

# QuaesitUM

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QuaesitUM is an annual publication  
that provides an academic forum where University of  
Memphis undergraduate students can showcase  
research from all disciplines.

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# Editorial Board

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*Success is a process for all of us, and as long as you are making consistent progress towards your goals – sincerely giving your best effort more often than not – then you are already successful and deserve to feel proud of yourself.*

– Hal Elrod

*You can't get there by bus, only by hard work and risk and by not quite knowing what you're doing. What you'll discover will be wonderful.*

–Alan Alda

## To Our Readers

Each year, The Oxford English Dictionary selects a “Word of the Year” that reflects the ethos, mood, or cultural significance in the previous year. Here, on the 10th anniversary of *QuaesitUM*, if I were to select a word to capture the ethos or mood of the work we have done, it would be pride.

*QuaesitUM* began with a casual, offhand remark from Dr. Shirley Raines, the U of M president at the time, to Dr. Shannon Blanton, then Vice-Provost. After hearing about an undergraduate journal at another university, Dr. Raines asked: “Why don’t we have one of these”? Thus began our journey -- a collaborative endeavor between the provost’s office, the English Department, and the Honors College to give undergraduate students a way to showcase the research they do while studying here.

We began ‘from the ground up’, doing everything from choosing a name & designing a logo to investigating copyright, finding a printing company, and navigating submission management software. Since then, *QuaesitUM* has grown and evolved into what it is today. With the publication of Volume 10 in 2023, we have had the privilege of working with 64 faculty sponsors, collaborating with and receiving input from 90 reviewers, and publishing papers written by over 108 authors. Their work has

spanned the breadth of research at our institution, including:

- Humanities
- Engineering sciences
- Physical and applied sciences
- Social and behavioral sciences
- Life and health sciences
- Professional

The authors whose work is included here have gained 1st hand experience with the academic publishing process. They have won international recognition for the work they first published with us. They have received financial awards, generously funded by the Helen Hardin Honors College. They have gone on to earn graduate degrees. They have translated the skills *QuaesitUM* taught them to the global workforce.

For me personally, *QuaesitUM* has given me opportunities I never anticipated. I have had the honor to meet and work with exceptional colleagues – people I probably would not have met otherwise. I am also much more aware of the research innovations on our campus and have learned about how research is conducted and published in disciplines other than my own. I have also learned how impressive our undergraduate students are. Most importantly, I have had the opportunity to develop something that gives me pride.

Melinda Jones, Director of the Honors College, has been by my side at every stage, from our early talk of what we thought the journal could be, to our ongoing discussions about how we can continue to make it better. She has been an invaluable colleague, collaborator, and friend, and I count myself privileged to work with her. Through the partnership we have forged, we have taken a blank canvas and painted a vibrant picture of research at the U of M.

Reflecting on the past 10 years of *QuaesitUM* has made us aware of how many people deserve thanks for making it what it is today. In particular, our previous Technical Editors -- Baxter Buck, Scott Dutt, Hannah Pitner, and Egemen Curuk -- have helped the journal grow and develop high publication standards in myriad ways – including creating and maintaining social media, eliciting submissions, communicating with authors, formatting final copy, and managing distribution. I personally could not have managed without this year's Technical Editor, Amir Rouhallahi, who brought his willingness to meet new challenges, his steadfast reliability, and his strong work ethic to our team. He has taken the foundation laid by the previous Technical Editors and continued to refine it; his diligence, thoroughness, and proactivity have

been critical components in bringing Volume 10 to fruition.

I also cannot overstate the contributions of Mr. Gary Golightly, Professor of Graphic Design in the Department of Art. He has been freely giving of his time and talent for all 10 volumes. With each one, I am impressed anew with his vision, ability, and passion in designing a cover that captures the essence of our students' research.

Many thanks also to members of the administration who have supported us over the years: Dr. Shirley Raines, Dr. Shannon Blanton, Dr. Jasbir Dhaliwal, Dr. Tom Nenon, Dr. Karen Weddle-West, and Dr. Abby Parrill-Baker.

The reviewers are also a critical cog in production every year. For Volume 10, we have benefitted from the expertise of reviewers who willingly shared their expertise to help the students (and the journal) shine in their best light.

