an incubator, a microscope, and a microtome (2). As bombs fell repeatedly onto the city, she lugged her microscope and slides to the basement each time, ensuring that they remain intact (1). She was inspired to study the neurobiology of chick embryos after reading embryologist Viktor Hamburger's works. But later on, their roles were reversed: it was Levi-Montalcini who inspired he who had first inspired her. Hamburger was intrigued by the publications of her bedroom-lab experiments and conclusions, and, two years after the war ended, he sent a one-year invite to Levi-Montalcini, asking her to work alongside him in Washington University in St. Louis. She agreed, and their enthusiasm in their studies led Levi-

Montalcini to stay there for 30 years (2). The research she conducted during WWII, a time of misery, laid the groundwork for much of her later research that won her a Nobel Prize during a far happier and more peaceful time in her life.

As Levi-Montalcini's years passed, she was persistently bombarded with challenges, each harsher than the next. But her determination to succeed in her research despite the skepticism and doubt in the world of academia, and despite the trauma of WWII, yielded a most crucial scientific discovery. Undeterred by the numerous blockades in her life, specifically in her studies, Rita Levi-Montalcini provided the scientific world with incredible discoveries. What she is most famous for is her and Stanley Cohen's discovery of nerve growth factor, for which they became Nobel laureates in 1986. Winning them the Nobel Prize in Physiology or Medicine, the discovery of NGF and its multiple functions was of vital importance to the world of science, especially in the medical field. Its discovery broadened scientists' understanding of many disease states such as "developmental malformations, degenerative changes in senile dementia, delayed wound healing and tumor diseases" (7).

With colleague Pietro U. Angeletti, Levi-Montalcini performed and recorded a fascinating experiment proving NGF's function of the proliferation and survival of sympathetic and sensory neurons. Their article "Essential role of the nerve growth factor in the survival and maintenance of dissociated sensory and sympathetic embryonic nerve cells *in vitro*" explains the procedure and its results: 200 samples of sensory nerve cells from chick embryos were placed into two culture dishes. 10% horse serum was added to one (the control group), and the nerve cells grew, but were round without any nerve fibers growing from them. By the end of the second day, all of the nerve cells had undergone degeneration (Fig 1). However, the second culture dish, supplemented with nerve growth factor, showed very different results: these cells grew immensely and their fibers lengthened, making a fibrillar net with clusters of nerve cells at the nodal points (Fig 2). The same procedure was done with 50 samples of sympathetic nerve cells and had parallel results (3).

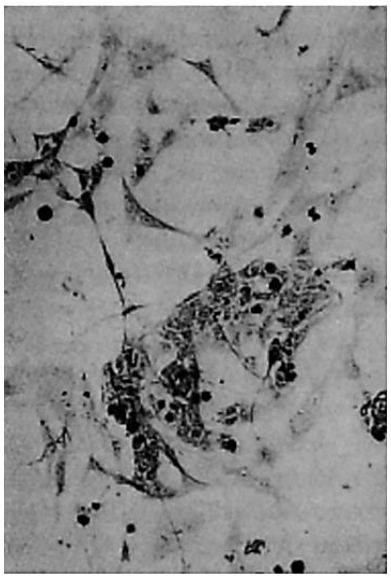


Fig 1: Two-day cultures of chick embryos' sensory neurons in 10% horse serum

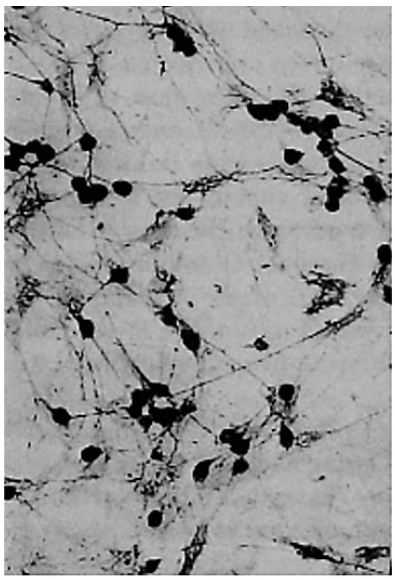


Fig 2: Two-day cultures of chick embryos' sensory neurons in NGF

The NGF gene provides instructions to make the nerve growth factor beta (NGFβ), which stimulates proliferation, growth, and differentiation by binding to neurons' receptors. NGFβ can bind to two kinds of receptors found on neurons: the neurotrophic receptor tyrosine kinase 1(NTRK1) receptor and the p75 neurotrophin receptor

(p75NTR). When NGFβ binds to NTRK1 (the gene that codes for the TrkA protein), signals are sent through the nerve cell to grow, mature, and take on a specialized function (Fig 3).

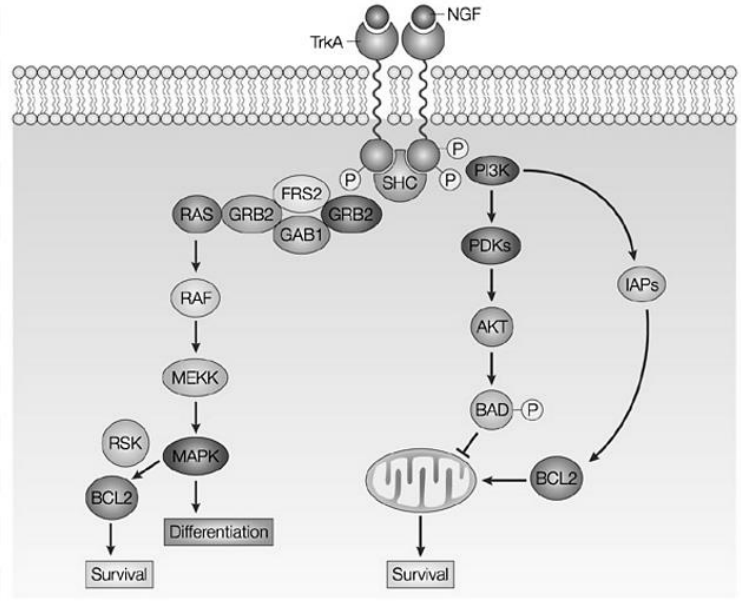


Fig 3: NGF bound to TrkA (protein coded by NTRK1), resulting in cell survival

This binding of NGFβ and NTRK1 also blocks signals that stimulate apoptosis, programmed cell death. Apoptosis is crucial to the balance of cells in a tissue. The number of programmed cell deaths balances the rapid cell division that occurs each second. During embryonic development, apoptosis is essential to synaptic pruning, a process which improves neuronal transmissions by eliminating excess neurons and synaptic connections. Newborn neurons "compete" with one another, each trying to "connect with [their] predetermined targets." The neurons that succeed receive trophic, or nourishing, factors (for example, NGF) and those that don't undergo apoptosis, so that only the functioning ones survive, and neuron growth is controlled (8). However, too much apoptosis would result in a neuron decrease, and therefore both growth and apoptosis must be controlled. Studies have shown that not only does NGF regulate growth, maintenance, proliferation, and survival of neurons, but it is so essential that in its absence, sympathetic and sensory neurons undergo apoptosis.

These discoveries have clarified the causes of many diseases and have been used in the development of many medications. Behind these discoveries is scientist Rita Levi-Montalcini, and behind this scientist is a story. Her story portrays her fascination in neurobiology and her determination to withstand difficult times, both in her personal life and on a national level. Levi-Montalcini not only coped, but thrived despite those hardships. She defied the societal beliefs at the time that women were not meant to study science or pursue professional careers. She was Jewish by identity and succeeded in her scientific career despite anti-Semitism of the mid-1900s.

Levi-Montalcini's life of 102 years was exceptionally full. It was filled with defiance against discrimination, with prevalence through war and its anti-Semitism, with several scientific awards and honors, with political titles, and with inspiration for multitudes of females and scientists and female scientists. She died December 30th, 2012, making her the longest living Nobel Laureate. As Rita Levi-Montalcini said, "Above all, don't fear difficult moments. The best comes from them," as her life so accurately portrayed.

WORKS CITED

1. Holloway, Marguerite. "Finding the Good in the Bad: A Profile of Rita Levi-Montalcini." *Scientific American*. Nature America, Inc., 30 Dec. 2012. Web. 14 Apr. 2017. https://www.scientificamerican.com/article/finding-the-good-rita-levi-montalcini/
2. Levi-Montalcini, Rita. "Rita Levi-Montalcini - Biographical." Nobel Prize. Ed. Wilhelm Odelberg. Nobel Media AB, 2014. Web. 21 Feb. 2017. https://www.nobelprize.org/nobel_prizes/medicine/laureates/1986/levi-montalcini-bio.html
3. Levi-Montalcini, Rita, and Pietro U. Angeletti. "Essential role of the nerve growth factor in the survival and maintenance of dissociated sensory and sympathetic embryonic nerve cells in vitro." *Developmental Biology*7 (1963): 653-59. *Research Gate*. Web. 18 Apr. 2017. https://www.researchgate.net/publication/9637197_Essential_role_of_the_nerve_growth_factor_in_the_survival_and_maintenance_of_dissociated_sensory_and_sympathetic_embryonic_nerve_cells_in_vitro
4. Maramorosch, Karl, and Gordon H. Sato, eds. *Elsevier*. 1st ed. Vol. 7. RELX Group: Academic Press, 1989. Web. 15 Mar. 2017. http://www.sciencedirect.com/science/article/pii/B9780120079070500153
5. "Rita Levi-Montalcini." *Famous Female Scientists*. WPtouch Mobile Suite for WordPress, 2015. Web. 16 Mar. 2017. http://famousfemalescientists.com/rita-levi-montalcini/
6. Tang, Joyce. "Levi-Montalcini, Rita." *American National Biography Online: Levi-Montalcini, Rita*. Oxford University Press, Feb. 2000. Web. 14 Apr. 2017. http://www.anb.org/articles/13/13-02688.html
7. "The Nobel Prize in Physiology or Medicine 1986." Nobel Prize. Ed. Magnus Gylje. Nobel Media AB, 2014. Web. 21 Feb. 2017. https://www.nobelprize.org/nobel_prizes/medicine/laureates/1986/
8. Kong, Rowena, and Irwin Feinberg. "Why Is Synaptic Pruning Important for the Developing Brain?" Scientific American. Nature America, Inc., 27 Mar. 2017. Web. 25 May 2017. https://www.scientificamerican.com/article/why-is-synaptic-pruning-important-for-the-developing-brain/

