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Table of Contents

Brief Letter from the Editor

Hello reader,

Thank you so much for taking the time to look through this issue. We have received many really great submissions in the last few months and appreciate all the effort and thoughtfulness of each paper. Thanks to the amazing efforts of our editors, we have reviewed all submissions and returned feedback to the writers. In a collaborative effort, we have identified the best papers, which are featured in this issue. Curieux Academic Journal was founded in 2016 with the intention of creating a place for high school students to express themselves in all academic subjects. We hope that we have accomplished this goal.

Thank you for your time and support,

Caroline Xue

May 2021

About the authors:

Adithya Prabakaran is a senior at the Trumbull Regional Agriscience Center in Trumbull, CT. Academically, he is interested in the molecular and nanomolecular scale of biotechnology and mathematics. Outside of school, he plays tennis, enjoys going to the gym, and plays tenor saxophone. He recently committed to Cornell University for biomedical engineering.

Katie Rebhan is a senior at The Potomac School in McLean, Virginia. She mostly writes fiction pieces and plays, but she has also recently branched out into research papers. Besides writing, Katie plays volleyball and golf, referees volleyball for her local youth league, and serves as an editor of both her school newspaper and yearbook. In her free time, Katie also enjoys reading, baking, and spending time with her family and friends.

Daksh Pandey is a sophomore at Army Public School, Jaipur, India. He is very interested in Mathematics, Physics and Computer Science. He is also a member of his school's Quiz Team and captain of the under 14 Table Tennis Team of his school. He is a devotee of 'The Great Indian Mathematician- Srinivasa Ramanujan' and 'Richard Feynman'. He intends to study Computer Science and Mathematics after his high school. In his free time, he enjoys playing guitar, harmonica, Rubik's Cube and solving Mathematical Puzzles.

Jiacheng Kang is a Junior at The Groton School. He is the founder and head of his school's current events club, and he is also the assistant opinions' editor of his school's official student-run newspaper. His writing has been honored by the Scholastic Art and Writing Awards, and he enjoys learning more about International Relations in his free time.

May 2021

Arjun Sharma is a senior from the San Francisco Bay Area. He is passionate about ocean conservation and is interested in the effects of xenobiotic pollutants on marine fauna and flora. He is also interested in exploring the intersection of xenobiotics and technology to address the impacts of the former.

Ethan Han is a junior at Boston Latin School where he enjoys learning history, economics, and computer science. In the Massachusetts National History Day Contest, Ethan received the 2020 Massachusetts Historical Society Special Award and the 2021 Clara Barton Birthplace Museum Special Award for his historical papers. Ethan enjoys volunteering with the Red Cross, Boston Cares, local news station WGBH, and is the founder of BLS Connect, a community outreach organization that bridges the Boston Latin student community with the Brighton Civic Association.

Flavr Savr Tomato: Future Improvements to the Fruit via Experimental Technologies

By Adithya Prabakaran

Abstract

In the early 1990s, tomatoes spoiled heavily a few days after harvest. To overcome this problem, Calgene created the Flavr Savr tomato, which became the first GMO crop to receive FDA approval and be sold commercially. The Flavr Savr tomato contained an antisense version of the endo-polygalacturonase gene (pTOM6), which prevented premature rotting. The application of antisense technology in the Flavr Savr tomato was well calculated and became one of the best approaches to be followed in the early 1990s. However, scientific discoveries since then suggest that there could be more effective ways to suppress pectin degradation. The first method examined is atomic prodding. This technology is not ready as of now, but could have huge implications once the field of mechanochemistry fully matures. Another alternative is the use of CRISPR technology to disrupt pTOM6 with the insertion of another gene, preferably one that makes a tomato taste better. Inserting a monellin gene is suggested since it makes tomatoes taste better, and indirectly increases nutrition. Silencing the endo-PG via a repressor allows scientists to fuse a repressor to deadCas9 and silence the gene. Lastly, CRISPR's versatility may even allow methylation (epigenetic changes) of the promoter sequence, or even the pTOM6 gene itself. Much of the alternatives suggested in this paper are experimental and would require more research in order to develop a commercial Flavr Savr tomato. However, if those technologies are proven, the Flavr Savr tomato could be the gateway modified product to a new generation of consumers.

May 2021

Keywords: Flavr Savr tomato, mechanochemistry, atomic prodding, CRISPR, versatility, more research

Introduction

Background and Reasoning for Creation of Flavr Savr

The Food and Agriculture Organization of the UN stated that "...the world produces more than 1 1/2 times enough food to feed everyone on the planet. That's already enough to feed 10 billion people…" [1]. However, post-harvest management of crops is a different story.

The three main goals of post-harvest crop management are: maintaining the quality of the crop, ensuring food safety, and minimizing losses during the entire post-harvest process [2]. In the case of the tomatoes sold in the 1990s, the fruit became very soft and rotted within a few days after harvest. To prevent this, farmers harvested tomatoes when they were not fully ripe (green) to prevent premature rotting. The toxic chemical tomatine was present in high concentrations as a result [3]. A more permanent fix for the softening of tomatoes was needed.

The Flavr Savr tomato utilized groundbreaking antisense RNAi technology to nullify the effects of endogenous polygalacturonase (PG is discussed more under "Characterization of Polygalacturonase"). Much of its commercial success was due to Calgene properly labeling it and seeking FDA approval by their own volition [4]. Its genetic success came from the incorporation of an antisense polygalacturonase gene within the tomato genome. Since the inception of recombinant DNA, "planned and realized applications in the field of antisense and nucleic acid nanotechnologies have produced astonishing results and posed new challenges for further developments" [5]. By either flooding a cell with millions of mRNAi antisense copies of a gene, or incorporating an antisense gene, the technology offers

a method for suppressing “unwanted” mRNA. Antisense is already employed in nature by *Arabidopsis thaliana* [6] and has been experimented with in other avenues, including muscular dystrophy in humans [7].

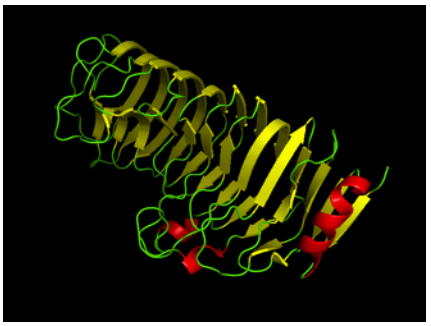
Objectives of this Paper

Nearly 20 years of scientific advancements followed since the success of antisense technology Flavr Savr. Given the rapid introduction of new technologies, there are bound to be better methods to suppress pectin (major cell wall component) degradation. This paper aims to: 1) critically evaluate the application of antisense technology in the Flavr Savr tomato, and 2) discuss alternatives that would prove to be better or simpler than antisense technology. The alternatives examined in this paper are: 1) The atomic prodding of the pectin chains, strengthening it at a molecular level; 2) Using CRISPR technology to disrupt the pTOM6 promoter, and also disrupt the endo-PG gene with genes targeted towards better taste.

Basics of Antisense in Flavr Savr Tomato

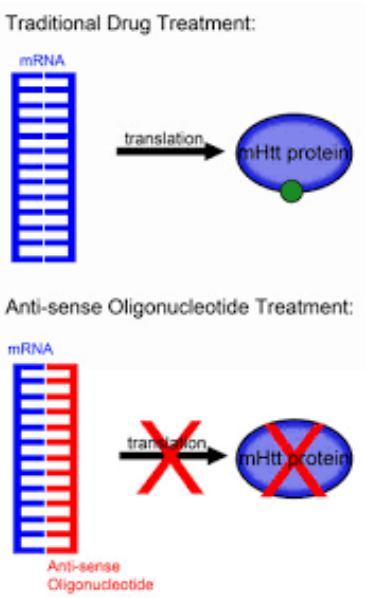
Characterization of Polygalacturonase

Don Grierson et al. isolated the polygalacturonase gene in 1986 and characterized the PG gene promoter in 1988 [8]. Endogenous polygalacturonase [poly-alpha-1,4-galacturonide glycanohydrolase; EC 3.2.1.15] is the pectinase enzyme responsible for the degradation of the cell wall in tomatoes. Composed of multiple parallel β-pleated sheets that form to create a β-helix (Right - a computer-generated image of PG in *Aspergillus aculeatus*), PG’s numerous hydrogen and disulfide bonds provide a stable structure that is characteristic of many pectinases [9]. It serves to hydrolyze the O-glycosyl bonds in random places along the pectin cell wall, resulting in the softening of the tomato in various locations [10, 11].



Basics of Antisense Technology

Scientists labeled the coding strand as the sense strand and the non-coding strand as the antisense strand [12]. Similarly, there is sense and antisense RNA. Commonly used for RNAi purposes, antisense RNA can be used to prevent mRNA from undergoing translation, as well as "Blocking RNA splicing… preventing introns from being spliced out of the mRNA… hindering translation, and the triplex formation in DNA" [13]. Pictured to the right is a simplified model of how antisense RNA functions. Antisense has already been experimented with and approved in combating Duchenne muscular dystrophy [14, 15], hereditary transthyretin-mediated amyloidosis [16], and cytomegalovirus retinitis [17].



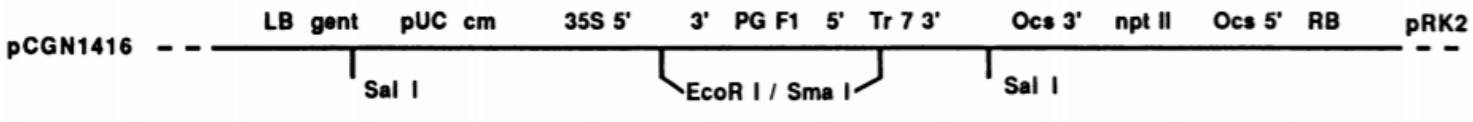
When considering antisense therapy, the common protocol is to flood a cell with millions of copies of the antisense RNA template. As long as there are more antisense RNA copies than there are functional mRNA templates, the majority of protein synthesis for that specific mRNA template will be inhibited. In the case of the Flavr Savr tomato, inserting millions of RNAi strands would not be the most efficient option. Since there are billions of cells in a tomato, the better option would be to introduce a stable antisense gene instead of unstable RNAi molecules [18].

Antisense in the Calgene Flavr Savr Tomato

Materials and Methods

Andrew Hamilton used antisense technology to identify genes that were involved in ethylene production [8]. In 1987, researchers at Calgene successfully cloned the endopolygalacturonase gene via recombinant DNA technology. They then constructed a

binary plasmid. This plasmid contained multiple restriction sites, most notably EcoRI,



BamHI, and HindIII [20]. After multiple digestions and re-ligations, pCGN1416 is the culmination of two other plasmid constructs: pCGN1410 and pCGN1414 [20]. To transform the tomato plant, *Agrobacterium*-mediated transgenics was used [20]. Kanamycin resistance was used as a screening agent to check for transformation. Polygalacturonase activity was quantified through homogenization with a Brinkmann Polytron [20], centrifugation, and then assayed.

Results

Since pCGN1416 contained the cauliflower mosaic virus 35S promoter, it was expected that the plasmid would generate high amounts of antisense PG mRNA. Before maturation, there was no sign of the mRNA [20]. The level of sense polygalacturonase mRNA in the transformed fruit was virtually undetectable when screened initially [20]. This reduction was then confirmed by a strand-specific probe, which found that "The steady-state level of PG mRNA in ripening fruit of 1416-1… was reduced by ≈90% of the level in [the untransformed] fruit" [20]. The steady-state level was preserved late into fruit maturation. Furthermore., "The level of inhibition observed varied from 69% (1416-7) to 93% (1416-30) in transformants with levels of antisense RNA detectable by RNA gel blots" [20]. Unfortunately, there was no identifiable relationship between the steady-state amount of antisense mRNA and observed inhibitory activity.