As in all previous volumes, the faculty sponsors for Vol. 10 offer a key contribution guiding student authors through their research and then encouraging them to submit: Michele Coffey, Ana Doblaz, Rebecca Howard, Chrysanthe Preza, Shawn Pollard, Courtney Santo (Complete list from Vols. 1-10 in Appendix A)

Finally, as I have noted for the past 10 years, the greatest words of thanks must go to the student authors. They have committed to excellence through their hard work at all stages of the publication process. Their work exemplifies the highest caliber research, and they should be proud of the way they represent the U of M. We hope that we have helped them develop skills that will benefit them in their future endeavors.

Since 2013, we have refined who we are and what we do. Here, on our 10th anniversary, I look back with genuine pride at who we are and what we have accomplished throughout our journey. I hope that all of those who have contributed something, no matter how small, feel that pride as well.



With gratitude,

Dr. Sage L. Graham

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My name is Ethan Costello, and I am a senior Electrical and Computer Engineering student at the Herff College of Engineering. After four years of college, I graduated in May 2023 with Magna Cum Laude distinction. I have spent my time in college making friends, studying, and finding new interests. One of those new interests is the study and design of optical systems, which I have expressed through working with my teachers and writing research papers. The time I have spent in college has been the best of my life and I am looking forward to what comes after.

Ethan's paper received a *QuaesitUM* outstanding paper award.

Ethan Costello

Design & evaluation of a confocal scanning microscope  
using off-of-shelf optical components by means of Zemax  
OpticStudio optical design software

Faculty Sponsor

Dr. Ana Doblaz



## Abstract

Confocal microscopes are known for optically removing the out-of-focus information (i.e., blur) in each transverse section of the sample's volume, providing a more accurate three-dimensional image of thick microscopic samples than widefield microscopes. In this work, we have designed and evaluated a confocal microscope using off-of-shelf optical components from Thorlabs' catalog, one of the major optical manufacturers. The design and evaluation have been implemented using Zemax OpticStudio, the standard optical system design software for realistic optical simulation. Here, we have also reported a practical protocol for building a confocal microscope using sequential mode.

## Introduction

Biological research relies heavily on cell imaging to provide valuable morphological and functional information within cells and tissues. Among the different microscopic imaging modalities, confocal microscopes have helped biological researchers to understand cell motility, behavior, and regulation in three-dimensional environments that mimic the specific organization of organs (Singh & Gopinathan, 1998; Matsumoto, 2003; Croix et al., 2018; Elliot, 2020). The major difference between conventional widefield microscopes and confocal microscopes is the point-based illumination and detection configuration, providing optically sectioned images (Martinez-Corral & Saavedra, 2009).

These optically sectioned images are two-dimensional (2D) images from transverse sections of a three-dimensional (3D) sample in which the out-of-focus information (e.g., blurred areas) has been optically rejected, providing clear imaging of the in-focus sections of the sample at each axial plane. Although this is the key feature of confocal microscopy compared to conventional fluorescence microscopy, another advantage of confocal microscopes is their ability to produce multicolor imaging in which different sections of the biological specimen are stained using multiple dyes, enabling colocalization studies in biological systems (Dunn et al., 2011; French et al., 2008; Jessen, 2013; Zinchuk et al, 2007). Thanks to these features, the applications of confocal microscopy are quite broad from live-cell imaging and analysis of cells and tissues to cancer pathologies and drug discovery.

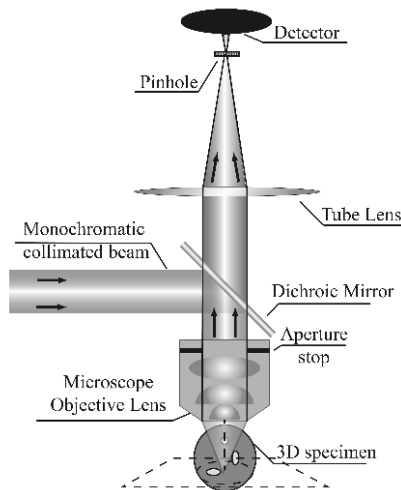
## Background of Confocal Microscopy

A confocal microscope is composed of two subsystems: the illumination and detection systems (Martinez-Corral & Saavedra, 2009). Figure 1 shows the optical configuration of a confocal system. The monochromatic light emitting from a laser source is collimated and focused onto the three-dimensional sample by a microscope objective lens. Although the focused beam illuminates all parts of the sample within the illumination cone, the small region surrounding the beam's focus receives the highest illumination energy. Assuming that the illumination wavelength is within the excitation band of the fluorescent dye, the sample's region stained by those fluorophores are activated, emitting fluorescent light (e.g., light with a longer wavelength than the illumination wavelength).