Figs 1, 2: https://www.researchgate.net/publication/9637197_Essential_role_of_the_nerve_growth_factor_in_the_survival_and_maintenance_of_dissociated_sensory_and_sympathetic_embryonic_nerve_cells_in_vitro

Fig 3: http://www.nature.com/nrc/journal/v3/n3/fig_tab/nrc1014_F4.html

X-RAY VISION: DOROTHY HODGKIN

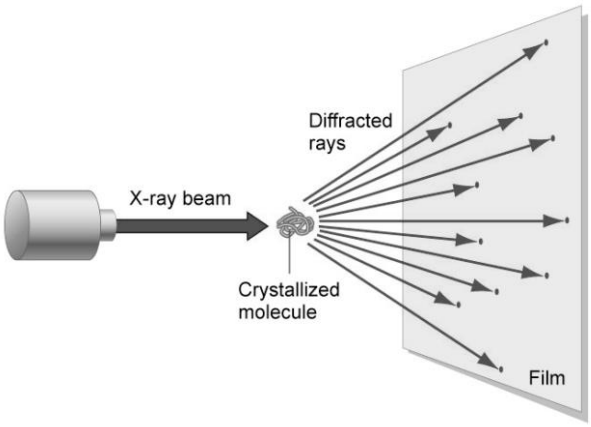
Minka Nussbuam & Tzophia Ulano

Little girls with dreams become women with vision. From the young age of 10, Dorothy Hodgkin was interested in chemistry and crystals. Her passion for science lived on from her childhood through her life as an adult, and soon was one of the most prominent women scientists. This was just the beginning of a girl following her childhood dreams to achieve something great.

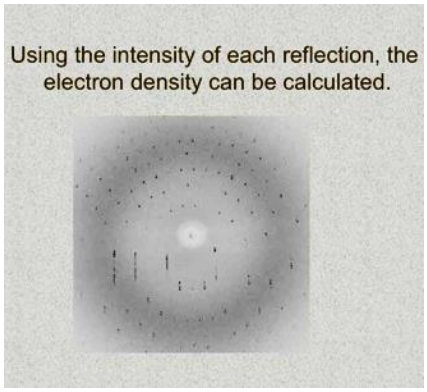
Born in Cairo in 1910 to parents John Winter and Grace Mary Crowfoot, Dorothy Hodgkin was brought up in a home that valued education and hard work. Her father worked for the Egyptian Educational Services and was later transferred to work in Sudan. Once in Sudan, Crowfoot became the Director of Education and Antiquities. Dorothy Hodgkin frequently visited the Sudan and acquired a strong love for her country. Her mother was a botanist and was intrigued by the country's flora and drew murals of them, which may have instilled a further appreciation for science in Dorothy.

Although Hodgkin was fascinated by archaeology, she went into the chemistry field, encouraged by Dr. A.F. Joseph, a friend of her parents in Sudan. He provided her with chemicals and helped her study and analyze ilmenite, a titanium-iron oxide mineral (1). Hodgkin attended school at Sir John Leman School in the UK where she was given the special opportunity to study chemistry along with the boys. At the age of 15, Sir William Henry Bragg, who won a Nobel Prize in physics with his son William Lawrence Bragg, gave her a copy of "Concerning the Nature of Things", and was captivated at the thought of being able to study atoms, and molecules using x-rays. She continued her education at the age of 18 at Somerville College, Oxford University where she studied archaeology and chemistry combined. She also took special courses in crystallography and following her tutor, F.M. Brewer's advice, went on to further her research in X-ray crystallography. She learned how x-ray crystallography is used to learn the structure of proteins, while being supervised by John Desmond Bernal. She assisted Bernal in the application of x-ray crystallography to pepsin, an enzyme that breaks down proteins into smaller peptides (amino acids linked in a chain joined together by peptide bonds) (1). This was the first time this method of x-ray crystallography was applied to a biological substance.

X-ray crystallography is a technique used to determine the three dimensional structures of proteins and biological macromolecules. Knowing the structures enables scientists to find answers to previously unanswered questions and provides scientists with more details for their research. X-ray crystallography has allowed scientists to discover new vaccines and drugs based on protein structures, which is extremely beneficial to people all around the world.

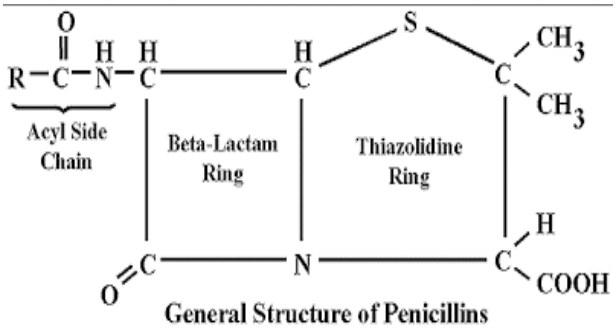


X-ray crystallography takes place as follows: A purified sample at high concentration is crystallized and the crystals are exposed to an *x* ray beam (see Figure left). The resulting diffraction patterns can then be processed, initially to yield information about the crystal packing symmetry and the size of the repeating unit that forms the crystal. This information is all obtained from the pattern of the diffraction spots. The intensities of the spots can be used to determine the "structure factors" from which a map of the electron density can be calculated (6) (see Figure right). Various methods can be used to improve the quality of this map until it is of sufficient clarity to permit the building of the molecular structure using the amino acid protein sequence. The resulting structure is then refined to fit the map more accurately. X-ray crystallography is a very important tool, especially in biochemistry, where it can be used to find mass of certain molecules used in experiments (5).



After her work with John Desmond Bernal was completed, she returned to Oxford University to earn her doctorate and to teach. Once she was back in Oxford, she had many challenges. Although she was a part of the staff, she was not allowed to participate in or attend research meetings because of her gender. Another challenge she faced was that in order to have sufficient lighting for her microscope, she had to climb an old rickety staircase daily in order to reach a window that would give her enough light. Despite these challenges, Dorothy Hodgkin was still able to make scientific advancements and was the first to discover the structure of an inorganic, cholesterol iodide through x-ray crystallography. She was awarded her doctorate from Oxford University in 1937 (3). The rest of her time at Oxford was spent as the official fellow and tutor in Natural Science, where she mainly taught chemistry for women's colleges. Hodgkin worked in the department of Mineralogy and Crystallography, with H.L. Bowman as the professor. She also became a University lecturer and demonstrator in 1946, a University Reader in x-ray crystallography in 1956 and, a Wolfson Research Professor of the Royal Society, which is a group of learned scientists, in 1960.

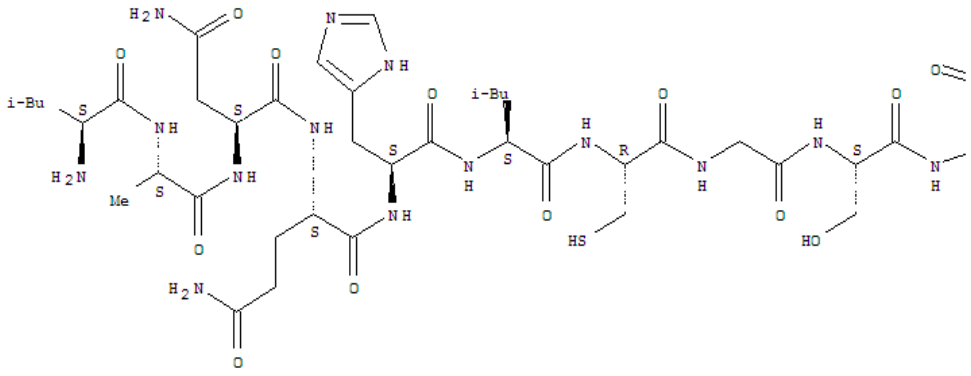
Dorothy Hodgkin achieved many things in the scientific world. In 1942 with only two research students, Dorothy began her research in the molecular structure of penicillin. At the time penicillin



General Structure of Penicillins

was the only effective antibiotic and had to be acquired from molds. If the structure would be found it would be possible invent a method of synthesizing it in chemical factories which would greatly decrease its cost. After much work Dorothy Hodgkin and her research students were able to determine its molecular structure in 1945 (see figure 1 below), and through the research they invented many new crystallographic techniques. This project had a snowball effect, as do many other scientific achievements, because whatever scientists discover allows other scientists after them to make more discoveries. When Hodgkin and her students discovered the molecular structure of penicillin, it enabled Ernst Boris Chain, to win the Nobel Prize for Physiology or Medicine in 1945 for his penicillin research (7).

After her triumph with penicillin Hodgkin took on the project of determining vitamin B-12's structure in 1948. This vitamin was known to prevent the disease of anemia, but its chemical makeup was still unknown. Most chemists deemed this project impossible because of its many unknown atoms, but after six years of toil, Hodgkin and her students achieved their goal in 1956. The process of determining the structure was multifaceted, using the method of x-ray crystallography. Use of this technique led to Hodgkin's discovery of the molecular structure of Vitamin B12, which has the most complex structure of all the vitamins (1). It wasn't until she received the Nobel Prize in chemistry in 1964 for solving structures of complicated biological molecules that that she was recognized by the scientific society for her work. In 1969 Dorothy started her third project, the determination of the structure of insulin (see image below) which was made possible because of the technical advances.