Discussion

A considerable advantage of this method is the use of the CMV35S promoter. During the green fruit stage, transformed fruit only synthesized the antisense PG mRNA. There was

no sign of endo-PG RNA in the transformed fruit during this stage [20]. While ripening, the endo-PG transcription rate appeared to be very similar in both the untransformed and transformed versions, indicating that the transcription of antisense mRNA is enough to overshadow the sense mRNA. Furthermore, because the expression of sense PG mRNA is temporally separated, the transcription of antisense mRNA has a 10-day head start. With transcription being controlled by the promoter, this can result in millions of copies of antisense mRNA before ripening begins.

Furthermore, according to Sheehy et al., "The fact that PG mRNA can accumulate to >1% of the total mRNA while the gene is transcribed at a relatively low rate suggests that it is the efficiency of post-transcriptional processing and stability of PG mRNA rather than the transcription rate which are responsible for its high level of accumulation" [20]. This once again highlights the importance of a promoter that codes for high volume transcription. It also reaffirms that Calgene's approach to focus on transcriptional regulation was the correct choice.

As expected, there are not many disadvantages to Calgene's Flavr Savr tomato. The only major downside is the possibility of gene escape, or the movement of genes from one organism to another [21]. According to a study done by Calgene in 1992, there are two modes of gene escape in tomatoes. The first is outcrossing. Calgene stated that "There will be no impact of transfer and expression of foreign genes… because no sexually-compatible wild relatives are present in the United States" [22]. Calgene did not provide confirmations for other nations. The second mode of gene escape is gene flow between plants and microbes. Horizontal transfer has a major role in antibiotic resistance, but Calgene claimed this concern is unimportant because there was no definition of horizontal transfer. Keeping in mind that Calgene's paper was written in 1992, it is important to note that there are three defined

mechanisms of horizontal gene transfer. Therefore, gene escape via horizontal gene transfer is a tremendous concern in the 21st century.

The antisense PG trait inserted in the Flavr Savr tomato also does not give any competitive advantage to other relatives [22]. If the antisense gene were to escape, the tomato fruit in wild *Lycopersicon* species would soften slower, and that is it. If anything, that is a good thing because the spreading of seeds will be mitigated to some degree.

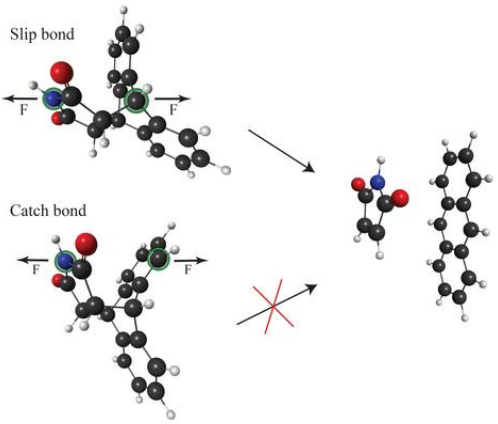
Conclusions - Calgene

Overall, Calgene's approach to the Flavr Savr was well calculated. By focusing on transcriptional regulation, the antisense gene successfully inhibited up to 93% of polygalacturonase expression [20]. In the United States, outcrossing would not be a major concern as there are no sexually compatible species for the commercial tomato to cross with. However, given that this paper is being written 25 years after the inception of the Flavr Savr tomato, there are new technologies that could make the tomato even better than it already was.

Alternative 1: Atomic Prodding

Basics of Atomic Prodding

Mechanochemistry is the study of using force to initiate a chemical reaction [23]. Atomic prodding refers to the use of high-frequency soundwaves to move the atoms in a molecule [24]. In an experiment done by Dmitrii Makarov, it was discovered that this process could create either slip or catch bonds [24]. A slip bond occurs when a bond is destroyed by increased force [25]. Conversely, a catch bond strengthens the bond [24].



Successes of Atomic Prodding

Dmitrii Makarov examined six different mechanophores through simulations [26]. By applying different piconewton and nanonewton forces at every atomic pairing, Makarov found a 50/50 relationship between the occurrence of slip bonds and catch bonds [26].

As of now, there is a small relationship between the type of force and the resulting bond. In one of Makarov's previous experiments (not simulation), "the mechanophore exhibited slip bond behavior when a pair of atoms was perturbed, but in an alternate pulling arrangement simulated by Makarov the bond was fortified into a catch bond" [26]. If this phenomenon is proven to be a reliable way to create catch bonds, strengthening the bonds in pectins could be relatively simple. A deeper understanding of quantum physics and other fields may provide an explanation as to why slip and catch bonds occur counterintuitively. It would also be a non-invasive and non-genetically modified approach that would alleviate concerns when using it as a consumable.

Disadvantages to Atomic Prodding

Mechanochemistry is still in its infancy, and researchers need to come up with an ironclad method to completely control chemical reactions. In fact, the initial appearance of catch bonds confused many mechanochemists, considering they are chemical oddities and go against chemical intuition. Furthermore, Makarov's experiment relied on six mechanophores that previously showed reactivity to external stimuli, including spirolactam, spiropyran, and dianthracene [27]. None of these materials are involved in a tomato's cell wall, and so a quest to find new mechanophores that are compatible with the tomato's cell wall biochemistry is needed to find alternate solutions to the antisense approach, i.e. without genetically modifying the fruit.

Conclusion - Mechanochemistry

Mechanochemistry is still in its infancy but can have huge implications on an

upgraded Flavr Savr tomato. Within a few decades, mechanochemistry may evolve to the point where thousands of materials can be influenced by external stimuli. Makarov's research also acted as a proof-of-concept experiment [26]. It is not designed to be a blueprint to mechanochemistry. The experiment shows that catch and slip bonds have about an equal rate of occurrence, nothing else.

This option is suggested because mechanochemistry offers a way to modify a tomato without any recombinant DNA, radiation, or chemical bombardment. Thus, the public is more likely to accept it, considering the only thing affecting the tomato is sound. Moreover, by strengthening the appropriate bonds themselves, it will be harder for endopolygalacturonase to hydrolyze cellulose. It could result in a tomato that can be stored for weeks or even months.

Alternative 2: Utilizing CRISPR to Edit pTOM6

Monellin and CRISPR

Monellin is a protein that was discovered in the serendipity berry (*Dioscoreophyllum cumminsii (Stapf) Diels*) [28]. With the 3000x increase in sweetness compared to sucrose, monellin does not need to be overly present in tomatoes. Therefore, a CMV35S promoter, or other promoters that code for rapid mRNA production should not be used. Since monellin is a protein, it is not pH or heat stable, and will be denatured if placed under stress. It was found that most monellin proteins denature at temperatures greater than 50℃ (122℉) [29].

A big advantage of using monellin is for diabetics. Although tomatoes do not have a high amount of carbohydrates [30], monellin is a good substitute for the sucrose found in tomatoes. Not only does a little bit of monellin decrease the carbohydrate count and increase the amount of protein, but it also makes the tomato taste sweeter. When eating uncooked tomatoes, like in a burger, the tomato will taste better.

Furthermore, by incorporating monellin and bettering the taste of a tomato, people

would be more likely to eat it. Eating tomatoes is important since they are an important source of lycopene. In fact, 80% of the United States' lycopene intake comes from tomatoes [31]. The U.S. Poison Control Center stated that "One study suggested that lower blood concentrations of lycopene were associated with early atherosclerosis in men" [31]. Furthermore, with its properties as an antioxidant, lycopene is too important for humans to forgo. Therefore, by making a tomato taste better, lycopene consumption would be indirectly, yet positively, affected.

Luckily, inserting monellin into the tomato genome is relatively easy. By using CRISPR/Cas9 nickase, sticky ends could be created. Then, a monellin gene construct could be inserted with ease without too much damage to the DNA. The gene construct would need to include the monellin gene, a slow promoter sequence, and a kanamycin resistance gene. The homology-directed repair pathway would do all the work, with the monellin gene construct being safely and efficiently incorporated into the tomato genome.

CRISPR and the pTOM6 Promoter

One way to silence the pTOM6 gene is to aim for the promoter sequence. By using deadCas9 in a CRISPR setup and fusing a transcriptional repressor such as a methyl group, the promoter would be turned off. Though methylation is a form of epigenetics, CRISPR has been proven to be effective in epigenetic changes as well. In a review article done by Nina Xie et al., it was stated that "The dCas9-DNMT3A complex was proved to be able to induce methylation at targeted CpG sites within multiple gene promoters. The highest methylation rate was estimated to be 50%" [32]. CRISPR's epigenome-editing capabilities are still being experimented with, though this study shows promising results. With 50% accuracy being reached already, CRISPR's epigenome editing capabilities should be close to 95% within the next few years.

Another way to deactivate the pTOM6 promoter via CRISPR is to create a frameshift

mutation. CRISPR/Cas9 nickase has been used to create these frameshifts. This method is even simpler than the first since no item needs to be fused to Cas9 and no repair template needs to be provided. With a proper sgRNA, Cas9 nickase would cut in the middle of the promoter sequence. Then, the non-homologous end-joining repair pathway will fix the DNA and will create a frameshift mutation simply by following this pathway.

By deactivating the promoter sequence, the endo-PG gene would be deactivated instantly. And, the tomato would not be too difficult to cut through, since ethylene ripens a fruit anyway [33]. Endo-PG only speeds up the process of pectin degradation.

Conclusions - CRISPR

CRISPR is a powerful tool, one that makes genetic engineering very efficient and precise. Inserting monellin would be a great benefit. Not only does it make the tomato taste better and help diabetics, but it also indirectly increases lycopene intake. Lycopene's properties as an antioxidant, as well as the numerous studies that prove it can prevent heart disease and other illnesses, make it an essential compound for humans' long-term survival. In terms of silencing pTOM6, CRISPR's versatility allows pTOM6 to be silenced in multiple ways. The method that this paper focused on is attacking the promoter sequence. CRISPR's capability to edit the epigenome is still unknown, yet based on the studies done already, it can be viable. More research into CRISPR's versatility could have implications with regards to the Flavr Savr tomato.

Conclusion

Calgene's Flavr Savr tomato was a great product. Their use of antisense technology in the tomato was masterful, and they were wise to focus on transcriptional regulation as opposed to translational regulation. All in all, the Flavr Savr was a well-developed and well-received product but is no longer in markets due to commercial issues [34]. Unfortunately, Calgene also did not have access to the most superior varieties of tomatoes, so

their product made minimal impact [34]. Had they received samples of superior varieties, the Flavr Savr tomato might still be in markets. Overall, the Calgene made little to no mistakes, and their product was a symbol that genetic engineering is the future.

As with any product, there are always improvements that can be made. As mechanochemistry evolves, there could be thousands of mechanophores as opposed to the 6 used in Makarov's experiments. As scientists' understanding of quantum physics increases, mechanochemistry will become more potent. As of now, atomic prodding is too experimental to be used in a commercial setting, perhaps even in a research setting. There is a high chance that atomic prodding might not affect pectin since it is not a known mechanophore, yet advances in the field may prove otherwise. Makarov's proof of concept experiment showed that mechanochemistry is a viable field. As more research is conducted (not simulations, but experiments with real mechanophores), atomic prodding could be proven to be a great way to create a Flavr Savr tomato that could last for weeks or even months.

CRISPR's versatility is one of the greatest advantages the technology has. Research into its epigenome editing capabilities is ongoing, but so far, the results are promising. With 50% accuracy in 2018, CRISPR will become more precise in the epigenome as the research develops. However, deadCas9 has already been proven, and fusing a repressor to the promoter sequence has been tested. While the methyl group was suggested, other repressors may do the job more efficiently. When Don Grierson characterized polygalacturonase, he did not provide any information about a repressor, so there are two options. The first is to heavily redesign the endo-PG to include an area where a repressor could bind. However, this method is very time-consuming and commercially unfavorable. The second, and more feasible, option is to experiment with different common repressors and find the one that is the most effective. This option is safer than the first option and will be less intensive overall.

Much of the proposals in this paper are experimental and act as a proof of concept,

similar to Makarov's research. The ideas discussed, mainly atomic prodding and mechanochemistry, and CRISPR's epigenome editing capabilities, have all been established, but not thoroughly explored. More research in these areas is key in order to create an improved Flavr Savr tomato. While the tomato is a smaller crop, it is an important source of lycopene and other antioxidants, meaning that it is a crop that cannot be overlooked.