In traditional confocal microscopes, the detection system is composed of the microscope objective lens, the tube lens, a pinhole (e.g., an optical aperture), and a photomultiplier as a detector. The fluorescent light scattered by the sample is collected by the microscope objective lens and focused on

the pinhole thanks to the tube lens. The photomultiplier is the ideal photometric detector for this imaging modality based on its speed and sensitivity. Experimentally, the photomultiplier is placed right after the pinhole to collect the maximum amount of light.

As previously mentioned, the feature of confocal microscopy is its optical sectioning capability (i.e., the optical removal of the out-of-focus information). This capability is a consequence of the fact that the object focal plane of the objective lens is conjugated with a pinhole plane. Therefore, parts of the sample outside the in-focus plane (e.g., object focal plane of the objective lens) are not conjugated with the pinhole (e.g., image plane), reducing the probability of fluorescent light detection (Martinez-Corral & Saavedra, 2009). In other words, point-based detection using the pinhole is responsible for providing optical sectioning capability. On the other hand, parts of the sample outside the in-focus plane receive a smaller illumination density, reducing the probability of fluorescent emission and photobleaching of the samples.



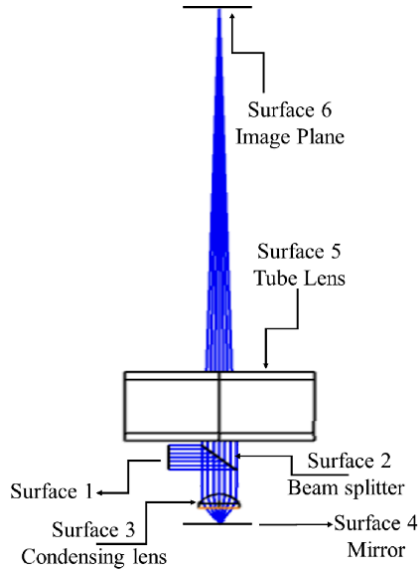
**Figure 1.** Optical configuration of a Confocal Microscope. The key feature of the point-based illumination and detection.

## Design of a confocal microscope using Zemax OpticStudio optical design software

This section provides a practical protocol for building a confocal microscope using off-of-shelf optical components from Thorlabs' catalog, one of the major optical manufacturers. The design and evaluation have been implemented using Zemax OpticStudio, the standard optical system design software. Zemax optical design software is a readily available commercial optical design software that allows us to conceptualize, design, optimize, and analyze virtually any optical system (Geary, 2002; Siew, 2017; Sun, 2017). It is widely used in the Optics industry as a standard design tool since one can evaluate the performance of realistic optical elements from the already implemented numerical methods, including a study of the aberrations and the impulse response. Zemax has allowed engineers, scientists, and researchers bring their optical designs into real commercial systems.

In our design, we have two main changes to Figure 1. The first one is the replacement of the dichroic mirror by a beam splitter. Dichroic mirrors reflect and transmit light at two different wavelengths (e.g., color). For example, a longpass dichroic mirror with a cutoff wavelength of 490 nm reflect light with wavelength shorter than 480 nm towards the microscope objective lens in the illumination system and transmit wavelength larger than 500 nm towards the tube lens in the detection system. Conversely, beam splitters are optical elements that split incident light into two beams regardless of the wavelength. Although a beam splitter is not the desired optical element to build an experimental confocal microscope due to the loss of energy, it allows us to analyze the performance of the confocal microscope at different wavelengths without replacing the dichroic mirror. The second change is replacing the microscope objective lens with a condenser lens for design simplicity.