It almost seems impossible that with all of her responsibilities Hodgkin was still able to raise a family, but she did. In 1937, Dorothy Hodgkin married Thomas Lionel Hodgkin. Prior to the marriage, he worked at the Colonial office in Palestine. Thomas Lionel wrote several works on African history and politics. He was also was also a member of the communist party. Together the couple had three children Luke, Elizabeth, and Toby. Their eldest son Luke became a mathematician. Their daughter

Elizabeth followed her father's career, becoming a historian, while the younger son Toby studied botany and agriculture (1).

Although Hodgkin's main focus was on science she also had a great sense of social responsibility. After the Second World War, she joined the Science for Peace organization which is a group of scientists getting together to promote world peace. Membership to this organization meant that Dorothy Hodgkin was denied a visa to attend a scientific meeting in the USA. Over the next 27 years, Dorothy had to gain a special entry permit from the US Attorney General in order to attend scientific meetings in America. In 1990 at the age of 80, Dorothy Hodgkin was finally given a visa application.

Dorothy Hodgkin was the second woman to receive the Order of Merit, an award recognizing significant work in armed forces, science, art, literature, or for the promotion of culture, the first woman to win was Florence Nightingale. She also won the Lenin Peace Prize and was the first woman to receive the Copley medal. Since she was a fellow of the Royal Society she became Bristol University's Chancellor from 1970 to 1988. She was also given an Honorary Degree of Science from the University of Bath in 1978 (2). Because of Hodgkin's outstanding work, a fellowship was established in her name by the Royal Society for those still in the early stages of their career in research (1). Dorothy Hodgkin died July 29, 1994 after living a fulfilled life of scientific and social achievements. Although she is not alive anymore her memory lives on. Her name is honored through many council offices and educational institutions. In 2010 the Royal Society published ten stamps that illustrated their most acclaimed members, one being Dorothy Hodgkin (1).

Throughout history women have been the underdogs of science and other academic disciplines, but truthfully there were so many prominent women of these academic societies to tribute to the different disciplines. Dorothy Hodgkin is a prime example of this; a little girl following her dreams to change the world. She had so many challenges along the way and pulled through them and came out on top. Be that little girl with the dream that becomes that woman with vision!

WORKS CITED

1. "Dorothy Crowfoot Hodgkin - Facts". Nobelprize.org. Nobel Media AB 2014. Web. 17 May 2017.
2. "Dorothy Hodgkin" Famous Scientists. Doug Stewart.
3. "Dorothy Hodgkin." Dorothy Hodgkin Facts & Biography | Famous Female Scientists. Web. 15 Mar. 2017.
4. Complete Dictionary of Scientific Biography. Encyclopedia.com. 20 Apr. 2017
5. Silva-Martin N, Daudén MI, Glatt S, Hoffmann NA, Kastritis P, Bork P, et al. (2016) The Combination of X-Ray Crystallography and Cryo-Electron Microscopy Provides Insight into the Overall Architecture of the Dodecameric Rvb1/Rvb2 Complex. PLoS ONE 11(1): e0146457. https://doi.org/10.1371/journal.pone.0146457
6. Smyth, M S, and J H J Martin. "x Ray Crystallography." Molecular Pathology 53.1 (2000): 8–14. Print.
7. "Ernst B. Chain - Biographical". Nobelprize.org. Novel Media AB 2014. Web. 21 Apr2017.

DAVENING IN A MINYAN: BONNIE BASSLER

Rivka Sabel

The flask illuminates the laboratory well into the dark hours of the night. Within the flask is not a light bulb or a flashlight; it is filled with the bacteria Vibrio fischeri. The woman in the lab whose face is illuminated by the glow is Bonnie Bassler and she has come to discern when, why and how this flask of Vibrio fischeri decide to produce light. In the process, she has drastically changed the way people think of bacteria. She has disproved the misconception of these tiny organisms, which people believe are so simple and asocial.

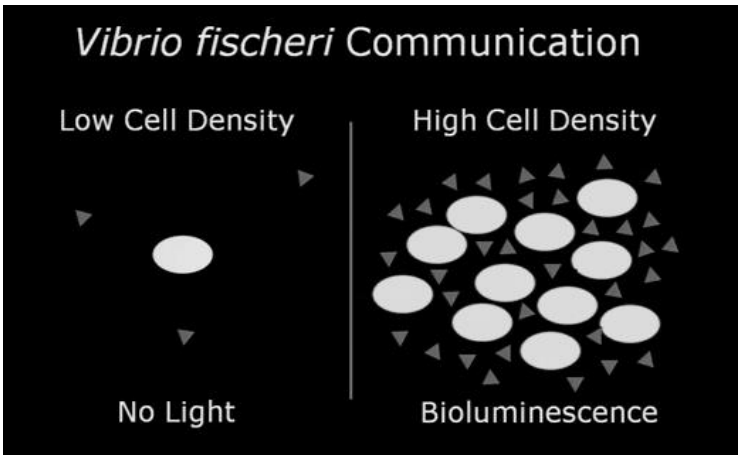
Bacteria are accountable for a human's protection but also can be the cause of much destruction; Bassler has discovered how these microscopic organisms are capable of so much. People mistakenly think these organisms are unsophisticated and reclusive, but in truth, they have a complex system of communication, and in large enough numbers, can turn on remarkable group behaviors, such as virulence and luminescence. The process involves in quorum sensing—taking a census—and when a critical number is reached, group behavior is initiated. Presently, as a professor of Princeton University, Bassler continues her momentous research and is working arduously to change the next generation's attitude toward science.

In 1962 a genius was born to the community of Danville, California. From a young age Bonnie Bassler was an intellectual pursuer. She was intrigued by logic problems and puzzles, which translated into her passion for solving biological puzzles. However, Bassler didn't realize her passion for bacteria right away. Her love for animals laid foundations of her hope for the future to become a veterinarian. In the University of California, Bassler realized this passion was not well suited for her as she disliked the dissections and the memorization in her anatomy class (1).

In her junior year of college, Bonnie Bassler's mother lost her life to colon cancer, which fueled her desire to make meaningful contributions to medicine (4). Bonnie Bassler discovered her passion for bacteria when working with Frederick Troye on Epstein-Barr virus and its relationship with cancer. She was fascinated by the daily surprise of bacteria's constant change. With Troye's advice, Bassler moved to Baltimore to attend John Hopkins University (5). There, Bassler's ambitious personality aided her tremendously and would continue to propel her for the duration of her career. At the onset of her scientific career, she recognized her limited repertoire of skills, but used this as a means to try harder, rather than accept defeat. She recognized the fact that she needed to prove herself and allowed her determination to lead the way.

Bonnie Bassler's career in quorum sensing ultimately began by pushing herself beyond her comfort zone. At a speech at John Hopkins by Michael Silverman, Bassler was left dumbfounded in the crowd. In his speech, Silverman described his experimentation on quorum sensing within marine life, which glow in the dark. Bonnie Bassler had an epiphany listening to Silverman describe the ease in genetically manipulating bioluminescent organisms, and realized this is what she wanted to do. Bassler took a leap of faith and asked Silverman, a man she had never spoken to before, for a job. To her surprise, he obliged and so began Bassler's research in quorum sensing.

Bassler has made many discoveries within the rich microbial life. Bassler has shown how bacteria are in fact highly social. They conspire with their species, build alliances with other species, and track environmental changes. All these strategies were previously attributed solely to the likes of ants, bees and humans, but Bassler has showed bacteria use it as well. Prior to Bassler's research, the knowledge of quorum sensing came from the bobtail squid. The bobtail squid lives in the shallow waters on the coast of Hawaii. It has a commensal relationship with its bacteria *Vibrio fischeri* which are housed in a special sac on its underside. These bacteria use quorum sensing to know when they have reached critical mass, to produce light by bioluminescence. Before they reach the critical number, it would be a waste of energy and effort because the amount of light produced will be too faint to be effective. The squid houses and protects the bacteria because it needs their light. When the bacteria emit light, the squid is counter-illuminated and does not cast a shadow so the prey cannot see it coming.



How do the bacteria know when they have reached their critical mass? They are not sentient beings after all. The process of quorum sensing entails that bacteria manufacture and secret special signaling molecules called auto-inducers, named A-1, which bind to special receptors which stud the bacterial surface. When the population density of bacteria is low, the concentration of A-1 is similarly low and very few receptors will be bound to A-1. When the population of bacteria has reached the needed mass, the concentration of A-1 in the growth media increases and most receptors on the perimeter of each bacterial cell will be locked in with the molecules. This then sends information deep into the cellular machinery that they can now perform the task. As illustrated in figure above, a solitary bacterium will secrete a specific molecule, A-1 the auto-inducer for intraspecies quorum sensing, but the molecule will just float away and not bind to a receptor and no light is produced. However, when the bacteria grow and double and secrete these molecules as a group, the molecule will grow to a certain concentration; the bacteria will recognize the molecule and then will collectively produce light in unison (2). Hence, a single *V. fischeri* bacterium will not be able

to produce light on its own, but when it communicates its presence to its fellow bacteria, they work as a unit and produce bioluminescence.

A similar parallel can be made to the Jewish people who must daven to *Hashem* with a *minyan*, a group of at least ten men, in order to say *Kaddish* and read from the Torah. It is only when together in this group of ten that men are permitted to engage in these additional prayers and observances. It has been said that the powers of prayers of a group of ten men is greater than the sum prayers of the individuals. Therefore, it is customary for men to seek opportunities to pray in large groups. Similarly, the bacteria must also unite in groups to achieve their goal and perhaps their gathering is to sing praises to *Hakadosh Baruch Hu.*

Bassler paved the way by showing numerous other uses for quorum sensing. She discovered through an experiment with *V. harveyi* that not only do bacteria communicate within their own species, but with others as well. *V. harveyi* cells not only light up when their own population reaches quorum density, but also when other species were added. She recognized the pronounced use of this bacterial ability, where bacteria in various mixtures must be able to communicate with their "neighbors" in order to survive (6). However, Bassler began to doubt her discoveries and worried if her research would support her financially (8). What she didn't know was that her discovery of inter and intra-species bacterial communication is what the whole field of quorum sensing is based on. Bassler also discovered the auto-inducer used for interspecies communication, A-2, which became known as Bacterial Esperanto—the molecular language for interspecies communication since the beginning of time (1).