This paper could not have been possible without the help of Dr. Thomas Vrabel and Dr. Prabakaran Krishnamurthy.

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[26] The Oden Institute for Computational Engineering and Sciences. (n.d.). Retrieved from https://www.oden.utexas.edu/about/news/290/

[27] Deneke, N., Rencheck, M. L., & Davis, C. S. (2020, June 11). An engineer's introduction to mechanophores. Retrieved from https://pubs.rsc.org/en/content/articlelanding/2020/sm/d0sm00465k#!divAbstract

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[31]May, M. E. (2020, October 28). What's Lycopene? Retrieved from https://www.poison.org/articles/lycopene-171

[32] Xie, N., Zhou, Y., Sun, Q., & Tang, B. (2018, July 08). Novel Epigenetic Techniques Provided by the CRISPR/Cas9 System. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6079388/

[33] Ethylene. (n.d.). Retrieved from https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/ethylene

[34] -, A. P., By, & -. (2018, October 31). Mistakes Shorten Flavr Savr's Shelf Life. Retrieved from https://www.genengnews.com/insights/mistakes-shorten-first-approved-gmos-shelf-life/#:~:text=“Flavr Savr failed because it,with FTO,” added Dr.

The Enigma Machine: Ultra Secret

By Katie Rebhan

Although World War II, which was waged from 1939 to 1945 across more than 30 countries, was the deadliest war in history, few people know the secret undercurrents that shaped its outcome. Kenneth W. Rendell, historian and founder of The International Museum of World War II, stated, "Military operations shrouded in secrecy altered the conflict time and again, despite efforts on all sides to discover through intelligence what the enemy was up to."[1] Both the Allies and the Axis powers sought to establish tactical advantage through innovative practices, but one of the most important technologies in the war remains unknown to most: the Enigma machine. The focused effort of the Allies to crack the Enigma code indicated the rising importance of intelligence in warfare and was a pivotal turning point in World War II, ultimately contributing to a quicker end to the war.

The Enigma machine represents one of the greatest technological advancements in history, as it allowed scientific intelligence to play as significant of a role as military power in World War II. Arthur Scherbius, a German electrical engineer, invented the Enigma, a rotor-based cipher machine, in 1918.[2] The machine used a rotor, a wired codewheel with the body of a disk made of a nonconducting material. The most revolutionary component of the Enigma was that the rotor could turn, as the pressing of a typewriter key pushed the rotor forward $\frac{1}{26}$th of a revolution, therefore giving each plaintext letter a different internal rotor path and ciphertext letter. With the addition of more rotors, the period (how long it takes for the machine to repeat a ciphertext) lengthened, increasing the number of possible

[1] Neil Kagan and Stephen G. Hyslop. *The Secret History of World War II: Spies, Code Breakers, and Covert Operations*. N.p.: National Geographic, n.d.

[2] Andrew Lycett. "Breaking Germany's Enigma Code." BBC. Last modified February 17, 2011. Accessed April 28, 2019. http://www.bbc.co.uk/history/worldwars/wwtwo/enigma_01.shtml.

combinations to over 150 trillion and making the codes exponentially more difficult to break. Although the German Navy and the German Foreign Office had originally rejected Scherbius' machine, they reconsidered their decision once Scherbius developed an enhanced machine in 1923. In addition, they discovered that the British had been reading coded German naval messages for much of World War I.[3] The navy therefore recognized the need to change its entire system of communication and returned to Scherbius' offer. Production of an Enigma specifically made for the navy, which had different rotor wiring, two more rotors, and three more contacts, began in 1925. After observing the effect of the Enigma machine on naval communications, the German Army (Wehrmacht), Air Force (Luftwaffe), and Secret Service (Abwehr) each generated their own versions of the machine.[4] By the beginning of World War II in 1939, the Germans had a supposedly airtight cipher system that "sought to preclude the dangers of operators' stupidity and laziness, the capture of some documents, betrayal, and superimposition."[5]

The Polish Cipher Bureau (*Biuro Szyfrów*) laid the groundwork for future codebreakers when it conducted the first attempt to break the Enigma cipher in 1930. Their proximity to Germany made Poland one of the first to recognize the impending threat of war and thus the importance of cracking Germany's new system of cryptography, the Enigma.[6] The Head of the Polish Cipher Bureau, Gwido Langer, discerned that solving the Enigma cipher was a task for mathematicians as opposed to linguists, so he sought help from Marian Rejewski, Jerzy Rózycki, and Henryk Zygalski, students at the University of Poznán in western Poland.[7] In 1933, the Polish Cipher Bureau received access to the Enigma operating procedures used by the German army when a clerk at the German Cipher Office, Hans-Thilo

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[3] Kahn, *Seizing the Enigma.*

[4] "History of the Enigma." Crypto Museum. Last modified March 14, 2012. Accessed April 28, 2019. https://www.cryptomuseum.com/crypto/enigma/hist.htm.

[5] Kahn, *Seizing the Enigma.*

[6] "History of the Enigma." Crypto Museum.

[7] Chris Christensen. "Polish Mathematicians Finding Patterns in Enigma Messages." *Mathematics Magazine* 80, no. 4 (2007): 247-73. Accessed May 10, 2019. http://www.jstor.org/stable/27643040.

Schmidt, sold information to the French Secret Service. The French then passed on their information to the Poles, giving them the ability to analyze and reconstruct the Enigma machine. Rejewski reduced the Enigma to mathematical equations, which he then solved with the aid of more documents from Schmidt.[8] Between 1933 and 1938, the Poles intercepted and decrypted the majority of German radio traffic. In order to keep up with daily changes and determine the rotor order and setting for Enigma messages, Polish cryptanalysts invented the *bomba*. *Bombas* were machines that automated rotors from six Enigmas such that they moved through thousands of settings in tandem.[9] In 1938, Poland saw a huge increase in the number of messages sent by the Germans, so they deduced that Germany was preparing for war. However, on September 15, 1938, the Germans abandoned their previous technique of using a common basic setting for all Enigma traffic. Instead, they added two additional rotors to the preexisting three, each with different wiring, increasing the possible rotor order from six to 60.[10] Thus, because they had been focused on the Enigma, the Poles correctly concluded that war was imminent and that it was imperative to share their information outside of the country.

Assembling a team of thought leaders from diverse professions, the British sought to build on the progress of prior Enigma code breaking efforts. In both January and July of 1939, the Polish Cipher Bureau, the British Government Code and Cypher School, and the Deuxieme Bureau of France convened at a conference to share their collective information on the Enigma and expand upon each other's ideas.[11] The Poles revealed their success in solving the cipher and introduced their replica machine to the British and French, continuing collaborative relations among the countries.[12] With the Polish government's lack of adequate

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[8] Kagan and Hyslop. *The Secret History of World War II: Spies, Code Breakers, and Covert Operations*.
[9] "Bombe." Crypto Museum. Last modified January 3, 2019. Accessed May 13, 2019. https://www.cryptomuseum.com/crypto/bombe/.
[10] Kagan and Hyslop. *The Secret History of World War II: Spies, Code Breakers, and Covert Operations*.
[11] Dirk Rijmenants. "Technical Details of the Enigma Machine." Cipher Machines and Cryptology. Last modified 2017. Accessed May 13, 2019. http://users.telenet.be/d.rijmenants/en/enigmatech.htm.
[12] Sinclair McKay. *The Lost World of Bletchley Park*. London, Great Britain: Aurum Press, 2013.

finances to advance the code breaking effort, the initiative shifted from Warsaw to Bletchley Park, an estate home to the British Government Code and Cypher School.[13] After the conference, in August 1939, the British assembled a diverse array of people at Bletchley, including professional codebreakers, mathematicians, chess players, and translators. On September 4, 1939, the day after Britain declared war on Germany, mathematician Alan Turing reported to Bletchley Park, joining a team of cryptanalysts.[14] Turing, working with Gordon Welchman, another mathematician at Bletchley,[15] quickly realized that German changes to the Enigma had made the Polish *bomba* obsolete. He therefore developed his own version of the *bomba*, which he called the bombe, that addressed Enigma advances, many of which had neutralized the early achievements of the Poles.[16] These Turing-Welchman bombes were incredibly efficient and greatly assisted the Allied cause, especially in cracking messages from the German Army and Air Force.[17] However, the German naval Enigma had an operating procedure that was much more complicated and allowed a choice of three rotors from a possible set of eight rather than six. In 1941, after recovering valuable Enigma documents from German ships and submarines, Turing and his colleagues were able to figure out the naval message procedure and decrypt naval code traffic.[18] In February 1942, the German navy introduced a new, more advanced Enigma machine, called the Enigma M4, with no warning.[19] To make matters worse, around this same time, German cryptanalysts were breaking and reading Allied codes, therefore giving them the ability to sink more than 1,000 Allied and neutral ships in the Atlantic Ocean. The Allies could not read any German messages for almost 9 months, until October 1942, when the German submarine *U-559* sank.

[13] "How Alan Turing Cracked the Enigma Code." Imperial War Museums. Last modified January 5, 2018. Accessed April 27, 2019. https://www.iwm.org.uk/history/how-alan-turing-cracked-the-enigma-code.
[14] "How Alan Turing Cracked the Enigma Code." Imperial War Museums.
[15] Kagan and Hyslop. *The Secret History of World War II: Spies, Code Breakers, and Covert Operations*.
[16] Gladwin, Lee A. "Alan Turing, Enigma, and the Breaking of German Ciphers in World War II." In *Archives.Gov*, 203-17. Accessed May 2, 2019. https://www.archives.gov/files/publications/prologue/1997/fall/turing.pdf.
[17] "Cryptography." Stanford. Accessed May 13, 2019. https://stanford.edu/class/archive/cs/cs106a/cs106a.1164/handouts/29A-CryptographyChapter.pdf.
[18] "The Enigma of Alan Turing." Central Intelligence Agency. Last modified April 10, 2015. Accessed April 27, 2019. https://www.cia.gov/news-information/featured-story-archive/2015-featured-story-archive/the-enigma-of-alan-turing.html.
[19] "History of the Enigma." Crypto Museum.

Onboard the sub were code tables for German naval weather reports.[20] With this information, Bletchley team members worked on decoding weather reports in conjunction with naval Enigma experts and began producing Ultra intelligence—the codename for all information coming from Bletchley Park—that revealed the location of U-boats in the Atlantic.[21] Thus, by building on the initial breakthrough by the Polish cryptanalysts, the British team at Bletchley Park invented the bombe and decoded the Enigma cipher, enabling Great Britain and the Allies to read German messages without their knowledge.

The breaking of the Enigma code, which directly influenced the results of several important battles at sea, in the air, and on land, provided the advantage the Allies needed to ultimately succeed against German forces and win World War II. Specifically, in the Battle of the Atlantic in 1939, the Allies employed Enigma intelligence to succeed in a major naval battle. The greatest threat to the Allied war effort was from German U-boat attacks, arranged in "wolfpacks," on their ship convoys in the North Atlantic.[22] U-boat attacks were extremely brutal and led to the loss of countless Allied ships, people, war cargo, and supplies.[23] However, once Bletchley broke the Enigma cipher, they intercepted, solved, and read coded radio messages between Admiral Karl Donitz, Hitler's commander of submarines, and his U-boats. This enabled the Allies to achieve victory in the Battle of the Atlantic, which Winston Churchill called "the dominating factor all throughout the war."[24] Additionally, Allied commanders used Ultra intelligence to prepare for air attacks and bombing during the Battle of Britain in 1940, when they discovered Germany's plan to use radio beams to guide bombers to targets at night or in bad weather. The British were then able to jam these radio beams, causing enemy aircrafts to miss their targets.[25] Stuart Milner-Barry, a chess player at

[20] Hodges, Andrew. *Alan Turing: The Enigma*. Princeton, NJ: Princeton University Press, 1983.
[21] Kahn, *Seizing the Enigma.*
[22] Lycett. "Breaking Germany's Enigma Code."
[23] "History of the Enigma." Crypto Museum.
[24] Kahn, *Seizing the Enigma.*
[25] Kagan and Hyslop. *The Secret History of World War II: Spies, Code Breakers, and Covert Operations*.