Let us start building a confocal microscope. The Zemax design of the microscope objective lens and tube lens are found on Thorlabs' website. The first element of the confocal microscope to insert is the beam splitter (Surface 2 in Fig. 2), which reflects the incident beam down at a 90° angle. Remember that the beam splitter separates the incident beam in two directions: one beam is transmitted through the beam splitter, and the second is reflected as a mirror does. The beam splitter was created by inserting a foldable mirror surface after the first element (a dumb surface, Surface 1 in Fig. 2) in our system with an angle of 45°. It is important to mention that a dumb surface in Zemax modeling refers to a surface that does not modify the trajectory of the optical rays in the optical design.



**Fig. 2.** Two-dimensional optical layout of the confocal microscope in Zemax OpticStudio

The second element in our system is an aspheric condenser lens (Surface 3 in Fig. 2), which replaces the microscope objective lens. Without any loss of generality, we select the AC1210U-A Thorlab's aspheric condenser lens with a diameter of 12 mm, a focal length of 10.5 mm, and a numerical aperture (NA) of 0.54. The AC1210U-A lens has a focal spot size equal to  $3.953 \mu\text{m}$  at a wavelength of 633 nm.

The third element of the confocal microscope is a flat mirror. This mirror mimics a perfect thin fluorescent sample, reflecting the light back into the condenser lens. Since the confocal microscope is a point-based illumination, the mirror should be located at the focal plane of the condensing lens. Based on the manufacturer's datasheet, the focal plane is placed at a distance equal to 6.725 mm distance from the last surface of the lens.

The diverging light reflected by the mirror is collimated by the condenser lens, generating a collimated plane wave after the condenser lens. A collimated plane wave is such a wave whose size does not change, generating a point source at infinity. The collimated plane wave meets the tube lens (TTL200-A, Thorlabs), which is Surface 5 in Fig. 2. The separation between the condenser lens and the tube lens is irrelevant since the wave is collimated. Nonetheless, we ensure that the distance was enough so that the tube lens is after the beam splitter in Fig. 2. Since the tube lens is illuminated



by a collimated plane wave, focusing the light into a point at its image plane. Based on the manufacturer's datasheet, the image plane is located at 152.008 mm to the last surface of the tube lens. In an actual experiment, the image plane is the plane to set the pinhole. It is important to mention that the tube lens is shown as a black box in Fig. 2. We have chosen this lens to optimize the performance of the confocal microscope. This type of tube lens is known for its careful design, which contains multiple optical surfaces to compensate the optical aberrations further.

## Evaluation of the confocal microscope using Zemax-Optic Studio

Zemax OpticStudio software allows the evaluation of the performance of any optical system using different metrics, including the analysis of the spot diagram, the aberrations present at each surface of the system, and the impulse response and its reciprocal Fourier transform. All these analyses are available on the Analyze tab of the software. Without any loss of generality, we have evaluated the performance of the proposed confocal microscope by analyzing the aberrations through the Seidel, the system's frequency response through the Modulation Transfer Function (MTF), and the variation of the spot size.

First, let us start with the Seidel diagram, which provides information about the aberrations up to the third order. In other words, Zemax OpticStudio informs us about the following aberrations: spherical aberration, coma, astigmatism, field curvature, distortion, axial color, and lateral color. A more detailed information of these optical aberrations can be found in Dereniak, (2008). Based on the Seidel diagram, we found that spherical and axial color aberrations were the only ones present in the system. Spherical aberration is present when the outer parts of an optical element do not focus the light rays at the same axial plane, generating a blurred image. On the other hand, axial color aberration is a type of chromatic aberration caused by the fact that light rays focus on different axial planes based on wavelength/color. In other words, if the material of the optical element presents normal dispersion, blue light always focuses on planes before red light. The aspheric condenser lens introduced these aberrations. However, since the light passes through the condenser lens twice (e.g., forward in the illumination system and reverse in the detection system), these aberrations cancel each other, not affecting the final performance of the confocal microscope (e.g., at the image plane there are not aberrations distorting the confocal system).