One of the most prominent uses of quorum sensing is to identify when the bacteria have reached sufficient density to release virulence. When bacteria seek to initiate a disease process, they exhibit similar behavior to that used by the tiny Lilliputians in *Gulliver's Travels*. The Lilliputians were minuscule compared to Gulliver and alone they could not defeat him, but working together they each assisted and were able to overcome him. So too, the bacteria will not secrete the infectious toxins on their own, because the human immune system will overpower it, but rather will work in tandem to secrete the toxins at the same time their fellow bacteria and overpower the immune system (7). Here is another lesson we can learn from these "lowly" critters: in *achdus* we can prevail.

Bassler's research is instrumental in finding cures for many drug-resistant diseases. It can be applied in manipulating the auto-inducer so that the bacteria will lock in with an inactivated receptor and therefore block quorum sensing. Therapeutics that disrupts quorum sensing can end bacterial buildup which can be used to combat the infections (3). Bassler along with other researches founded Quorex Pharmaceuticals where they are working on discovering drugs to cure cholera, salmonella, strep and many other bacterial infections. Their research is close to finding cures for several diseases, as Bassler has discovered the structure of molecular language of the bacteria involved with stomach cancer, Lyme disease and many others.

Bonnie Bassler is a living legend who continues to change the face of science. Bassler has received the "President's Award for Distinguished Teaching" and almost every other award scientists strive for. She has received a nomination from former President Obama, which placed her on the National Science

Board, where she determines the nation's research and educational priorities in STEM. At 55, she is very mindful of her health; she walks a mile five times a week to teach an aerobics class. Bonnie Bassler has been described as perfect for the line of work she chose. The meticulous work involved with quorum sensing research requires one to be engrossed in their work. Bonnie Bassler is well suited for this type of work as she obsesses over everything, including her weight, her hours in the lab, and of course her bacteria. All of Bassler's colleagues enjoy working with her, as she is charismatic and ambitious. Mike Silverman described her at the beginning of her career as "starry eyed and differential" and that "once she started getting traction, she began pulling." Even though Bassler is at the forefront of much research, she continues to be humble. When a representative of the MacArthur Foundation called to offer her a fellowship, she first played coy asking Bassler if she knew someone worthy of receiving the "genius grant." Bassler answered she doesn't "hang out with people of that caliber." Unbeknownst to her, the grant was for her, because she is a genius (8).

Bassler recognizes how she was very lucky in her success in the science field, where there are many obstacles for women and minorities. Bassler is "doubly grateful" and uses her position to attract more people to the field. Bassler is working to end the deterrent of entering the field of science and the stigma of dreadfulness associated with it. She is advocating for women and minorities to pursue their passions for science. She is also working to change students' attitudes toward science. One of Bassler's ventures at the moment is to show students the "fun" and "mystery" involved in science and advocating for the creativity encompassed in science, where students who enjoy writing and philosophy can find opportunities in this field as well. Bonnie Bassler thinks anyone can masterful in the area of science and is striving to expand the outreach of the subject. Bassler is working now as a professor at Princeton University where she is trying to show her students the beauty of science and hopes her experience will inspire the next generation of future scientists (4).

WORKS CITED

(1) Ahmed, Farooq. "Profile of Bonnie L. Bassler." Proceedings of the National Academy of Sciences. National Acad Sciences, 24 March 2008. Web. 16 May 2017.

(2) Bassler, Bonnie. Bonnie Bassler: How bacteria "talk" | TED Talk | TED.com. N.p., Feb. 2009. Web. 16 May 2017.

(3) Bassler, Bonnie . "Bonnie L. Bassler | Department of Molecular Biology." Princeton University. The Trustees of Princeton University, n.d. Web. 16 May 2017.

(4) Bassler, Bonnie . The Shaw Prize - Top prizes for astronomy, life science and mathematics. 24 September 2015. Web. 19 Apr. 2017.

(5) Neill, Ushma S. "A conversation with Bonnie Bassler." The Journal of Clinical Investigation. American Society for Clinical Investigation, 01 Apr. 2014. Web. 16 May 2017.

(6) "Princeton Alumni Weekly." Google Books. N.p., n.d. Web. 19 Apr. 2017. V harvey

(7) Salmans, Sandra. "For the Love of Bacteria." The New York Times. The New York Times, 09 Nov. 2002. Web. 16 May 2017.

(8) Silberman, Steve. "The Bacteria Whisperer." Wired. Conde Nast, 01 Apr. 2003. Web. 19 Apr. 2017.

Figures:

Figure 1: http://www.pbs.org/wgbh/nova/body/bassler-bacteria-au.html

Figure 2: https://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate

SPACE TIME—WHAT IT IS AND HOW IT WORKS

Gabrielle Hawk

Physics, and all other areas of science, is a malleable topic. Concepts are consistently revisited and revised as physicists gain access to more exact tools of measuring the laws of nature. Einstein's theories of relativity gave rise to a four-dimensional continuum known as space-time, a composite of three-dimensional space with the added dimension of time.

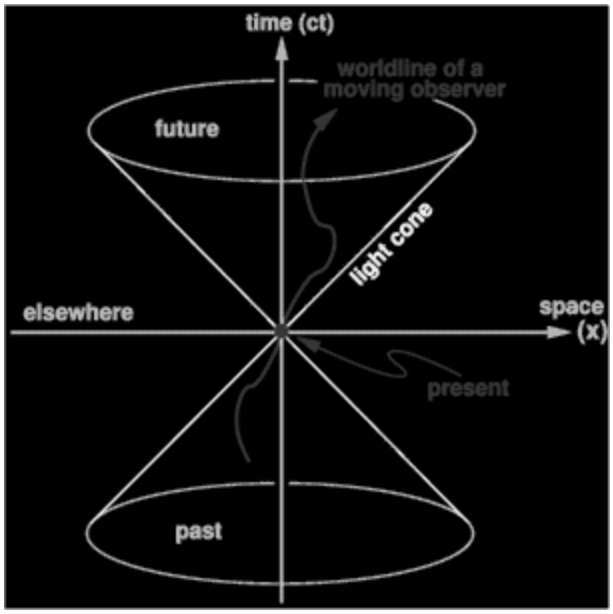
At the end of the nineteenth century, Newton's theories of mechanics and Maxwell's theories of electromagnetism seemed to contradict each other. Physicists including Michelson performed experiments with light that showed the electromagnetic force to travel with a constant velocity, no matter the speed of its source. George Fitzgerald and Hendrik Lorentz, and late Henri Poincare, tried to reconcile the seeming contradictions. Finally, in 1905, Albert Einstein introduced his Special Theory of Relativity, which gave way to a new understanding of how the universe runs.

The Special Theory of Relativity (or Special Relativity) states that the speed of light is constant in an inertial frame of reference. The inertial reference means that every object in the given plane of observation is moving at a constant speed without acceleration. In that case, any object will observe light to be moving at the same, constant speed (approx. 300,000 km/sec), regardless of the speed of the object or the source of light.

The Lorentz Transformation equation mathematically proves that no matter how fast two different objects are moving, both will observe the light to be moving at the same speed. A necessary conclusion from the Lorentz Transformation and Special Relativity indicates that space and time are relative—they depend on the motion of the observer. In fact, a stationary person watching a spaceship pass by at a speed near the speed of light will observe the clock on the spaceship to be slower than his own clock. This concept is known as time dilation. They also lead to the concept of Lorentz Fitzgerald Contraction, the idea that if two people have rods of the same length, the length of the other person's rod will seem shorter if it passes by at a speed close to the speed of light.

These theories form the idea that no object can be accelerated to the speed of light. The inertial mass of a body directly correlates to its energy in the famous equation $E=mc^2$, or the Energy of an object equals its mass times the square of the speed of light. Manipulation of the equation shows $m=E/c^2$. As an object increases its speed, its energy, and therefore mass, necessarily increases. Therefore, it becomes increasingly harder to apply enough force to a particle to raise its speed, thus preventing any known method from effectively getting a particle to move at the speed of light.

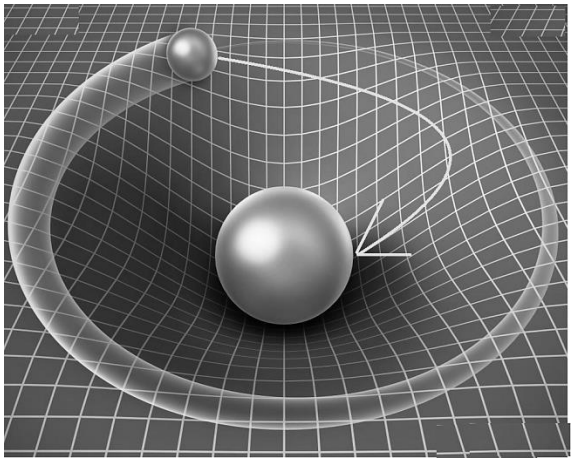
Using Special Relativity, Hermann Minkowski dramatically combined space and time into a single continuum with the words: "Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."