Bletchley, stated, “The advantage conferred on the Allies must have meant a very great saving of lives and, I imagine, a considerable shortening of the war… the intelligence advantage became a match-winning factor.”[26] Enigma intelligence was also the decisive factor in British Lieutenant General Bernard Montgomery’s success against German Lieutenant General Erwin Rommel’s army. Bletchley Park cryptanalysts cracked messages sent between the Berlin Cipher Bureau and Rommel’s headquarters. Forces under Montgomery then attacked Axis ships in the Mediterranean that carried cargo supplying Rommel’s army, cutting off their resources and ultimately leading to Rommel’s surrender in March 1943.[27] Overall, breaking the Enigma code saved approximately 14 million lives, as the war would probably have continued for another two to three years if the Allies hadn’t been able to discover the location of German U-boats.[28] In fact, General Dwight D. Eisenhower told the British Intelligence Chief in July 1945, “Ultra saved thousands of British and American lives and, in no small way, contributed to the speed with which the enemy was routed and eventually agreed to surrender.”[29]

The cracking of the Enigma cipher, which required the cooperation of multiple countries for practically the entirety of the war, indicated the necessity of strategic military intelligence in warfare and ultimately contributed to Allied success in multiple battles and World War II as a whole. However, the Enigma code was not only significant to the World War II legacy; it also laid the foundation for modern technology. The machine itself represents the beginning of information security and hacking, which is especially relevant in the current economy, as it requires people and institutions to protect data in unbreakable codes. In fact, the entire cyber security industry offers pivotal protection to governments, economies, and citizens. Turing’s mathematical and logical work, including his revolutionary

[26] F.H. Hinsley and Alan Stripp, eds. *Codebreakers: The Inside Story of Bletchley Park*. N.p.: Oxford University Press, 1993.
[27] Kagan and Hyslop. *The Secret History of World War II: Spies, Code Breakers, and Covert Operations*.
[28] Copeland, Jack. "Alan Turing: The Codebreaker Who Saved 'Millions of Lives.'" BBC. Last modified June 19, 2012. Accessed May 13, 2019. https://www.bbc.com/news/technology-18419691.
[29] "The Enigma of Alan Turing." Central Intelligence Agency.

idea to combine machine and human intelligence, was especially important in this respect, as it was the basis for the modern computer, essentially established the field of computer science, and was a precursor to the concept of Artificial Intelligence.[30] As historians have continued to explore the secret elements of World War II, the achievements of the Enigma cryptanalysts have emerged as more than just the turning point for the Allies; they enabled much of the military and commercial technological advancements for the next several decades.

[30] New York Times Company. "World War II's Greatest Hero: The True Story of Alan Turing." The New York Times. Accessed May 14, 2019. https://www.nytimes.com/paidpost/the-weinstein-company/world-war-iis-greatest-hero-the-true-story-of-alan-turing.html.

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China's Industrialization Prerequisite: The Agrarian Reform Law as a Policy to Facilitate Industrialization, 1950-1953

By Jiacheng Kang

In 1950, when China was plagued with political unrest and embroiled in war, the Communist Party of China turned to the agricultural sector as a mechanism to save the economy. Though there was often a breakdown in the food supply in previous imperial times, there had never been such a lack of food production in China as between 1920 to 1949.[31] Since agriculture was an integral part of the Chinese economy, Mao Zedong promulgated the Agrarian Reform Law, which called for the abolition of the 'land ownership system of feudal exploitation' and the confiscation of landowners' holdings and farm implements for the redistribution to landless peasants."[32] Furthermore, it aimed to confiscate landowners' holdings and farming paraphernalia so that it could be effectively redistributed to landless peasants.[33] In order to undergo reform, however, the government first had to change their administration to become both centralized and powerful enough to enforce their policy. With a stronger government, they effectively disrupted landlordism and increased production by distributing more land to peasants who utilized the land effectively. The Agrarian Reform Law led to social stratification that increased the position of peasants, provided more fluid

[31] John K. Fairbank and Denis Twitchett, "The Agrarian System," in *Republican China 1912-1949, Part 2*, ed. John K. Fairbank and Albert Feuerwerker, vol. 13, *The Cambridge History of China* (Cambridge, Great Britain: Press Syndicate of the University of Cambridge, 1986), 257.
[32] Immanuel C.Y Hsü, "The People's Republic: Its First Decade," in *The Rise of Modern China*, by Immanuel C. Y. Hsü, 3rd ed. (Oxford, Great Britain: Oxford University Press, 1970), 652.
[33] Fairbank and Twitchett, "The Agrarian," 257.

social classes, created a more centralized administration, and bolstered peasants' trust in the government. Furthermore, the Agrarian Reform Law generated funding to strengthen the military and provided the means to support industrialization. After the Agrarian Reform Law sparked even more reforms, China's land became more collectivized; this integrated Mao's socialist ideas into Chinese society.

However, despite preventative measures to alleviate tension, the rapid change of social classes led to conflict between the landlords and the peasants, evident from 1950 to 1952. The government initially passed a policy which "allowed the landlords to keep their portion of the redistributed land and exempted the rich peasants' land from confiscation that they themselves cultivated."[34] They implemented this seemingly contradictory treatment of landlords because they wanted to preserve peace and maximize profits using landlords' assets.[35] Although the government tried to reduce conflict by passing the aforementioned policy, violence still ensued due to vindictive peasants. Specifically, "many injustices and acts of violence were committed in local accusation meetings, where virulent denunciations of landlords and rich peasants took place under the guidance of overzealous party cadres and vengeful peasants. Both landlords and rich peasants suffered grievous losses at these meetings, and many were summarily shot after a brief public trial."[36] The government was not able to achieve their ideal reform because of the peasants' violence, and the previous landlords were stripped of their power, economic assets, and high social standing. [37] In addition, "a new elite of village cadres emerged from the ranks of poor and middle peasants whose horizons had been broadened by the class-oriented perspective of the CCP."[38] Due to

[34] Immanuel C.Y Hsü, "The People's Republic: Its First Decade," in *The Rise of Modern China*, by Immanuel C. Y. Hsü, 3rd ed. (Oxford, Great Britain: Oxford University Press, 1970), 653.
[35] B N Ganguli, "An Analysis of New China's Agrarian Law Reform," *Indian Economic Review* 1, no. 3 (February 1953): 16, https://www.jstor.org/stable/45149657.
[36] Hsü, "The People's," 653.
[37] John K. Fairbank and Denis Twitchett, "Establishment and Consolidation of the New Regime," in *The People's Republic, Part 1: The Emergence of Revolutionary China 1949-1965*, ed. John K. Fairbank, Denis Twitchett, and Roderick MacFarquahar, vol. 14, *The Cambridge History of China* (New York, USA: Cambridge University Press, n.d.), 87.
[38] Fairbank and Twitchett, "Establishment and Consolidation," 87.

peasants who were resentful of the landlord class, the previous feudalism-based social stratification —which was highly contingent on centralized land ownership — was disrupted to a significant extent, and a new, elite peasant class emerged.

Furthermore, the Agrarian Reform Law, by redistributing land, increased class fluidity because it alleviated economic burdens and changed the rigid social structure of the landlord-dominant agricultural system. Specifically, "land reform succeeded in redistributing about 43 percent of China's cultivated land to about 60 percent of the rural population."[39] Concurrently, the debt that peasants owed to exploitative landlords was abolished.[40] This considerable amount of land distribution significantly increased rural living conditions and the economic resources of peasants. It was clear that after the Agrarian Reform Law, "the average Chinese farmer [was] much better off than before. He [had] gained economic stability, self-respect and a sense of purpose." [41] This newfound respect came from the new social stratifications. More importantly, there was an element of economic mobility, because "in the past, due to the fact that capital accumulation of the Chinese farm was slight, it took a long time, if at all possible, for a person to climb the agricultural ladder from farm laborer to land owner."[42] Accordingly, the peasants gained unprecedented economic freedom due to the easier transition from a peasant to a land owner. Many peasants experienced an increase in social mobility because they no longer had to overcome previously existing economic barriers.

To enact the Agrarian Reform Law, The Chinese Communist Party had to create a new type of bureaucracy to better utilize human resources, which caused the government to become stronger and more centralized. The government used party leaders selected by the

[39] Fairbank and Twitchett, "Establishment and Consolidation," 87.
[40] Ganguli, "An Analysis," 32.
[41] Ganguli, "An Analysis," 32.
[42] Shao-Er Ong, "Economic Status of the Chinese Peasants after Agrarian Reform," *Land Economics* 29, no. 1 (February 1953): 37, https://www.jstor.org/stable/3144283.

Chinese government to carry out mass campaigns.[43] These "campaigns not only uncovered and knocked off victims who were of doubtful use or loyalty, they also uncovered activists of ability who could be recruited into the CCP, which had 2.7 million members in 1947 and 6.1 million by 1953."[44] By having a new organizational structure, the Agrarian Reform Law was expedited. Moreover, by creating a bureaucracy led by government-appointed party leaders that expedited campaigns, the government increased its own power by eliminating dissidents of its policy and creating an increased base of human-resources to draw from.

The relationship between peasants and the government empowered peasants by giving a legitimate reason to resist the landlords, which solidified the effects of the Agrarian Reform Law. Previously under feudalist China, peasants were feared the landlords, so they did "not take part in land and property confiscation and redistribution, unless the shield of the Red Army was strong enough to protect them and give the new property a system of measure of permanency."[45] Evidently, peasants were afraid of the consequences of turning against powerful landlords and needed military backing from the government. However, the government helped the peasants overcome the underlying psychological fear of the previous landlord elites "by demonstrating its credibility during land reform as both a force to be feared and a provider of a better life."[46] Since the government provided the adequate military backing for the peasants, the peasants aided the government in seizing land from landlords. The government and the peasantry class formed a relationship that helped peasants seize land from the landlords, which further cemented the effects of the Agrarian Reform Law.

By taxing peasants and harnessing their agricultural output, the government increased their own power due to the increased supply of food and revenue. In 1949, shortly before the

[43] Chao Kuo-chün, "Current Agrarian Reform Policies in Communist China," *The Annals of the American Academy of Political and Social Science* 277 (September 1951): 118, https://www.jstor.org/stable/1030257.
[44] Fairbank and Twitchett, "Peasant Movements," 280.
[45] John K. Fairbank and Denis Twitchett, "The Communist Movement 1927-1937," in *Republican China 1912-1949, Part 2*, ed. John K. Fairbank, Denis Twitchett, and Albert Feuerwerker, 2nd ed., vol. 13, *Cambridge History of China* (New York, USA: Cambridge University Press, 1990), 189.
[46] Fairbank and Twitchett, "Establishment and Consolidation," 89.

Agrarian Reform Law "inflation had rocketed beyond control; floods had affected 30-40 percent of the arable land; and industrial and food output had plummeted to 56 and 75 percent of the prewar peak, respectively."[47] To address these economic issues, Mao Zedong prioritized agricultural development and the military. [48] The government's primary source of income during the Agrarian Reform Law was from taxes on rural areas. Although debt was abolished and peasants no longer had to pay rent, they still were the backbone of the government's finances. In 1950, almost 90 percent of China's national income came from rural taxation, such as the "Public Grain Tax."[49] It is inextricably tied with The Agrarian Reform Law because the increase in production from the fields increased the amount that the government extracted from the lands. Peasants funded the military and provided an essential source of revenue for the government. Even though the peasants no longer worked under punitive landlords, they still were strained by the government to the extent of taxes. Furthermore, "the truth [was] that the red soldiers and their party, engaged in building a base area, needed men and money,"[50] and peasants provided the human resources necessary for strengthening the army. Agrarian Reform Law, by both taxing peasants and incorporating peasants into the army, strengthened the military.