The second metric used to analyze the performance of the confocal microscope was the MTF plot. This curve informs us how the information is

transferred through the imaging system. In particular, we can find which and how much the spatial frequencies are distorted by the system. In other words, the MTF plot provides a quantitative measurement of the image contrast versus the spatial frequency. A key feature of Zemax OpticStudio software is that we can plot the system's MTF and compare it with the theoretical limit (known as the diffraction limit), providing us with another way to visualize if our system is distorted by aberrations. Although we cannot identify the type of aberrations by observing the MTF plot, as a general rule, the lower the area under the curve of the MTF plot, the higher the number of aberrations. Figure 3 shows the MTF plot of the confocal microscope for different wavelength (blue curve in Fig. 3) and its comparison with the diffraction limit (black curve in Fig. 3).

As we can see, both blue and black curves overlap for the different wavelength, meaning that the system does not present any aberration. Observing Fig. 3, we have estimated the maximum spatial frequency passing through the confocal microscope. This maximum spatial frequency is known as the

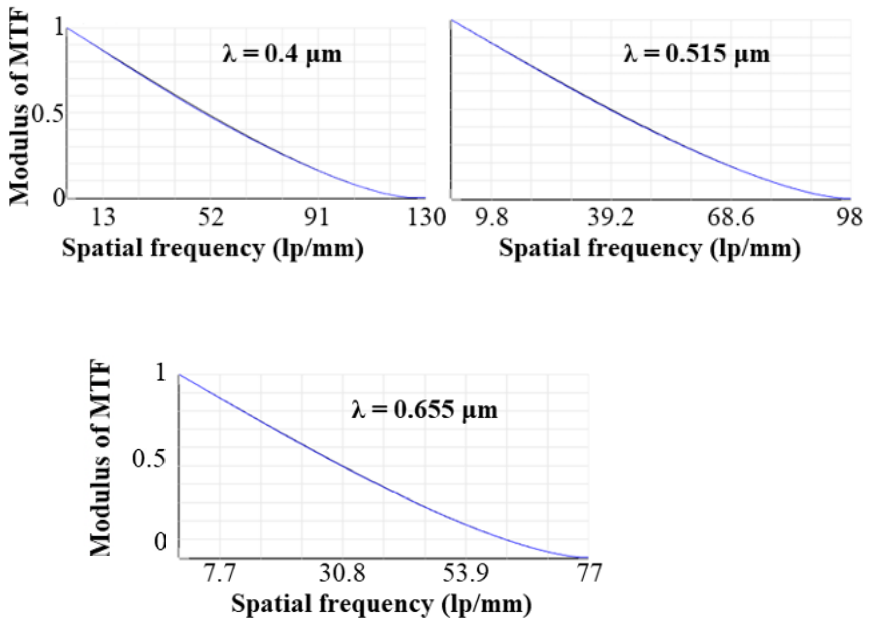
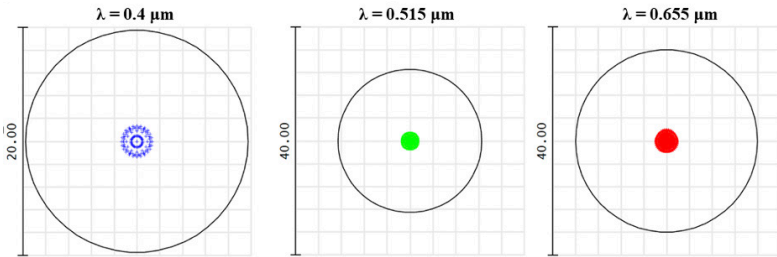


Figure 3. System's MTF for different wavelengths.

cutoff frequency, the first frequency at which the MTF value is null. The cutoff frequency of the confocal microscope is wavelength dependent, being 130 lp/mm for violet color ( $\lambda = 0.4 \mu\text{m}$ ), 98 lp/mm for green color ( $\lambda = 0.515 \mu\text{m}$ ), and 77 lp/mm for deep red color ( $\lambda = 0.655 \mu\text{m}$ ). The higher the value of the cutoff frequency, the higher the resolution of the confocal microscope, being able to discriminate finer details. This behavior is already known in Optics; the same optical instrument has a better resolution capability using purple-blue color light than red.