Four-dimensional space-time is often depicted as a two-dimensional light cone diagram centered of the horizontal "space" axis and the vertical "time" axis. The bottom cone is the past, and the top cone is the future. The diagram represents the passage of a flash of light from the past to the future through the present (the intersection between the axes). Stanford's website on space-time explains that "the trajectories of all real objects lie along 'world-lines' inside the cone" (2). In other words, an object in the present (the point of intersection) can only affect an event within the upper light cone. Any event outside the cone is too far away for light to move there in time to affect it. Meaning, if an event is close in time but far in space, the object's effects will not reach the event before it happens in order to affect or cause it. Causation requires the "effect" to be within the limits of the speed of light relative to the "cause."

Space and time are relative. Observers in areas far away may view events in different orders. Observer A may see two events occur simultaneously. However, Observer B may see one event occur before the other. The simultaneity depends or is relative to the distance the observer is standing from each event and how long it takes the light (or other result) of the event to reach him. *Space-time*, in contrast, is absolute. It is essentially the composite of all events within time and space. It determines what events can influence others, as demonstrated by the light cone diagram, and regardless of where the observer stands.

Einstein's Special Relativity eventually developed into General Relativity to incorporate an explanation of Newton's "gravity." General Relativity states that gravity affects all observers in all states of motion—including acceleration—and in all coordinates the same way. Einstein's space-time is curved, and gravity is strongest where the continuum is the most curved. Gravity is likewise weakest where space-time is the most flat. The theory of General Relativity is often summed up in these words: "matter tells space-time how to curve, and curved space-time tells matter how to move."



Imagine a bowling bowl on a rubber sheet (see graphic to left). The ball pushes the sheet inwards so that a marble placed on the sheet would inevitably roll towards the bowling ball. The more matter placed in a given spot, the more the

continuum curves in that area, and the curvature directs the movement of nearby objects, such as the marble on the rubber sheet.

The idea of space-time's curvature can at first seem contradictory to Newton's theory of gravity which must be somewhat valid. Newton established that an object moves in a straight line, unless an external force acts upon it. Newton's gravity explained then that gravity is a force—it pulls planets out of straight-line trajectory and causes them to orbit in elliptical motion. However, if gravity is instead defined as the curvature in space-time, why then do the planets not move in straight lines? The answer is that all trajectories are straight in space-time, even though they appear elliptical in space. Each planet and object in space has a world-line that is nearly straight, as Newtonian mechanics predict. For example, the earth's world-line is 1 astronomical unit wide but lightyears long.

Caltech physicist Kip Thorne once said, "In the realm of black holes and the universe, the language of general relativity is spoken, and it is spoken loudly. But in our tiny solar system, the effects of general relativity are but whispers." Therefore, any relativistic effects of gravity around earth must be measured with extreme precision. Gravity Probe B was a satellite set into orbit around Earth for a year and a half between 2004-2005 to test two aspects of General Relativity. Most recently, France's Microscope, a microscopic satellite, was sent into orbit in 2016 to test the validity of Einstein's Equivalence Principle over the course of two years. These experiments are helping to solidify as best as possible some of the least tested, but now most basic, principles of physics.

One of the effects that Gravity Probe B tested was the frame-dragging effect. Proposed by two Austrian physicists following Einstein's general theory of relativity, the frame-dragging effect suggests that "as a celestial body spins on its axis, it drags local space-time around with it" (1). This effect mimics that of the magnetism generated by rotating electrically charged particles, and seems to almost be a spiraling effect on space-time. Judaism, in fact, views time itself as a spiral.

Perhaps contrary to the space-time concept of linearly progressing time, Jews have largely held by the idea that time progresses in a spiral motion. As the *Ramchal* (Rav Moshe Chaim Luzzatto) explains in his book, *Derech HaShem* in chapter 4, section 7.6, every Jewish holiday marks a specific time when a "great Light shone." Every year thereafter, when the calendar date is the same, that power of the original holiday comes through once again. For example, the Jews were redeemed from Egypt in the month of *Nissan*. During every *Nissan* since, there is the same spiritual force of redemption in the air, so to speak. It is for that reason, says the *Ramchal*, that we are commanded to celebrate the redemption in the same way as we did 3,000 years ago. The same holds true for every other significant date on the Jewish calendar.

We do not return to the same period in history, but we return to the same Light on the date many years ahead. It's as if every year spirals on top of each other so that the months line up in such a way to create slices with different spiritual energies.

Rav Dessler explains that in fact we experience this spiral every week when we experience *Shabbos*, which has the same holiness as the first *Shabbos* during the week of creation. He further explained that the Hebrew word for holiday is *moadim*, meeting place, because we meet up with and recapture the

spiritual energy of that date long ago. Furthermore, the word *zman,* time, means "designated" because every date has an appointed specific spiritual purpose.

WORKS CITED

1. Kahn, B., Range, S., & Spencer, J. (2008). Gravity Probe B Testing Einstein's Universe. Retrieved February 26, 2017, from <https://einstein.stanford.edu/MISSION/mission1.html>
2. Kahn, B., Range, S., & Spencer, J. (2008). Einstein's Space-time. Retrieved February 26, 2017, from <https://einstein.stanford.edu/SPACETIME/spacetime2.html>
3. (2017, February 15). Microscope. Retrieved February 26, 2017, from <https://microscope.cnes.fr/en/MICROSCOPE/index.htm>
4. Muller, E., Possel, M., & M. (Eds.). (n.d.). Special relativity. Retrieved February 26, 2017, from <http://www.einstein-online.info/elementary/specialRT>
5. (n.d.). Special Relativity: Section 8. Retrieved February 26, 2017, from <http://www.phys.vt.edu/~takeuchi/relativity/notes/section08.html>

OPTOGENETICS AND GENE THERAPY:

Pathway to Parkinson's cure

Rachel Jacobi

A facial expression that lacks free movement, voluntary body movements that are slow, muscle tremors or muscle rigidity, and a stooped posture are all characteristics of a disorder of the nervous system: Parkinson's disease (1). In Parkinson's disease, there is a decrease in the level of dopamine produced in the brain, caused by the degeneration of neurons that manufacture this chemical messenger (2).

Parkinson's generally affects people of age 50 and older, and severely limits daily activities due to the fact that Parkinson's renders mobility of the body difficult, and in more extreme cases, impossible. One of the most unfortunate characteristics of Parkinson's is that the disease is a progressive one, and as the symptoms increase, free mobility drastically decreases (1).

While the exact cause of Parkinson's disease is unknown, there have been treatments developed to treat Parkinson's (1). It can be currently treated with drugs, or Deep Brain Stimulation (DBS). While the results of the DBS treatment, in comparison to drugs, have been quite impressive, DBS still contains a few flaws. During this treatment, parts of the target area are not under perfect control (4), so side effects—especially psychiatric ones—can occur, ranging from hypomania to suicidal ideation (5). This is where optogenetics comes in. In recent years great strides have been made in the field of optogenetics, a form of gene therapy that many scientists regard with great optimism as the possible remedy to maladies originating in the brain, such as blindness, depression, epilepsy, or Parkinson's Disease.

Optogenetics is a newly developed tool, defined as control over specific events within specific cells of nervous tissue, through the integration of genetic engineering and optics. This tool within neurons gives scientists a level of precision that was previously unachievable due to the complicated nature of the mammalian brain, which containing tens of billions of intertwined neurons, each with its variety of neurotransmitters (3). A set of genes for light sensitive receptor channel proteins (channel rhodopsin) are inserted into a targeted neuron and when expressed, the neuron is rendered "light-obedient." This means that when exposed to light, the channel proteins will open to allow the passage of ions into the cell and the neuron will be activated. The neuron will now transmit signals when exposed to light. Only specific cells are targeted so that the cell activity is controlled using light on a sensitive millisecond by millisecond timescale (6). The optogenetics method offers greater precision than DBS. With optogenetics, the targeted structure in the brain would be activated via light sources without any of the side effects that DBS can bring. This can hold true not only for Parkinson's Disease but perhaps for

Epilepsy as well, because both Epilepsy and Parkinson's Disease affect only certain areas of the brain's cortex (4).

A team of researchers at Stanford university, working in Karl Deisseroth's lab, have used channel rhodopsins to study why DBS is effective in treating Parkinson's Disease by probing the neural networks of the brain that are thought to be responsible for the causation of Parkinson's (6). Julius Steinbeck and his group at the Lorenz Studer Lab furthered this research by harnessing optogenetics as an on-and-off switch for the neural activity of transplanted human neurons, including dopamine release (attempting to see if the release of dopamine by neurons could be controlled) in experiments on mice (8). In this study, Parkinsonian symptoms such as motor deficits were induced in the mice using optogenetics and then re-introducing motor functions to the mice, once again with the exploitation of the optogenetics technique (9). This study demonstrated that the transplantation of dopamine neurons is a step towards restoring the motor functions that Parkinson's disease deprives individuals of.

The first time optogenetics was used in a human subject was almost exactly a year ago (February 2016) in Texas. In an experimental trial, doctors administered the gene therapy to a blind woman with hopes that it would allow her to regain her eyesight. David Birch, one of the doctors leading this woman's treatment said that he tells patients that "this is like the Apollo mission—it's potentially a big step forward but it's entirely experimental" (7). Without dismissing the importance of her case, the results of these treatments this woman has undergone has implications much larger than the attempt for this woman to regain her eyesight. If the gene therapy that was administered to this woman using optogenetics is successful, then an entire world of possibilities can become accessible, with treatments for individuals that suffer from Parkinson's disease being at the forefront.