In China, the reallocation of land from feudal lords to peasants was necessary for industrialization. Mao Zedong understood the importance of the agricultural sector and wrote: "emancipating [the peasants] from feudal agrarian relations, thereby mak[es] possible the transformation of an agricultural country into an industrial country."[51] Mao believed the shift in the possession of land was required before industrialization because peasants have a greater ability to buy goods and fuel the economy. Liu Sao-Chi, the First Vice Chairman of

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[47] Hsü, "The People's," 652.
[48] Mao Tse-Tung, "Economic and Financial Problems in the Anti-Japanese War," in *Selected Books of Mao Tse-Tung* (Peking, China: Foreign Languages Press, 1965), 3:113, PDF.
[49] Ganguli, "An Analysis," 31.
[50] Fairbank and Twitchett, "The Communist," 189.
[51] Tse-Tung, "The Land," 3:297.

the Chinese Communist Party, explained, the "industrialization of China must rely on the vast rural markets at home which can develop only through the increase of agricultural production and expansion of rural purchasing power."[52] While the peasants were seeming freed from the economic burden of paying debt to landlords, they still had to pay government taxes. Despite these taxes, the peasants increased overall economic production, which enabled Chinese industrialization.

The subsequent reforms sparked by the need to perpetuate the effects of the Agrarian Reform Law led to the collectivization of land, which further implemented the socialist ideas of Mao into Chinese society. Mao, in a book published in 1944 entitled "The Land Problem", believed that "the working class [would] be able to build up the strength to lead China in the direction of socialism."[53] The reforms afterwards evidence China's further trajectory towards socialism; shortly after the first Agrarian Reform Law was completed in 1952, "the government started a second phase of agrarian reform -- a drive toward collectivization in 1953, with a view to raising production, preventing the re-emergence of rich peasants, achieving greater agricultural specialization and proceeding faster toward the goal of socialist transformation." [54] Many other land reforms were sparked as a result of the initial Agrarian Reform Law, and land became more collectivized among the peasants. This collectivization perpetuated the societal changes by permanently inhibiting the re-emergence of landlords and displayed Mao's efforts towards a more socialist China.

The Agrarian Reform Law, driven by Mao's desire to advance socialism, completely redesigned the social and political atmosphere in China, which were tied with economic changes. After the reform, peasants were able to efficiently use land and increase agricultural productivity, which was integral to the development of China's economy. Simultaneously, as

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[52] Ganguli, "An Analysis," 16.
[53] Mao Tse-Tung, "The Land Problem," in *Selected Books of Mao Tse-Tung* (Peking, China: Foreign Languages Press, 1965), 3:297, PDF.
[54] Hsü, "The People's," 653.

the military continuously backed up the peasants, the peasants increasingly trusted the government and helped the government seize land from landlords. The peasants, because of the new changes of the Agrarian Reform Law, also increased their ability to buy items in the rural market and better provide for the economic demands of industrialization. Lastly, the collectivization of land was due to Mao's desire to perpetuate the results of the Agrarian Reform Law. Due to the cascading effects of Mao's implementation of the Agrarian Reform Law, he significantly prepared China's economy for industrialization and incorporation of socialism into Chinese society.

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3X3 Magic Square Structure For 3n

By Daksh Pandey

Abstract

Magic squares are usually used for encrypting any image, for religious and astrological use. The purpose of this research is to find a basic structure of a 3X3 Magic Square. With the structure solved down below, we can easily make a 3X3 magic square, given any 3X3 magic sum.

Introduction

A **Magic square** is a **square** array of numbers consisting of the distinct integers (…–1, 0, 1, 2, ...) arranged such that the sum of the numbers in any horizontal, vertical, or main diagonal line is always the same number.

The mathematical study of magic squares typically deals with its construction, classification, and enumeration.

In a perfect 3X3 Magic Square, the sum of any row, column, and diagonal is always a multiple of 3. If the given sum is not a multiple of 3, then a sum of at least 1 line (which can be any row, column, or diagonal) will not be equal to the rest of the lines.

Magic squares that include repeated entries do not fall under this definition and are referred to as **trivial**. Some well-known examples, including the Sagrada Família magic square and the Parker square, are trivial in this sense. When all the rows and columns (but not both diagonals) sum to the magic constant, we have **semi magic** squares. These are sometimes called **orthomagic** squares.

It takes a great deal of skill to be able to arrange numbers in a **square** to make all the rows,

columns, and diagonals have the same sum. The use of **magic squares** dates back as far as the ancient Chinese. They are still used today as challenging **math** puzzles.

Basic Structure for 3X3 Magic Square

Objective- To make a magic square in which the sum of all rows, columns, and diagonals is 3n (where $n \in Z$ and $n \neq 0$).

Method

Let n be any integer and 3n be a multiple of 3, and the central number = x.

Given that 3n is sum of the magic square, therefore, 3n=r

Then x = r/3

x=

x= 3n/3

x= n …....(i)

	n	

Putting n in the middle square of the grid (from i).

Since both diagonals in a magic square are in an arithmetic progression,

[Corollary 1. Ramanujan's Notebooks Part I]

by filling 1st diagonal with A.P. of n+1, n, n-1 in which d = -1and a=n+1, and, the second diagonal with A.P. of n-3, n, n+3 in which d=3 and a=n- 3,

	1	2	3
A	n-3		n+1
B	z_1	n	z_2
C	n-1		n+3

We get,

$$(n-3) + (n-1) = (n+1) + (n+3) \text{ and,}$$

$$(n-1) + (n+3) = (n-3) + (n+1)$$

Let z_1 and z_2 be value of empty spaces in column 1 and 3 respectively,

we get,

$$(n-3) + z_1 + (n-1) = 3n$$

$$\Rightarrow z_1 = 3n - (n-1) - (n-3)$$

$$z_1 = n+4$$

Similarly,

$$z_2 = 3n - (n+1) - (n+3)$$

$$\Rightarrow z_2 = n-4$$

Here, we notice that,

(n-3) + (n-1) = n + (n-4) and (n+1) +

(n+3) = n + (n+4)

and we also notice that,

(n+4) + n + (n-4) = 3n, which satisfies the condition of a magic square. Therefore, for a 3X3 magic square numbers should satisfy,

A1 + C1 = B2 + B3,

A3 + C3 = B2 + B1, and

C1 + C3 = B2 + A2, A1 +

A3 = B2 + C2

	1	2	3

A	n-3	y_1	n+1
B	n+4	n	n-4
C	n-1	y_2	n+3

Let y_1 and y_2 be the value of two empty spaces in rows A and C respectively, We get,

$$(n-3) + (n+1) + y_2 = 3n$$

$$\Rightarrow y_1 = 3n - (n-3) - (n+1)$$

$$y_1 = n+2$$

Similarly,

$$(n-1) + (n+3) + y_2 = 3n$$

$$\Rightarrow y_2 = n-2$$

We can see that,

$(n-1) + (n+3) = n + (n+2)$, and,

$(n-3) + (n+1) = n + (n-2)$

Therefore, the values of y_1 and y_2 satisfy the criteria for forming a 3X3 Magic Square.

So, 3X3 Magic Square with sum of any column, row or diagonal is equal to 3n, where $n \in Z$ and $n \neq 0$,

n-3	**n+2**	**n+1**
n+4	**n**	**n-4**
n-1	**n-2**	**n+3**

Conclusion- If the sum of diagonals, rows, and columns is a multiple of three in a 3X3 Magic Square, then it would be a perfect 3X3 Magic Square and, by dividing that sum by three, we would get the middle element of the magic square. Then, we can apply that number in the given structure and we would end up with a perfect magic square.

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Impacts of Xenobiotic Pollution on Marine Ecosystems, Fauna, and Flora

By Arjun Sharma

Abstract

Xenobiotic pollutants are synthetic chemical substances that are artificially introduced into the environment or a biological system. Examples of these pollutants include polychlorinated biphenyls (PCBs), trichloroethylene (TCE), and dioxins. Sources of this type of pollution include pharmaceutical and chemical industries, mining, fossil fuels, and agriculture. Some xenobiotic substances are unsusceptible to degradation and, as a result, accumulate with ease in the environment. Xenobiotics have wide-ranging adverse effects on organisms, the environment, and the aquatic ecosystems they accumulate in. This paper presents an overview of the impacts of xenobiotic pollution on marine flora and fauna, as well as a look into the relationship between these pollutants and the more well-known plastics and microplastics.

I. Background

A. Microplastics and Nanoplastics

Microplastics are microscopic fragments formed from the degradation of plastic debris; their presence in oceans presents a significant threat to marine ecosystems and organisms (*Marine Microplastics* 2019). Several definitions exist for the size range of microplastics. This paper classifies microplastics as plastic fragments with dimensions less than

approximately 5 millimeters and greater than 1 μm (Tang 2020). From this definition, plastics with dimensions smaller than 1 μm (100 nm) are classified as nanoplastics (ibid.)

The abundance of microplastics is rather alarming; they have been identified in almost every ecosystem on the planet, with a particular prevalence in marine ecosystems (ibid). These microplastics come from several sources, including runoff from rainwater and atmospheric transportation by wind (Jiang 2018). Current estimates identify approximately four-fifths of all plastic in the ocean as a byproduct of littering and other land pollution by humans (Gregory and Andrady 2003). Research shows that the accumulation of microplastics in the environment has increased two-fold over the last forty years in regions like the North Pacific subtropical gyre (Obbard et al. 2014).

Although plastic polymers themselves are biologically inert, additives (such as bisphenol A and phthalates) and pollutants on the plastics themselves can cause toxicity and are challenging to eliminate (Andersson 2014). For instance, Bisphenol A can quickly accumulate in sediment, as it only degrades in aerobic environments (Teuten et al. 2009). Meanwhile, phthalates are not bound to the plastic fragments they are added to, and can therefore bioaccumulate with ease upon consumption (Koch and Calafat 2009).

Microplastics and nanoplastics are hydrophobic and have large surface areas, the combination of which gives them their tendency to attract and accumulate persistent organic pollutants (POPs) on their surfaces. These pollutants can have a wide range of effects on the organisms they encounter (Andersson 2014). Nanoplastics are particularly dangerous because their small size gives them the ability to impact organisms on a cellular level (Tang 2020). As with microplastics, nanoplastic toxicity depends on the nanoplastic, the species it is affecting, and the dose consumed (ibid.).

B. Persistent Organic Pollutants

Persistent organic pollutants (POPs) are potentially harmful chemical pollutants that bioaccumulate with ease due to their innate resistance to environmental degradation (Ritter et al., 2007)

Persistent organic pollutants are frequently attracted to the large, hydrophobic surfaces of microplastics and nanoplastics (Andersson 2014). This attraction is not, however, irreversible due to the "inherent lipophilicity" of these pollutants (Jamieson et al. 2017). This gives POPs their ability to bioaccumulate in marine fauna and flora upon microplastic consumption (Andersson 2014), with increasing levels of concentration per each trophic level (a process known as biological magnification) (Jamieson et al. 2017). Among the more well-known persistent organic pollutants are Dichlorodiphenyltrichloroethane (DDT) and Polychlorinated biphenyls (PCBs). For the sake of brevity, a focus is placed on the latter in this literature review.

C. Polychlorinated biphenyls

Polychlorinated biphenyls (PCBs) are a type of persistent organic pollutants associated with microplastics. They were primarily manufactured for use in electronic equipment (such as in dielectric fluids) and plastic products (Andersson 2014). Following research in the 1970s that revealed the environmental toxicity of PCBs (as well as their resistance to degradation and ability to bioaccumulate), PCB production was restricted and prohibited in most places (for instance, the United States banned PCB production entirely in the late 1970s). By this point, PCBs had already been in production for four decades, and approximately 1.3 million metric tons had been produced globally (Breivik et al. 2007). Current estimates place around 65% of PCBs in landfills or old electrical equipment, and the remaining 35% on coasts and in the oceans (Jamieson et al. 2017).