Finally, we have evaluated the spot diagram of our confocal system, see Fig. 4. The spot diagram shows the image produced by our confocal system assuming that the object was a point source (e.g., the spot of light). Aberrations such as astigmatism and coma are instantly viewed on the spot diagram since they produce asymmetric images. Figure 4 shows that the spot diagrams for the different wavelengths are symmetrical, confirming that astigmatism and coma aberrations are not present. This result already agrees with the conclusion provided by the Seidel diagram. From Fig. 4, we can see that the spot size is wavelength dependent. The root-mean-square (RMS) radius is:  $1.015 \mu\text{m}$  for purple color ( $\lambda = 0.400 \mu\text{m}$ ),  $1.138 \mu\text{m}$  for green color ( $\lambda = 0.515 \mu\text{m}$ ), and  $1.339 \mu\text{m}$  for deep red color ( $\lambda = 0.655 \mu\text{m}$ ). Note that there is a variation of  $0.329 \mu\text{m}$  within the visible spectrum.



**Figure 4.** Performance of the confocal microscope by comparing the spot size at different wavelengths

## Discussion and Conclusions

We have implemented a confocal microscope using off-of-shelf optical components and evaluated its optical performance in terms of the aberrations, the spot size, and the MTF plot. Because confocal microscopes are typically used for multicolor imaging, it is important to ensure that the design is invariant to different wavelengths within the visible range. To simplify the design of the microscope, we replaced the dichroic mirror with a beam splitter. Note that another alternative exists to build a confocal microscope for inexperienced users of Zemax OpticStudio. This alternative is the design of a confocal microscope following an inline configuration. In other words, no dichroic mirror and beam splitter are considered, and we insert all the elements in a sequence. If one follows this configuration, the microscope objective lens must be inserted twice and in reverse order since the light passes through it twice. In the proposed confocal microscope, we have also replaced the microscope objective lens with an aspheric condenser lens.

The latest change would reduce the cost of the experimental system since the cost of the proposed aspheric condenser lens is \$32.61 versus \$1,2667 for a Nikon microscope objective lens with the similar NA (N20X-PF, Thorlabs). The results shown here demonstrate the effectiveness of our design in comparison with the theoretical expectation. We have also shown that the proposed confocal microscope is quite robust to the change of the wavelength, showing a slight variation of  $0.329\ \mu\text{m}$  in the spot size from 400 nm to 655 nm. The small variation ensures the use of the same pinhole size for multicolor imaging without affecting the performance of the experimental confocal microscope. Future work should be focused on a more detailed comparison of the system's performance using an aspheric condenser lens, including experimental results since no reported system has used it.

This work allows undergraduate students interested in Optical Engineering to increase their knowledge in optical system design using the Global Academic Program of Zemax (e.g., free license for academia). In the event of insufficient funding to implement an optical laboratory, Zemax OpticStudio also allows undergraduate students to become familiar with different imaging systems, providing them with a virtual hands-on tool to design and analyze optical systems.

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David Adaway was born and raised in Marion, Arkansas, and currently attends the University of Memphis as a freshman in the Helen Hardin Honors College, pursuing his BS in Computer Engineering.

Bilha Magu grew up in Kenya and the United Arab Emirates and moved to the United States of America in 2018. She is a sophomore pursuing her BS in Computer Engineering with a minor in Business Information and Technology at the University of Memphis.

Brandon Walton is from Memphis, TN, and completed his Associate in engineering at Southwest TN Community College. He is pursuing his Bachelor's degree in Mechanical Engineering and Mathematical Sciences at the University of Memphis.

Bereket Kebede received his BS in Electrical Engineering from the Korea Advanced Institute of Science and Technology (2020). He is pursuing his MS/Ph.D. at the University of Memphis in Electrical and Computer Engineering, researching deep learning applications in structured illumination microscopy. He is a graduate mentor to David, Bilha, and Brandon.

All students have written this research paper by participating in Dr. Chrysanthe Preza's Vertically Integrated Projects team ([www.memphis.edu/vip](http://www.memphis.edu/vip)), in the Computational Imaging Research Laboratory (CIRL), since the fall of 2022.