WORKS CITED

1. "Parkinson's: Overview." *National Center for Biotechnology Information*. U.S. National Library of Medicine, 08 Apr. 2015. Web. 09 Mar. 2017. <https://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0076679/>.
2. "Parkinson's Disease Causes." *Mayo Clinic*. N.p., n.d. Web. 09 Mar. 2017. <http://www.mayoclinic.org/diseases-conditions/parkinsonsdisease/basics/causes/con-20028488>
3. Deisseroth, Karl, M.D., Ph.D. "Optogenetics: Controlling the Brain with Light (Extended Version)." *Scientific American*. N.p., n.d. Web. 25 Jan. 2016.
4. Barkataki, Manash P. "Potential Benefits." Optogenetics. N.p., n.d. Web. 25 Jan. 2016.
5. Cyron, Donatus. "Mental Side Effects of Deep Brain Stimulation (DBS) for Movement Disorders: The Futility of Denial." *Frontiers in Integrative Neuroscience* 10 (2016): 17 *PMC*. Web. 10 Mar. 2017.
6. Posted by Mo on March 24, 2009. "Optogenetics Controls Brain Signalling and Sheds Light on Parkinson's Therapy." *Neurophilosophy*. N.p., n.d. Web. 09 Mar. 2017. <http://scienceblogs.com/neurophilosophy/2009/03/24/optogenetics-controls-brain-signalling-and-sheds-light-on-parkinsons-therapy/>.
7. Bourzac, Katherine. "A Blind Woman in Texas Is First Person to Undergo Optogenetic Therapy, Which Could Let Her See Again If Successful." *MIT Technology Review*. MIT Technology Review, 18 Mar. 2016. Web. 09 Mar. 2017. <https://www.technologyreview.com/s/601067/texas-woman-is-the-first-person-to-undergo-optogenetic-therapy/>.
8. Chen, Yuejun, Man Xiong, and Su-Chun Zhang. "Illuminating Parkinson's Therapy with Optogenetics." *Nature biotechnology* 33.2 (2015): 149–150. *PMC*. Web. 10 Mar. 2017.
9. "Optogenetics Enables Functional Analysis Of Human Embryonic Stem Cell–Derived Grafts In A Parkinson's Disease Model". *nature.com*. N.p., 2017. Web. 10 Mar. 2017.

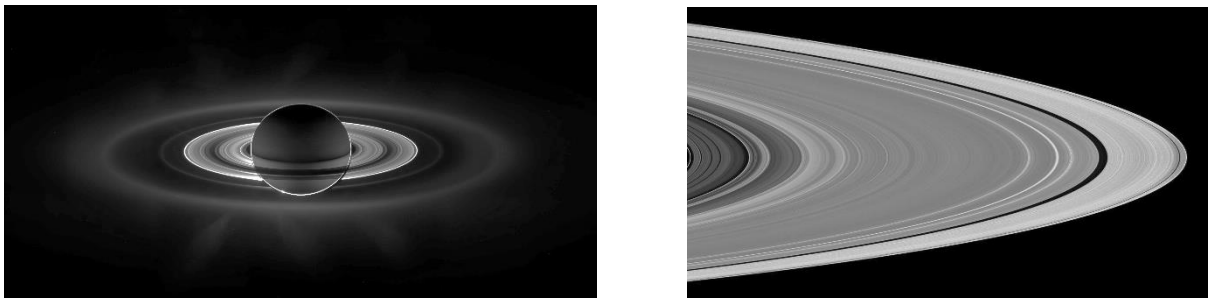
THE ROCHE LIMIT: RING AROUND A ROSY

Chana Leah Seif

On October 15, 1997 Cassini was launched from Cape Canaveral to explore Saturn, its rings, and moons. On November 1, 2002, NASA received its first clear visual of Saturn and its majestic rings. For the next few years, Cassini studied Saturn's storms and moons. On September 15, 2016, Cassini photographed images of Saturn's rings revealing the previously unknown faint ones. On June 1, 2008, Cassini's primary mission was over.

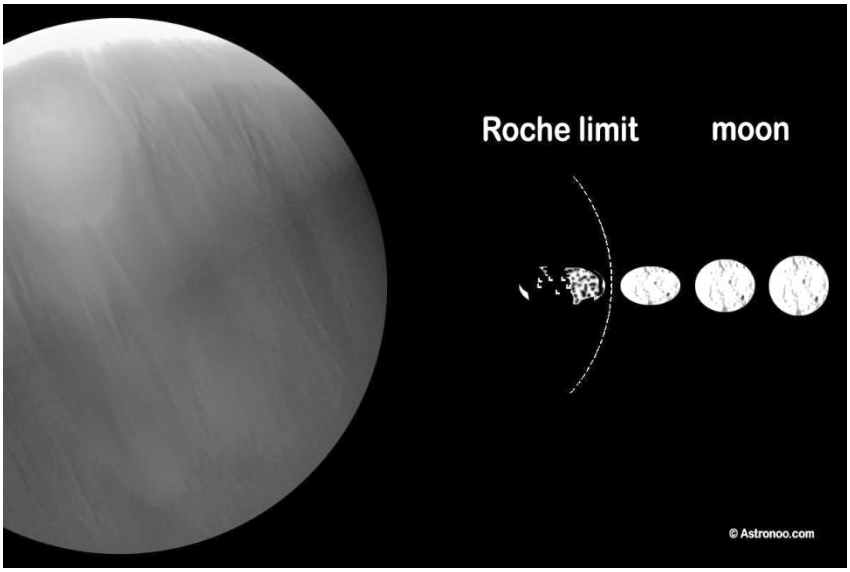
However, NASA continued to use *Cassini* to study Saturn. *Cassini* studied the solstice and equinox effects on Saturn's rings. On November 17, 2016, *Cassini* studied the F rings on Saturn. In April 2017, *Cassini* will make its final descent towards the planet and getting closer than ever to Saturn. On September 15, 2017, *Cassini* will say goodbye to Saturn as it plunges into the planet and gets destroyed by its atmosphere. Over its lifetime, *Cassini* has made many calculations and collected much data on Saturn and its moons and rings.

Rings on a planet are torn apart celestial bodies. This happens when the gravitational pull of the planet exceeds the gravitational pull of the object and pulls it apart into rings. The rings continue to orbit the planet as if it were a satellite. Within a calculated distance of a planet no moons of a certain size are able to form. This distance is called the Roche Limit. Beyond the limit, the object becomes a satellite. As the planet grows the Roche Limit grows as well.



Images taken of Saturn by Cassini

Roche Limit applies to satellites disintegrating due to the tidal force of its primary object. The Roche Limit is different for each planet. The Roche Limit is also usually calculated for the case of a circular orbit. It also depends on the density of the object being pulled apart. For rigid-satellite objects the formula is the distance of the primary object equal to the tidal force pulling away the object.



Visual of Roche Limit and effect on a moon

The Roche Limit on Earth to any moon is 9,492 Km. The Roche Limit on Earth to an average comet is 17,887 Km. Within the limit, the object will be pulled apart by Earth's gravitational force. The density of Earth is 5,513 (kg/m^3). The radius of Earth is 696,000,000 (m). The density of the Moon is 3,346 (kg/m^3). The Moon is well outside Earth's Roche Limit.

$$d \approx 1.26R\left(\frac{\rho_M}{\rho_m}\right)^{1/3}$$

Roche Limit Formula for rigid objects

d = distance from the primary

R = the radius of the primary

pM = the density of the primary

pm = the density of the satellite

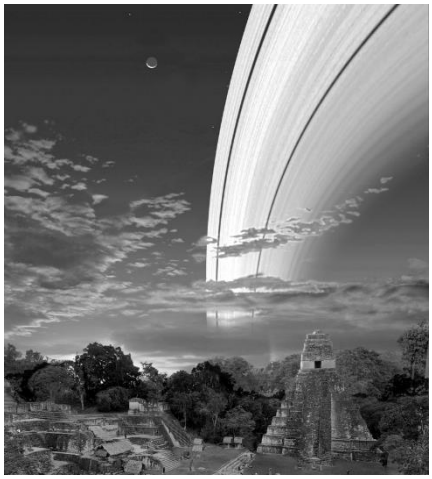
Any possibility of moons within the Roche Limit of Earth could have created rings around our planet. If Earth once had rings it would have disappeared as the particles combined with Earth or the Moon. If a large enough comet the size of the Moon went within the Roche Limit of Earth, it would be torn apart and form rings.

How would the rings affect tidal and weather patterns on Earth? The rings would have little noticeable affect on the tides of Earth because the mass of Earth is much greater than that of the rings. However, the rings may pose a threat to the weather conditions on Earth. If Earth had rings like Saturn, the dust and ice from the rings would block out 15% of the sunlight. The planet would cool off and in the winter hemisphere, the region would be dark and freezing. Rings may put Earth into an everlasting ice age. But, rings would create a majestic view!

Proposed views of Earth with rings

Tropic of Capricorn at Midnight

Washington DC



Guatemala

Equator

According to the Talmud, there are seven Celestial bodies that exert their respective astrological influence on earthly affairs in hourly rotation. The seven bodies are the sun, the Moon, Mercury, Venus, Mars, Saturn, and Jupiter.

Blood-letting is an ancient method of healing. In *Mesechet Shabbos* 129b, *Shmuel* writes about when to not do this ritual because certain times are not fortuitous.

The proximity of an object to a planet within the planet's Roche Limit will pull apart the object into a ring. The Roche Limit is the cause for Rings on Saturn and other Jovian planets. Earth does not have rings because there was never a body within its Roche Limit that has not yet coalesced with Earth or the Moon. If Earth did have objects that turned into rings, the rings would affect the planet negatively. There will be areas that will remain dark for months and Earth would be significantly colder.

Not only do planets have gravitational and tidal influence on other objects, but they have astrological influence on objects. There are limits as to when to perform certain ceremonies due to the influence of a planet at that time. For example, the *Gemara* does not allow bloodletting on Tuesdays because of the influence of Mars.