Restrictions and bans on PCB production in the 1970s lent credence to predictions that PCB contamination levels would decrease in the following years (Halcrow, Mackay, and

Bogan 1974). However, their resistance to environmental degradation (both biological and chemical) has complicated matters (ibid.); although PCB concentrations and levels have likely dropped, recent studies have shown that their levels are still relatively substantial in areas that originally had large quantities of PCBs (from direct dumping or the natural movement of the particles while adsorbed onto other larger objects). This can be attributed to a combination of the aforementioned slow-degradation and resulting bioaccumulation, as it is reasonable for an area with high concentrations of a slowly-degrading particle to continue to see high concentrations of said particle in the future as well. The assimilation of persistent organic chemicals such as PCBs on the surface of microplastics in seawater presents a threat to organisms that ingest microplastics (Andersson 2014).

II. Impact on Marine Fauna

Xenobiotic pollutants have wide-ranging and potentially devastating effects on marine fauna. Research has shown that microplastics bioaccumulate and biomagnify at each trophic level, releasing chemicals from additives (e.g. bisphenol A) and POPs in the process. (ibid.)(Tang 2020).

A. Marine animals

Phthalates, bisphenol A, and other plastic additives have a powerful impact on amphibians, crustaceans, and mollusks, in which they act as hormone disruptors and affect reproductive capacity (Oehlmann et al. 2009)(Andersson 2014). Fish exposed to phthalates display altered behavior and increased oxidative stress, while amphibians exhibit changed sexual behavior and adverse effects on their thyroid hormone. For mollusks in particular, exposure to phthalates is known to cause DNA issues, such as in hindering the process of mitosis due to chromosomal aberrations. (Oehlmann et al. 2009).

Polychlorinated biphenyls (POPs attracted to microplastic surfaces) in particular have been associated with chronic and sub-lethal effects on certain species of marine fauna. PCB bioaccumulation has also been detected in the tissues of marine fauna living in waters contaminated by PCBs (Duke et al., 1972) (Yoshida, Takashima, and Watanabe 1973) (Halcrow, Mackay, and Bogan 1974). It has been suggested that stress from microplastic ingestion, as well as leakage of additives from the plastics and their associated pollutants, is partly responsible for their toxic effects (Gregory and Andrady 2003). Studies have also shown that exposure to PCB caused hormonal disturbances, negatively impacted reproductive capability, and increased risk of disease and death in animals (Ryan, Connell, and Gardner 1988) (Andersson 2014).

Due to their smaller size, the effects of nanoplastics are more challenging to identify and characterize. Nanoplastics from polystyrene have, however, demonstrated the ability to "permeate the membrane bilayers and induce alteration of membrane structure," disrupting cellular functions and diffusion across membranes (Tang 2020)(Rossi, Barnoud, and Monticelli 2014). The ability of nanoplastics to cross cellular membranes with ease facilitates the transportation of any toxic chemicals adsorbed into the tissues of an organism (Lambert, Sinclair, and Boxall 2014). The small size of nanoplastics further exacerbates their danger to marine fauna, as it allows them to cross the blood-brain barrier of certain species. For example, researchers detected nanoplastic particles from latex in the gills, blood, and brain of Oryzias latipes (Japanese rice fish) (Norén and Naustvoll 2010). Thus, the toxicity of nanoplastics from the chemicals adsorbed onto them could negatively impact marine fauna not only on a cellular level, but also in the brain directly.

B. Coastal and Seafaring Birds

Microplastics, when ingested, have negative effects on seafaring and coastal birds. Researchers found that in the *Phalaropus fulicarius*, an Arctic shorebird, birds with higher

levels of plastics in their stomachs had lower fat levels, and vice versa (Connors and Smith 1982). Research on *Puffinus gravis* shows that individuals with higher plastic content also displayed high PCBconcentrations (Andersson 2014) (Ryan, Connell, and Gardner 1988). In contrast, however, no such correlation between plastic and fat levels was found in short-tailed shearwaters (Yamashita et al. 2011).

III. Impact on Marine Flora

Just as microplastics, additives, and persistent organic pollutants can bioaccumulate and biomagnify in marine fauna, so too can the same occur in marine flora. A 2017 study conducted by Jamieson et al. found a relatively significant degree of POP bioaccumulation in ocean fauna in two of the deepest and most remote trenches (depths greater than 10,000 meters) in the world: the Mariana Trench and Kermadec Trench. The presence of PCBs and PBDEs (Polybrominated diphenyl ethers, another type of POP) were identified in every sample across all flora species and depths, indicating “potent anthropogenic contamination and bioaccumulation” of persistent organic pollutants in the flora of those trenches (Jamieson et al. 2017). The remoteness of the trenches where these pollutants were identified did not hinder their levels either; the researchers measured PCB levels "fifty times more contaminated than crabs from paddy fields fed by the Liaohe River, one of the most polluted rivers in China” (ibid.)(Teng et al. 2013). Thus, two POPs (PCBs and PBDEs) bioaccumulated to a relatively significant degree in two of the deepest trenches’ marine flora.

Although persistent organic pollutants can bioaccumulate in marine flora just as they can in marine fauna, less data is available on the actual impact of these xenobiotic pollutants on marine flora. While there is a lack of information on whether such pollutants negatively affect flora directly, the ability of POPs to transcend trophic levels indicates that their uptake in marine flora could contribute to bioaccumulation in fauna, where these pollutants do have a

negative effect. Thus, at the very least, marine flora seem to serve as another point of entry for persistent organic pollutants to reach marine fauna.

IV. Conclusion

Microplastics (plastic fragments with sizes ranging from 5 mm to 100 nm) are a major contributor to xenobiotic pollution. Additives in these plastic fragments are known to affect certain marine fauna negatively. Bisphenol A, for example, disrupts hormones in amphibians, crustaceans, and mollusks, and hinders their reproductive process as well. Further, microplastics' large and hydrophobic surfaces facilitate the attraction of persistent organic pollutants (POPs), which accumulate and travel from organism to organism. Polychlorinated biphenyls (PCBs) are a type of persistent organic pollutants. They have a wide range of effects on the marine fauna they encounter, ranging from hormonal disturbances to increased mortality rates. The effects that these POPs can have on organisms depends on several factors, such as the specific pollutant and species in question. Thus, no generalizations can be made on the overall dangers that POPs pose to all organisms, nor can it be stated that all POPs affect all marine fauna and flora in the same manner. It is, however, reasonable to conclude that, as forms of xenobiotic pollution, chemical additives to plastics and the POPs that accumulate onto plastic fragments both have the potential to negatively impact the marine fauna they encounter.

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Remember the History of Berlin Divided:

Monuments, Memory, and History

By Ethan Han

Abstract:

The purpose of this paper is to highlight how monuments affect modern memory and remembrance of the history of a divided Berlin during the Cold War. The paper provides an overview of the history of a divided post-World War II Germany, illustrates daily life in both East and West Berlin, and argues that monuments like the Berlin Wall are vital to how present-day Berlin remembers its divided past. The goal of this paper is to recognize the two opposing histories of Berlin and acknowledge that what monuments represent is a reflection of each individual's interaction with them.

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The Cold War is perhaps the closest humanity has ever come to extinction. With newfound weapons of mass destruction, humankind gained the power to annihilate itself for the first time in history. Nowhere else in the world was this tension felt more than in Berlin. Split into two halves by foreign intervention and clashing ideologies, the people of Berlin were forced to suffer decades of isolation. With the country of Germany also divided, Berlin became a microcosm of the entire conflict. In the space of the city, western backed free market capitalism was set uncomfortably close to USSR backed communist policies. The physical division of these two spheres was the Berlin Wall, a concrete barrier built in August of 1961 as a symbol of three decades of insufferable separation.[55] In this way, the wall also

[55] Pertti Ahonen, "The Berlin Wall and the Battle for Legitimacy in Divided Berlin," *German Politics and Society* 99/29 (Summer 2011), 40–56.

came to symbolize Europe's unending struggle in the aftermath of World War II and the world's unanswered question. But nearly thirty years after its fall, the Berlin Wall has become a monument which displays both the memory of one of Europe's darkest times as well as a pathway to a more unified city, Europe, and world.

The role that Berlin has played in twentieth century history has had a significant impact upon the subject of history. The study of the city as a microcosm of the Cold War has influenced scholars to rethink paradigms of history. Questions that scholars have asked in the wake of the Cold War include: What is history? What is the relationship between history and memory?[56] What should be remembered, and in what way? Monuments hold the answers to all of these questions, and with the Berlin Wall being one of modern history's most influential monuments, its symbolic weight is immense. In the following paper, I will examine the meaning of the Berlin Wall as a monument in the contemporary city. In order to do so, I will first offer a description of the political history of divided Germany followed by a comparison of daily life between East and West Germany. Thereafter, the paper will draw upon recent theory of monuments in order to provide an analysis of the tensions and possibilities that the Berlin Wall has evoked for Berliners and Europeans today.

Political History of Divided Berlin

In order to approach an analysis of the Berlin Wall, it is necessary to begin with the background of the history that led to the period of the divided city. After World War II, Germany was divided into four occupation zones by the Allies at the Yalta Conference.[57] Berlin was divided in a similar manner; the east side was controlled by France, Britain and the US, while the west was controlled by the Soviet Union.[58] The Allies then tried to deal

[56] See Paul Connerton, *How Societies Remember* (Cambridge: Cambridge University Press, 1989); Pierre Nora, "Between Memory and History: Les Lieux de Mémoire," *Representations* 26 (1989), 7–24.
[57] Mary Fulbrook, *A Concise History of Germany* (3rd ed.; Cambridge: Cambridge University Press, 2019), 480.
[58] Jason P. Coy, *A Brief History of Germany* (New York: Facts on File, 2011), 196.

with the millions of refugees created by the war. Germany was in ruins and the Allies were slow to provide aid, so many people went hungry during the initial period of reconstruction. In July 1945, Allied leaders Harry Truman (US), Clement Attlee (UK), and Joseph Stalin (USSR) met at Potsdam to discuss how the German occupation should proceed.[59] Eastern Europe was also brought up, and the US and UK failed to shake Stalin's control over the region. The three powers agreed to focus on their own zone's rebuilding.[60] Differences quickly developed, as the Soviets were much firmer with denazification. Many former Nazi officers were tried and sent to reeducation camps or executed. All remaining factories and banks in East Germany were nationalized, and private agricultural land was redistributed.[61]

Eventually, a communist party was established to manage the region known as the Socialist Unity Party, or SED.[62] This new communist regime set out to create a Marxist utopia, establishing institutions like the Free German Youth organization and the Democratic Women's League to indoctrinate young men and promote women's rights respectively. West Germany developed in a slightly different direction. Multiple political parties were permitted, the first being the Christian Democratic Union, or the CDU. A Social Democratic Party (SPD) also formed, becoming the voice of socialism in West Germany. They constantly butted heads with the Soviets, and this was the precursor to the Cold War. After Churchill spoke at a US college about the totalitarian Eastern European regimes, US president Harry Truman issued the Truman Doctrine, which promised US aid to anyone trying to resist the spread of communism. The US announced the Marshall Plan in June of 1947, which provided billions of dollars of economic aid to European countries so they could rebuild.[63] The USSR did not allow its satellite states to participate in this economic recovery plan.

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[59] Ibid.
[60] Fulbrook, A Concise History, 484.
[61] Harry Harrison, *Driving the Soviets up the Wall: Soviet-East German Relations*, 1953–1961 (Oxford: Princeton University Press, 2003), 15.
[62] Coy, *A Brief History*, 200.
[63] Fulbrook, *A Concise History*, 492.

When the plan was implemented in 1948, Western Europe experienced explosive economic growth. This also unified Western Europe, and the possibility of a European Union being formed in the future grew. The Soviets tried to prevent the economic aid from the Marshall Plan from reaching West Germany by blocking off all road access into Berlin. Stalin hoped this would pressure the west into pulling out of the city all together. However, the Allies decided to bring in supplies by air, and the Berlin Airlift sustained the city from June of 1948 to May of 1949.[64] The Soviets then reopened the roads to Berlin. The Western powers decided to draft a constitution for the governing of West Germany. This constitution established the government until West Germany was ultimately reunified with the East. It included a president, a chancellor, and two legislative bodies in the Bundestag and the Bundesrat. During West Germany's first elections, the CDU barely got more seats in the Bundestag than the SPD. The CDU's leader, Konrad Adenauer, was elected chancellor.[65] Theodor Heuss, a liberal, was elected as the new nation's first president. In the East, the Soviets established their own German government, the GDR, on October 7th 1949.