WORKS CITED

1. Cassini: Mission to Saturn: Timeline. (n.d.). Retrieved from https://saturn.jpl.nasa.gov/the-journey/timeline/#liquid-water-on-enceladus
2. How would having rings (akin to Saturn) affect the planet Earth? - Quora. (n.d.). Retrieved from https://www.quora.com/How-would-having-rings-akin-to-Saturn-affect-the-planet-Earth
3. How would having rings (akin to Saturn) affect the planet Earth? - Quora. (n.d.). Retrieved from https://www.quora.com/How-would-having-rings-akin-to-Saturn-affect-the-planet-Earth
4. If Earth Had a Ring Like Saturn. (n.d.). Retrieved from http://io9.gizmodo.com/if-earth-had-a-ring-like-saturn-508750253
5. Roche Limit - Wikipedia. (n.d.). Retrieved February 26, 2017, from https://en.wikipedia.org/wiki/Roche_limit
6. What size body of moon or asteroid would it take to make rings around Earth on a similar scale to Saturn? - Quora. (n.d.). Retrieved from https://www.quora.com/What-size-body-of-moon-or-asteroid-would-it-take-to-make-rings-around-Earth-on-a-similar-scale-to-Saturn
7. What would Earth's skies look like with Saturn's rings? | The Planetary Society. (n.d.). Retrieved from http://www.planetary.org/blogs/jason-davis/20130626-earths-skies-saturns-rings.html

WEB DESIGN

Nechama Weiner

As a young boy, Dovid Hamelech would watch over his father's sheep, and he often came upon spiders' webs strung across tree branches and shining in the sun. Dovid thought the spiders were wonderful to weave such webs, but he could see no use for them. So Dovid asked Hashem, "Why, O Creator of the world, did you make spiders? You can't even wear their webs as clothing!"

Hashem answered *Dovid*, "A day will come when you will need the work of this creature. Then you will thank me."

With Divine assistance, *Dovid Hamelech* won many battles. He defeated *Golias* and many enemies of the people of Israel. King *Shaul* feared that *Dovid* would usurp his throne so he sent his soldiers to kill him. *Dovid* ran into a cave to hide. He heard the footsteps of the soldiers and knew that they would soon find him. David was so afraid, his bones shook and hurt.

But then *Dovid* saw a big spider at the front of the cave. Very quickly, it was spun a web all the way across the opening. Just before the soldiers came up to the cave, the spider finished the web. As the men started to enter the cave, they ran into the web. "Look," they said, "This web is unbroken. If *Dovid* were here, he'd have torn the web to pieces. He must be hiding somewhere else. Let's go!" So because of the spider, *Dovid's* life was saved. Although spider webs are often despised, due to their strength and flexibility they can be used in many helpful ways.

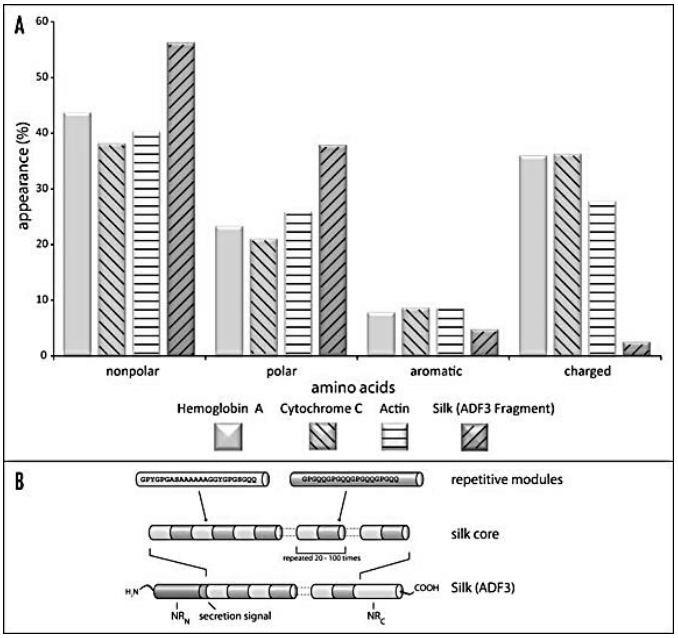
Spiders create webs by using silk. The silk is produced in silk glands with the help of the spider's spinnerets. Spinnerets are organs that allow the spider to decide what type of thread it needs for the web. The silk threads can be thick or thin, dry or sticky, beaded or smooth. The threads a spider uses to construct its web begin as liquid, but they dry quickly in the air. When a spider begins a web, it releases a silk thread. It anchors the thread to a nearby object and uses it as a frame to hold the web. As the spider moves back and forth, it adds more threads, strengthening the web and creating a pattern. Lines that go from the center of the web outward are called "radial lines." They support the web. Threads that go around and around the web are called "orb lines." The main reason spiders spin webs is to catch their food. When an insect, such as a fly, flies into a spider's web, it gets stuck on the sticky threads. When a spider catches prey in the sticky strands of its web, it approaches the trapped insect and uses its fangs to inject venom, thus killing or paralyzing the insect (1).

Cobwebs have antifungal and antiseptic properties that keep bacteria away, minimizing the chances of an infection. It works so well that cobwebs efficiently stop bleeding. Spider webs have been used to stop bleeding since ancient times when Greeks and Romans treated wounded soldiers with spider webs. Although the Greeks and Romans knew little about viral and bacterial infections, through trial and error, they discovered the surprising benefits of spider webs. Soldiers would even use a

combination of honey and vinegar to clean deep wounds and then cover the whole thing with balled-up spider webs. Additionally, spider webs are high in vitamin K, a vitamin that triggers blood clotting As long as the web is clean, it will not cause any infection or aggravate the wound's condition at all (2).

Scientists have long sought to mimic the chemical perfection of a spider's web. Recent work characterizing the proteins responsible for the incredible strength and elasticity of spider silks could lead to durable and resilient new materials for artificial human tissues, and surgical sutures and bone regeneration (3). Molecular biologists at the University of Wyoming are planning to use the proteins from super strong dragline silk to build artificial tendons and ligaments. The researchers needed more silk than they could harvest from spiders in captivity, so they genetically engineered goats to produce the proteins in their milk. These goats express one of two spider silk proteins in their milk; Major ampullate silk protein 1 (MaSp1) or major ampullate silk protein 2 (MaSp2). These proteins are expressed only in the milk as the proteins production is linked to milk specific proteins (whey acidic protein or casein). The spider silk proteins then have to be purified from the other milk proteins. After the silk proteins are extracted and purified, a machine spins them into the needed fibers (4).

Biomaterials, often exceed man-made materials in their properties. Spider silk is one outstanding fibrous biomaterial which mostly consists of large proteins. Spider silk is primarily made up of proteins that possess large quantities of nonpolar and hydrophobic amino acids like glycine or alanine. Furthermore, spider silk proteins contain highly repetitive amino acid sequences, especially in their large core domain. The repetitive sequences account for more than 90% of the whole spider silk protein and are composed of short polypeptide stretches of about 10–50 amino acids. These motifs can be repeated more than a hundred times within one individual protein. Each polypeptide repeat therefore has distinct functional features resulting in the outstanding mechanical properties of spider silk threads. Nonrepetitive regions are located at the protein's termini. These nonrepetitive terminal domains of the proteins are crucial for the assembly of spider silk proteins into fibers. The



(A) Amino acid composition of three common proteins in comparison to spider silk. (B) Model of the hierarchical structure of a MA silk protein. For example, Araneus diadematus Fibroin-3 (ADF3) has a highly repetitive core domain flanked by two nonrepetitive domains (aminoterminal domain: NRN; carboxyterminal domain: NRc). The aminoterminal domain also comprises a secretion signal sequence to allow protein export.

regions comprise approximately 100–200 amino acids and show secondary and tertiary structures in solution (5).

After secretion from the silk glands, silk proteins are in aqueous solution and lack considerable secondary or tertiary structure, particularly in their repetitive core domains. However, the long repetitive sequences allow weak but numerous intra- and intermolecular interactions between neighboring domains and proteins upon passage through the spinning duct. The elasticity of silk is based on the areas with low electron density. Different types of silk reveal different structural distributions (different compositions of crystalline-and hydrogel-parts). MA silk which is used for constructing the frame of the web contains a high amount of crystalline (β-sheet) structures.

Two theories on the mechanism of silk fiber assembly have been proposed. One is based on the crystalline alignment of the underlying proteins in the laminar flow inside the spinning duct. Monomers or disulfide-linked multimers pass the spinning duct at very high concentrations. The alignment in one direction together with the high concentration results in a liquid-crystalline like behavior of the spinning dope. The proposed liquid crystalline state is the basis for the formation of intermolecular interactions like van-der-Waals forces and hydrogen bonds between neighboring molecules. Upon further loss of solvent the conformational conversion is finalized and a silk fiber can be drawn out of the spinning duct (5). According to the second theory, silk proteins first assemble into small micelles with a diameter of approximately 100–200 nm due to their amphiphilic properties inside the spinning dope. A multitude of these micelles form globules with diameters in the micrometer range. Shear forces, which arise during passage through the spinning duct, force these globules into an elongated shape resulting in fiber formation (5).

The most marvelous property of spider silk is its maximal resilience. Distinct spider silk threads are able to absorb three-times more energy than Kevlar, one of the strongest materials. Synthetic materials typically show a higher stiffness and strength compared to natural fibers, whereas natural fibers tend to be more elastic. Spider silk shows a well-balanced combination of strength and elasticity and therefore mechanically outperforms other natural fibers as well as synthetic threads under certain circumstances. In addition, MA silk shows a torsional shape memory that prevents the spider from twisting and turning during its descent on a MA silk thread. Spider silk also shows a high super-contraction rate. Absorption of water leads to shrinkage and tightens the thread. This process is important to ensure the rigidity of the spider's web during its lifetime and is thought to be caused by the organization and arrangement of individual silk proteins (5).

Spider silk is often compared to insect silk. The commercially available silkworm silk is reeled from cocoons of caterpillar pupae, however it is costly. MA spider silk can be obtained by manually drawing the silk thread out of the spinning wart of immobilized spiders. However, this process is only suitable for MA silk and not for the other spider silk, and it is time consuming and highly expensive (6). The differences between insect and spider silks are evident on all levels. On a molecular level, insect silk comprises a large amount of sericin-proteins, which are absent in spider silk. The proteins which are responsible for the fibrillary structure are, in contrast to spider silk spidroins, composed of light and

heavy chain counterparts. Mechanically, silkworm silk is much weaker and less extensible as compared to MA silk of spiders. Interestingly, depending on spinning conditions, silkworm silk is either strong or elastic, whereas spider silk combines both properties (6). Although the mechanical properties of both types of silk crucially depend on spinning conditions, it is primarily the proteins involved that make the real difference. Therefore, genetic recombination techniques have long been sought to produce and engineer natural spider silk proteins (6).

Hashem has created a world full of hundreds of species of creeping-crawling insects, each with their own specific characteristics. Something that seems so unimportant and insignificant like a spider's web really has the power to enhance the medical field and change the way people live. By opening up our eyes and seeing the positive in all of *Hashem's* creations we can come to appreciate even a spider's web. And hey, you never know, maybe it will be the spider that ends up saving your life.

WORKS CITED

1. <http://wonderopolis.org/wonder/why-do-spiders-spin-webs>
2. <http://www.healthydietbase.com/using-spider-webs-to-heal-wounds>
3. <http://www.uwyo.edu/spider/transap_goat.asp>
4. Barth, A, "The Chemistry, Biology and Engineering that Make Spider Webs Awesome." *Discover* (2010) <http://discovermagazine.com/2010/sep/06-chemistry-biology-engineering-awesome-spider-webs>
5. Römer, Lin, and Thomas Scheibel. "The Elaborate Structure of Spider Silk: Structure and Function of a Natural High Performance Fiber." *Prion* 2.4 (2008): 154–161. Print. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2658765/>
6. Kumari, P, et. al. "Spider Web Ointment: A Traditional Based Approach in Cutaneous Wound Healing." *Indian Journal of Traditional Knowledge* 12.4 (2013): 657-663 <http://nopr.niscair.res.in/bitstream/123456789/22197/1/IJTK%2012%284%29%20657-663.pdf>

JEWISH LIFE IN SPACE

Nev Sivan Yakubov

The possibility of finding a planet that can support life aside from Earth has tickled astronomers' minds since the beginning of space exploration. Because the only known habitable planet is Earth, scientists look for planets with similarities to Earth when searching for habitable planets. Astronomers compare many factors, like size and temperature, but focus mainly on finding water — the source of life on Earth.

The Habitable Zone

With this in mind, it is not surprising that the habitable zone was established. According to NASA, the habitable zone is a range of distance from a star where the possibility of finding water on the surface of planets there exists. Once a planet is found in the habitable zone, astronomers observe its orbital period, size, and temperature (among other factors) and compare them to Earth.

NASA's Kepler Mission and Exoplanet Discovery

NASA has played a big role in discovering possible habitable planets. The Kepler Mission was begun in 2009 by NASA with the intent of discovering planets other than Earth that support life. The scientists on the Kepler Mission use transits to discover extrasolar planets. A transit is when a planet passes over its star and causes a dark dot to cross the star's surface as seen from Earth. After an extrasolar planet is detected, its orbital size and temperature is calculated in order to determine its habitability.

In 2014, a planet, similar in size to Earth, was found in the habitable zone using the Kepler Space Telescope. The planet is called Kepler-186f and is around 500 light-years away from Earth. Kepler-186f has an orbital period of 130 days around a star with half the size and mass of our sun. More recently, on February 22, 2017, seven exoplanets were found in the habitable zone of a star named TRAPPIST-1. These planets are thought to be rocky and reside 40 light-years away from Earth in the constellation of Aquarius.

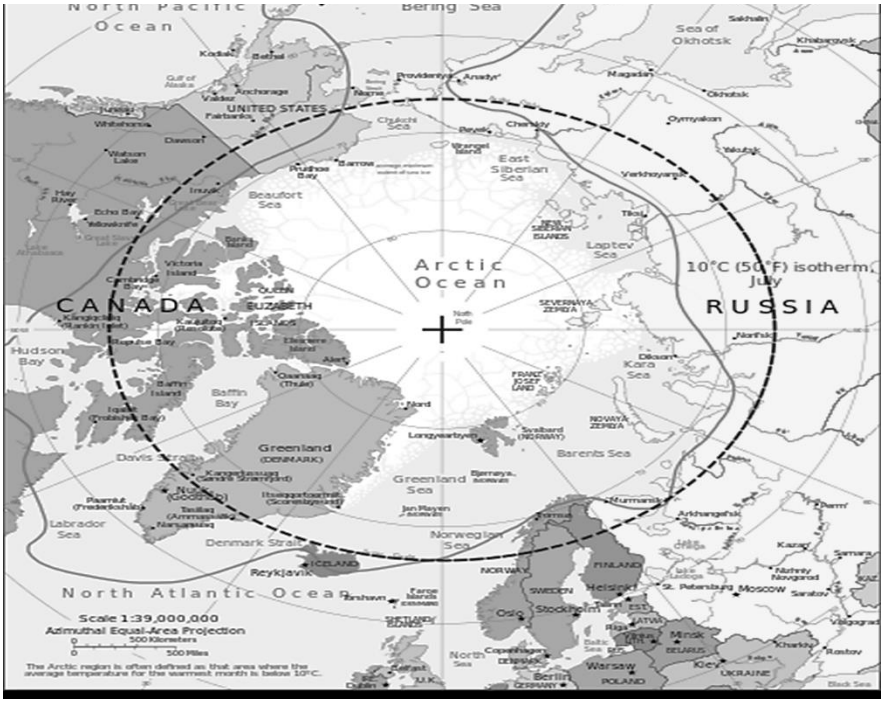
Jewish Life on Other Planets

With the possibility of habitation on other planets comes the possibility of human life on other planets. As Jews, another question comes into play: how would Jewish life be structured on other planets? On Earth, the Jewish year is structured around the moon. Not all planets have moons, and some have multiple moons. As this is a relatively recent issue, Rabbis haven't discussed this issue yet, but the questions remain clear.

The Issues Regarding Jewish Life in Space

- Jewish life on Earth revolves around the moon. What if the planet doesn't have a moon or has multiple?
- The Torah in דברים states "שמור את חודש האביב" regarding the holiday of Passover. How would this be upheld if the planet doesn't have seasons?
- When would Rosh Chodesh fall out?
- When would the holidays be observed?
- When would one daven?
- How would the Zmanim be organized?

The Arctic Circle — one place where the days aren't clear throughout the year.



Tefillah and Shabbos When There is No Day

Although there are no answers to the above questions yet, assumptions can be made based on decisions regarding places on Earth. For example, areas like Alert, Nunavut in Canada where the sun does not set for five months of the year. There are many opinions regarding this matter. The *Tiferes Yisroel* stated that the visitor should daven and observe Shabbos when the people of his hometown do. From here one might guess that someone visiting such a planet would observe Shabbos and daven the times that Earth does. With this answer, however, comes the question of if the person is a resident of the region or planet. They would have no home country or planet to follow. The *Moadim*

U'Zmanim states that a day would start and end when the sun would be at its lowest point in the sky. Since all habitable planets orbit a star (because they are found using the star they orbit) this could be a possible method of observing Shabbos and davening on a different planet.

Observing Mitzvot in Space

There is the question of whether *mitzvot* even need to be observed in space. Rabbi Ben-Zion Firrer mentions that in *Devarim*, the Torah states that you must follow the commandments "כל הימים אשר אתם חיים על האדמה". Assuming that אדמה means earth, Rabbi Firrer suggests that this statement means that the *mitzvot* need only be observed on planet Earth and not in space on another planet.

Conclusions

There is much to be discovered about space and newly discovered possibly habitable planets before a final answer can be reached. Perhaps Jews should simply not go to space like the *Minchas Elazar* discourages people from going to places where the days and nights aren't clear. Or maybe there is no Jewish life in space — meaning, the *mitzvot* weren't meant to be observed there. This is much like the idea of *mitzvot* that are only observed in *Eretz Yisrael*. However, some *mitzvot* that are meant solely for *Eretz Yisrael*, are done out of the country as a reminder. Perhaps such reminders would be observed on another planet. Whatever the case, planets that sustain human life haven't been found yet, but they soon may, and the question of Jewish life on other planets will become relevant. At that point, we have no doubt that our *chachamim* will illuminate the way for us.

WORKS CITED

1. Culler, J. (2015, March 24). Kepler Finds 1st Earth-Size Planet In 'Habitable Zone' of Another Star. Retrieved February 27, 2017, from <https://www.nasa.gov/ames/kepler/nasas-kepler-discovers-first-earth-size-planet-in-the-habitable-zone-of-another-star>.
2. Johnson, M. (2015, April 13). Mission overview. Retrieved February 27, 2017, from <https://www.nasa.gov/mission_pages/kepler/overview/index.html>.
3. Northon, K. (2017, February 22). NASA Telescope Reveals Record-Breaking Exoplanet Discovery. Retrieved February 27, 2017, from <https://www.nasa.gov/press-release/nasa-telescope-reveals-largest-batch-of-earth-size-habitable-zone-planets-around>.
4. Summer Travel. (n.d.). Retrieved February 27, 2017, from <http://www.star-k.org/articles/articles/travel/515/when-does-one-pray-when-there-is-no-day/>
5. What defines "on this earth" from a halachic standpoint? (n.d.). Retrieved February 27, 2017, from <http://judaism.stackexchange.com/questions/27107/what-defines-on-this-earth-from-a-halachic-standpoint>.
6. When does somebody living in space (e.g. ISS) observe Shabbat? (n.d.). Retrieved February 27, 2017, from <http://judaism.stackexchange.com/questions/9250/when-does-somebody-living-in-space-e-g-iss-observe-shabbat>.