The Western powers denounced this new government, calling it a Soviet puppet regime and did not acknowledge its legitimacy. With the east and west becoming separate countries, Germany was now truly divided. In the 1950's both Germanies benefited from strong leaders. In the West it was chancellor Konrad Adenauer, who was determined to rebuild Germany's ruined economy and restore its reputation. The failures of the Weimar Republic previously led to the rise of the Nazis, so Adenauer had to convince the people that this time it would be different. In the East it was Wilhelm Pieck, who was elected to become the new leader of East Germany, becoming its first president in 1949. Assisted by Otto Grotewohl, they set out to build a communist state with a state run economy and a totalitarian

[64] Coy, *A Brief History*, 203.
[65] Fulbrook, *A Concise History*, 498.

political system. The most influential man in East Germany was not either of these men though, instead it was Walter Ulbricht, leader of the Socialist Unity Party.[66]

In response to the Marshall Plan, the Soviets created COMECON, or the Council of Mutual Economic Assistance to coordinate economic planning between the satellite states.[67] They tried to implement Five Year Plans similar to those of Stalin, but these efforts to rapidly industrialize failed miserably.[68] The task of meeting these new quotas fell heavily on the GDR's workforce. When the quotas were once again raised in 1953, the workers rioted. With the help of the Soviet military, the revolt was violently suppressed, providing a precedent of how future uprisings within the Soviet Union would be dealt with. Even though the first Five Year Plan's quota led to a strike, the Ulbricht government implemented a second, more aggressive Five Year Plan. This time, the plan focused on heavy industry and collectivization of agriculture, the two areas which the first Five Year Plan failed to address. By now, people realized that the Marxist-Leninist economy of East Germany could not surpass the capitalist economy if its western counterpart. It did provide stable employment to the workers of East Germany, it could not replicate the economic recovery that capitalism offered to the west.

West Germany fared far better. Using the massive funding provided by the Marshall Plan, the West German administration was able to reintegrate millions of refugees, foster capitalist investment, and create a welfare system that promised a large range of benefits. The miraculous recovery of West Germany is considered an "economic miracle", and by the mid 1950s, the country was one of the world's leading economies.[69] West Germany also made strides diplomatically. In order to make up for their predecessors mistakes, West Germany paid billions of dollars to Israel to compensate for the Holocaust. The West German

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[66] Ibid, 499.
[67] Coy, *A Brief History*, 206.
[68] Fulbrook, *A Concise History,* 554–555. For further on the role that the COMECON played in attempts to develop the economy of post-war Berlin, see Jenny Brine, *COMECON: The Rise and Fall of an International Socialist Organization* (New York: Transaction Publishers, 1992).
[69] Coy, *A Brief History*, 207; Fulbrook, *A Concise History,* 499..

chancellor Adenauer also announced that the Ruhr, a region bordering France, would be controlled by France, Germany, Belgium, Luxemburg, the Netherlands, and the US. This was to repair German diplomatic relations with its neighbors and to open up future economic opportunities. West Germany's efforts were rewarded in 1950 when they were allowed to rearm and join the North Atlantic Treaty Organization (NATO).[70] The purpose of this mutual defense alliance founded in 1949 was to provide security amid the rising cold war tensions. In 1952 at the Bonn-Paris conventions, a series of agreements were reached between the US, France, and West Germany which allowed West Germany full sovereignty by 1955. When that finally happened, West Germany joined NATO as a fully sovereign nation. As the country rearmed, it made the promise that its military would not operate unless one of its allies was attacked.

Similar to the Soviet response to the Marshall Plan, the USSR responded to NATO by creating its own treaty organization officially called the Warsaw Treaty Organization (WTO), or the Warsaw Pact.[71] Founded on May 14th, 1955 with the signing of the Treaty of Friendship, Cooperation, and Mutual Assistance, the Warsaw Pact bound the Soviet Union and its satellites, which included East Germany, in a military alliance closer than before. With the west a part of NATO and the east a part of the newly formed Warsaw Pact, hopes of unification seemed all but lost.[72] In 1954 the Soviets announced that East Germany had gained full sovereignty, West Germany refused to acknowledge East Germany with the Hallstein Doctrine.[73] In it, the Bonn government insisted that the only sovereign Germany was West Germany and it would not engage in diplomatic relations with any nation that considered East Germany a country. East Germany countered with the Ulbricht Doctrine, which encouraged strengthening bonds between the Warsaw nations along with not

[70] Coy, *A Brief History*, 208.
[71] Ibid, 209.
[72] Laurien Crump, *The Warsaw Pact Reconsidered: International Relations in Eastern Europe, 1955–69* (London and New York: Routledge, 2015), 39.
[73] Coy, *A Brief History*, 209.

recognizing West Germany's sovereignty until East Germany's was respected.[74] These open hostilities between the two Germanys pushed them even further apart.

Facing open opposition, Adenaur sought to strengthen West Germany. Despite protests from the West German left, he further pursued rearmament and introduced conscription in 1956. By signing the Treaty of Rome in 1957, West Germany played a key role in integrating the European economy.[75] This new agreement allowed unimpeded trade and joint nuclear energy regulation between France, Italy, Belgium, Luxembourg, and the Netherlands. A new commission was created, called the European Economic Community (EEC) to administrate this new trade agreement.[76] With West Germany prospering, Adenaur and the CDU won 43 percent of the votes during the 1957 elections, establishing a solid majority in the Bundestag along with its allies the CSU. Things would quickly change for the west from here.

In November of 1958, the new leader of the Soviet Union Nikita Khrushchev demanded that the allies leave Berlin, threatening to retake the city by force if they did not comply. When NATO refused this option, Khrushchev presented another: a permanent division of Germany and Berlin could remain a demilitarized city. NATO refused this motion as well. By 1961 East Berlin was dealing with a unique problem. During the 1950s, almost 2 million East Germans fled to West Germany.[77] Over 400,000 East Germans made the trip to West Germany to escape communist oppression in 1953 alone. This communist oppression in East Germany was best exemplified by the Ministry for State Security, a secret police organization also known as the Stasi. Founded in 1950, its original head Wilhelm Zaisser was ousted by his subordinate Erich Mielke in 1957, who would run the Stasi until the fall of the

[74] Fulbrook, *A Concise History*, 501.
[75] Coy, *A Brief History*, 211.
[76] Ray C. Rist, "The European Economic Community (EEC) and Manpower Migrations: Policies and Prospects," *Journal of International Affairs* 33/2 (Fall/Winter 1979), 201–208. For further on the origins of the EEC, see Wilfried Loth, "60 Years ago: The Foundation of EEC and EAEC as Crisis Management," *Journal of European Integration History* 23 (2017), 9–28.
[77] Coy, A Brief History, 211.

Berlin Wall. The Stasi created an elaborate network of agents involving tens of thousands of informants to monitor their fellow East Germans. During the early 1960s, the Stasi cracked down on dissenters harder and the number of defectors increased dramatically, draining the country of young talent.

Faced with this crisis, Khruschev authorized the construction of the Berlin Wall, a physical concrete barrier between East and West Berlin that would stand for three decades.[78] A hundred people were killed in attempted crossings, while others had their families torn apart by the wall. The mayor of West Berlin, Willy Brandt, sought aid from the allies to prevent his city being cut off from the rest of the world. After the Soviets issued an ultimatum ordering West Berliners to leave the city, American and Soviet troops confronted each other for 22 months. US president John F. Kennedy personally went to Berlin and made his famous "Ich Bin Ein Berliner" speech on June 23rd, 1963, showing his support for the people of West Berlin. After seeing the American determination to not give up the city, the Soviets chose not to send in the troops.

West Germany's chancellor Konrad Adenaur was forced to resign that same year, due to a scandal involving a West German magazine *Der Spiegel*.[79] In order to cement his victory in the 1961 election, Adenaur worked out an alliance between the conservative Christian Democratic Union and Christian Social Union and the liberal Free Democratic Party.[80] Shortly after his reelection, the magazine *Der Spiegel* criticized Adenaur's security measures by writing about weaknesses in the army. Adenaur's response was extremely rash; he had the magazine's office raided, and its publisher Axel Springer charged with treason. The public backlash was enormous, leading to his already fragile network of support to collapse. Adenaur would later apologize for his actions, but the damage was done. In January of 1963,

[78] Ibid, 211.
[79] Ibid.
[80] Fulbrook, A Concise History, 488.

Adenaur's government signed the historic Élysée Treaty with France.[81] This treaty brought the two nations closer in matters concerning diplomacy, trade, and security. Adenaur would retire on October 15, 1963.

On East Germany's end, the Five Year Plans they had tried to implement were failing. Desperate to improve the situation, they switched to a less rigid annual system of quotas at the regional level. Despite these changes, East Germany's economy continued on a downward trend, forcing the government to change once again to more centralized planning.[82] In West Germany, Adenaur's absence created a political void that needed to be filled. The Christian Democratic Union's Ludwig Erhard, a trusted advisor of Adenaur, was chosen to be chancellor. Erhard immediately tried to improve relations with Warsaw countries. While having some success in Berlin, Erhard was unable to mend the damage created by Adenaur's administration. He was once again tested when France's President Charles de Gaulle opted out of the NATO alliance. Forced to either live up to its promises to France or NATO, Erhard resigned in November 1966 during an economic recession in West Germany which led to the dissolution of the CDU/CSU/FDP political alliance when the FDP withdrew its support.[83]

In December, West Germany had Kurt Georg Kiesinger as chancellor, supported by his own Christian Democratic Union and the SPD. Kiesinger's history as a former Nazi Party official would come to plague his political career.[84] His political allies were branded as traitors for supporting a Nazi, and the East German press created massive amounts of propaganda highlighting the fact that the West had allowed a Nazi to rise to their highest seat of power. Despite these challenges, Kiesinger was a competent administrator, able to curb the rising tensions with several Warsaw nations including Czechoslovakia, Romania, and

[81] Coy, *A Brief History*, 212.
[82] Ibid.
[83] Fulbrook, *A Concise History*, 488.
[84] Coy, A Brief History, 213.

Yugoslavia. His cabinet enacted a series of policies that brought West Germany out of its economic recession in 1968.

Later that year, radical protests would sweep across West Germany. The protests that occurred in West Germany followed soon after their US and French counterparts. After witnessing the horrific bombing campaign named “Operation Rolling Thunder" the US employed during the Vietnam War, protests by college students on campus became increasingly frequent. Compounded by the overall leftist discontent in West Germany, student led groups organized violent demonstrations throughout West Germany, berating what they thought of as the defects of German society.[85] Citing reasons such as the morally bankrupt government, blind faith in capitalism, and Germany’s failure to atone for its Nazi past, these students demanded democratic reforms in the West German political system.[86]

As protests increased, police and the demonstrators clashed more and more often during the late 1960s. In May 1968 the government passed the Emergency Acts, an amendment which allowed the executive branch to act without the legislative branch’s consent, suspend certain constitutional rights, and use military force when necessary.[87] With the memories of Hitler’s use of a similar bill to obtain power fresh in their minds, the protestors fiercely resisted the bill in vain. Despite all the backlash, the Emergency Acts went into effect in June. There were many reactions to the rising unrest in West Germany. The student movement was radicalized when an unarmed 26 year old graduate student protester Benno Ohnesorg was shot and killed by the police. This incident along with Marxist theory spawned the “urban guerrilla” organization known as the Red Army Faction (RAF), also known as the Baader-Meinhof Gang, led by its two cofounders Andreas Baader and Ulrike Meinhof.[88] Under this alias, the RAF committed bank robberies, arson attacks, bombings, and

[85] Coy, A Brief History, 214.
[86] Ibid.
[87] Ibid.
[88] Ibid, 215.

assassinations in the 1970s and 80s in the name of an armed struggle against "fascist imperialism."[89]

Daily Life in Divided Berlin

Having given an overview of the political history of divided Germany, the following section will compare the two sides of the Berlin Wall with a focus upon daily life in both countries. The most obvious difference between the two Germanies has to be their economic systems. East Germany pursued a perfect Marxist utopia, while West Germany sought to rebuild their country under capitalism. With differing economic systems, we should expect to see some striking differences between the two Germanies, and we do. Out of 8,445,300 economically active people in the GDR in 1983, only 397,100 of them were involved with private business.[90] Compared to West Germany, where the vast majority of capital was still in private ventures, and you could see the economic divide rather clearly. This gap between public and private ownership also showcased the difference in ideologies. Despite West Germany being seemingly more "advanced" economically, there were some sectors in which East Germany had more laborers. One such trade was agriculture: while the west only had 5.9% employed in that field, the east boasted double that, at around 10%.[91]

Another interesting statistic was population density. West Germany was a far more urbanized country than its eastern counterpart, with only 6% of West Germans living in communities with less than two thousand inhabitants by 1980.[92] 24% of East Germany's population was still in smaller rural neighborhoods during this time. Looking at the overall population, East Germany experienced a small rise and subsequent decrease in population that led them to 16.7 million people in 1980, the same amount they had over forty years ago

[89] Fulbrook, *A Concise History*, 509.
[90] Ibid, 504.
[91] Fulbrook, *A History of Germany*, 184
[92] Fulbrook, *A History of Germany*, 184

in 1939.[93] For comparison, West Germany had a population of 43 million in 1939, and by 1980 that number had grown to 61.7 million.[94]

After looking at some numbers, I want to tackle social inequality next. This is one of the few times where capitalism and communism directly clashed, and through analyzing how "equal" these two countries were can provide clues as to if the communist East Germany lived up to its creed. Some people have argued that 1970 West Germany is a "classless" society. Although the aristocracy was not as distinct as in a country like Britain, it still existed in West Germany, and several aristocratic families still asserted their social superiority. East Germany was commonly separated into two groups of people: the working class and the bourgeoisie. Although this sharp division is not entirely fair, there are some truths to this statement. It is true that the vast majority of people living in East Germany were considered working class. The aristocracy didn't survive as much as it did in the west; those who were wealthy were mainly the politically privileged. Many East German factory workers were in similar if not identical situations and those in West Germany, however they may have been more willing to work because of socialist ideology. When thinking through the lens of unification, these two relatively different Germanys pose a problem. After their forced separation, the two nations had grown to become exactly that: two different countries.

One of the most obvious conclusions that can be drawn is that there were more consumer goods to buy in West Germany. By nature of being capitalist, their capacity to produce various types of goods or acquire them through trade was far superior to their eastern counterpart. This meant that, overall, consumers were happier in the West. West Germany also had a higher average income rate, but almost as a byproduct of capitalism, the gap between the rich and poor was larger.[95] East Germany had its own set of advantages. Although East German workers had no right to strike, they were guaranteed employment.

[93] Fulbrook, *A History of Germany*, 184
[94] Fulbrook, *A History of Germany*, 185
[95] Fulbrook, *A History of Germany*, 188

Another thing to keep in mind is that many families in East Germany were two income families, meaning both parents worked. This meant that money was not the biggest issue in the east, but the lack of consumer goods to spend said money on became the problem.

As time went on, the disparity between East German households and West German households gradually shrunk. When comparing average four member households in both West and East Germany, you see that in East Germany in 1988, 99% of households had a washing machine and a fridge, 96% owned a television, and 52% owned automobiles. Compared to West Germany's 99% for washing machines and fridges, 98% for televisions, and 97% for automobiles, you can see that the difference in material wealth in households is not that large.[96] With material wealth being very similar, another very important commodity is food. With everything subsidized in East Germany, food was extremely cheap. Even though there was little variety, people did not go hungry in the GDR. Curiously, by the mid 1980s people in East Germany had a higher average caloric intake than those living in the west, eating more meat, eggs and dairy, but less fruits and vegetables.[97] The image of people lining up for food every day is more associated with Poland, both those in the GDR generally did not have to queue for food, unless it was an exotic item like bananas. There were issues along with the advantages in the GDR, namely the regulation of certain goods. Oftentimes when purchasing a big-ticket item, like a car, normal citizens would need to sign onto a waiting list. There was also the issue of access to Western currency in East Germany. Many luxury goods could only be purchased using Western currency, and it was later that the so-called Delikat or Exquisit shops opened to the general public, selling the same goods but using East German currency.[98]

Another important point is healthcare and welfare. Due to government ownership of many industries in the east, healthcare was covered by the state, and there were many

[96] Fulbrook, *A History of Germany*, 188
[97] Fulbrook, *A History of Germany*, 188
[98] Fulbrook, *A History of Germany*, 189

maternity benefits as well.[99] Retirement plans were also quite good, as pensions along with a generally low cost of living provided enough for people to comfortably live out their lives. Rent was also quite cheap, although the quality was sometimes questionable.

After hearing about what East German life was like, some may begin to think that life was not that bad after all. And they would be partially correct. The nail in the coffin that drove many people to search desperately for a route to the west was simply East German citizen's access to western media. Every night, an East German worker would come home to western television, read western magazines, and long for the comparatively more luxurious life. Life in the GDR was not terrible, but West Germany just looked better.

Analysis: The Berlin Wall as a Monument of History

Using the city of Berlin as a model for historical enquiry allows us to reexamine the foundations of the discipline of history. What does it mean to reconstruct the past? Whose past? Which memories are considered worthy of reconstructing? Given Berlin's deep and turbulent past and the fact that it continues to be a "lived" city, how do we think about the intersection of past and present in a material form?

Now that I have given you a comparison between East and West, I want to explore how New Berlin choses to remember its divided past. What we get by offering such a detailed glimpse of Divided Berlin in the first two parts of the paper is an opportunity to see how the memory of Berlin in its present day monuments is just as much about forgetting as it is remembering. The city chose to keep a few buildings, art pieces, and areas which they believed to be essential to telling the story of divided Berlin intact. With the city now considered as one of Europe's cultural centers, how does it embrace its history of separation? As the city was being reconstructed, many different architect groups wanted to participate in

[99] Fulbrook, *A History of Germany*, 189

the rebuilding of Berlin. In order for newer buildings to be constructed, older establishments had to be either remodeled or destroyed. In the present section, I will describe some of the questions that have arisen as New Berlin has attempted to embed the past of Divided Berlin into its current cityscape.

The first problem that arises in thinking about how modern Berlin emplaces a monument like the Berlin Wall into its cityscape involves how a monument might evoke very different memories.[100] What I mean here is that any monument that correctly or truthfully represents Divided Berlin would have to evoke the two perspectives on the different sides. The Berlin Wall represents the division of a city along social, political, and economic lines. As a result, any monument that attempts to evoke the memory of the wall must consider how it was perceived by people who lived in both East and West Berlin. One challenge then that this aspect of monumentality raises has to do with what exactly the Berlin Wall is in the memory of contemporary inhabitants. Are the remnants of the wall symbols of West Berlin triumphalism? Are the remains of the Berlin Wall symbols of oppression and a time better forgotten? These questions require the contemporary inhabitants of the city to ask the deeper historical question of whose memory of the wall should be embodied in the current city. For example, if an East Berliner has to wake up every morning to the sight of the Berlin Wall, the structure which had utterly isolated him from the rest of the world, his appreciation for the monument may not be as strong compared to a tourist from a country free of communism. This reality of having such a stark reminder of a not so distant past at your doorstep may unsettle those who must live with it, and it is a question like this that must be tackled in order for monuments to achieve their intended effect. The period of division might have seemed normal, just that there was a section of the city that one could not access. However, for

[100] Anna Saunders, "Remembering Cold War Division: Wall Remnants and Border Monuments in Berlin," *Journal of Contemporary European Studies* 17/1 (2009), 9–19. See also Leo Schmidt, "The Berlin Wall: A Landscape of Memory," in *On Both Sides of the Wall: Preserving Monuments and Sites of the Cold War Era* (eds. L. Schmidt and H. von Preuschen; Berlin: Westkreuz, 2005), 11–15.

someone who experienced East Berlin, their story might reflect a less economically prosperous reality. This duality of memory is critical when considering the impact of monuments in modern cities.

What the previous observation leads to is the larger and perhaps more difficult question of who is engaging with an aspect and a material form of history.[101] Who is the Berlin Wall for in the contemporary era? Citizens of Berlin? Citizens of Europe? Tourists? This is the second question that Saunders seeks to explore. When someone who lived in West Berlin views the Berlin Wall, it may not evoke as strong a reaction as someone from East Berlin. For those on one side the period of separation might have felt something like a relatively brief and painless span of years, but for those on the other it may have been an insufferable three decades of oppression and isolation. However, the number of wreaths that are placed annually at the Bernauer Straße monument showcases how remembrance has become somewhat of a civic duty, similar to observing fireworks on the Fourth of July in America.[102] Why is this ritual important to Berliners? This ritual reminds people who do not live in Berlin that a large part of the monumentality of the Berlin Wall is deeply attached to its location in a specific city. So maybe the question of who the Berlin Wall is for and the difficulties involved in answering this question actually points to a significant part of its monumentality. The wall serves as a monument to history it allowed people to reflect within Europe and throughout the broader world and find their own stories on its concrete face. Not everyone can claim to have lived in a physically divided city, but the idea of being cut off resonates with citizens of other Soviet satellite states who have experienced similar alienation firsthand. In addition, as many people experienced the Cold War throughout the world the Wall also became a monument to the tensions between the Soviet Union and the West.[103] In

[101] Saunders, "Remembering Cold War Division," 12.
[102] Ibid, 12.
[103] F. Baker, "The Berlin Wall: Production, Preservation and Consumption of a 20th-century Monument," in *Landscapes from Antiquity* (ed. S. Stoddart; Cambridge, UK: Antiquity Publications, 2000), 289–315.

this way, many others around the world who did not inhabit the city also were able to relate to the wall in a more distant yet still meaningful way.

Since monuments are always physical locations, that is, they are grounded in specific places, they require consideration of how they interact with and interfere with other sites of memory.[104] This is one of the more difficult issues with history as monuments. When we think about history as memorials or monuments we must contend with the reality that when we form history we inevitably make decisions about what to cover or withhold another part of history. We might have infinite room to write on paper or better on the internet but in a city we have very limited space. This is compounded by the fact that Berlin today is a cultural center of Europe, making this issue of space even more grave. Some people may even argue that this incessant clinging to the past is counterproductive, and instead prevents any forward progress. Furthermore, limited space in the city usually necessitates that some other preexisting building must be sacrificed in order for new monuments to be constructed. Another problem is proximity. Unfortunately, Berlin's separation is not the only tragedy that it is obligated to remember. The Memorial for the Murdered Jews of Europe is also an immensely important piece of history, and having these two monuments too close may be seen to create an undesirable overlap of interest that is difficult to remedy in physical space.

Conclusion

Human memory is ultimately flawed because it is finite. Our brains can only retain so much information deemed as "important" before it reaches saturation. The next time an idea is judged to be important enough to be remembered, by nature another previous memory must be forgotten. This fact is the very reason that since ancient times humans have strived to preserve their knowledge either through oral tradition, literature, and more recently databases

[104] Saunders, "Remembering Cold War Division, 12.

on the internet. This act of ceaseless preservation is an effort to ensure that future generations can look back upon the successes and failures of their predecessors and learn how they might move forward. Naturally, this is the case with monuments as well. Being the physical manifestation of human memory, there can only be so many monuments in a functioning modern cityscape. Therefore, the memories that we choose to immortalize as monuments should be carefully selected and considered before constructing them. Even so, the Berlin Wall is essential to our understanding of the modern era. The violent and abrupt division caused by radically different ideologies which the wall embodies is an important message for generations to come. As the monument of the Wall now highlights the openness between East and West, it has become a symbol of hope for human progress not only in Europe but also in the larger world.

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