David Adaway, Bilha Magu, Brandon Walton, and  
Bereket Kebede

Exploring 3D Structured Illumination Microscopy Images  
using the ImageJ Software

Faculty Sponsor  
Dr. Chrysanthe Preza





## Abstract

The use of ImageJ and fairSIM software to interpret and analyze 3D Structured Illumination Microscopy (3D SIM) images in the field of computational imaging is the main topic of this study. The study offers a thorough tutorial for brand-new users looking to master the fundamentals of utilizing ImageJ to work with 3D SIM images. The paper provides a platform for people to become familiar with the techniques and procedures required for assessing 3D SIM images by offering step-by-step instructions to help readers learn how to use ImageJ to manipulate 3D SIM images. The study's objective is to enable young researchers to develop new skills in using open-source programs, like ImageJ and Fiji, to explore and process 3D SIM data, thereby fostering the use of computational imaging science in microscopy.

## Introduction

The motivation for this paper is to provide researchers with a helpful resource for analyzing and reconstructing 3D Structured Illumination Microscopy (3D SIM) images, as this technique is becoming increasingly popular for high-resolution imaging of biological samples [1]. By understanding how to use open-source software such as ImageJ [2] and fairSIM [3] to analyze these images, researchers can better extract information about the structure and function of cells and tissues, which can be used to further our understanding of various biological processes.

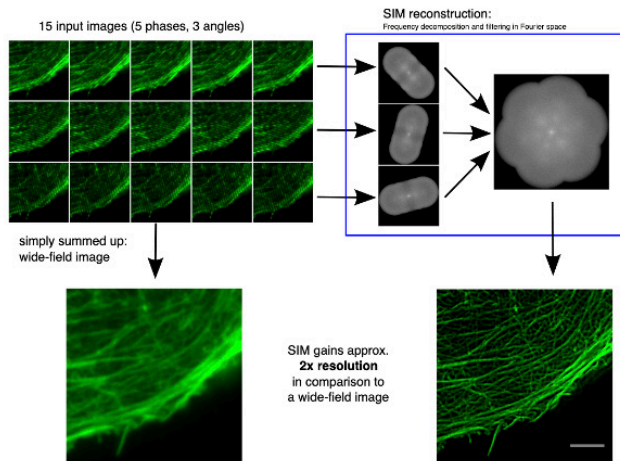
Super-resolution imaging methods like 3D SIM are used to see small features in biological material. In SIM specialized illumination and computational methods enable the reconstruction of high-resolution images of the underlying samples. Compared to conventional fluorescence microscopy, this method can increase lateral and axial resolution by a factor of 2, enabling imaging intracellular structures at high resolution [4]. Compared to wide-field fluorescence microscopy (light microscopy with uniform illumination), the advantages of 3D SIM include compatibility with common fluorophores, rapid recording times, high sensitivity, and good contrast. However, SIM requires longer data processing times, has a lesser improvement in lateral resolution than other super-resolution methods, and is susceptible to reconstruction artifacts due to insufficient system calibration and sample quality. For our study, we use Fiji, a variant of ImageJ2, a Java-based scientific image processing application that works with several image formats and has a wealth of documentation on manipulating images. The next two subsections in this introduction section briefly introduce the realm of 3D SIM and the ImageJ software.

### 3D Structured Illumination Microscopy (SIM)

Structured Illumination Microscopy (SIM) is a super-resolution imaging technique that visualizes fine details in biological samples that cannot be resolved using traditional light microscopy methods [4]. SIM uses a specific illumination pattern to excite specific regions of the sample selectively and then uses computational algorithms to reconstruct a high-resolution image from the resulting interference patterns. This technique was first developed in the early 2000s and has since become a popular tool for studying the structure and organization of cells and other biological samples at the sub-cellular level. 3D SIM is a wide-field imaging technology that illuminates the entire field of view with Moiré fringes, a striped structured pattern created by interfering light. Usually projected onto the specimen, the grid shadow effect is only visible in the focused plane. The out-of-focus light is removed

by capturing multiple images with the structured pattern placed in different orientations and using computational methods for data post-processing, and the specimen's higher-resolution information is revealed (Figure 1). Over traditional (widefield) fluorescence microscopy, 3D SIM increases lateral and axial resolution by 2 and is compatible with multicolor imaging [4].

The number of grid rotations and image resolution have a complicated relationship. The grid frequency, the number of rotation angles, geometric relationships between the grid lines, and the specimen characteristics significantly impact the outcome. Increasing the number of grid rotations can improve the final resolution but doing so inevitably results in slower data acquisition and more photobleaching.



**Figure 1.** Overview of the SIM process, as seen on fairSIM's website [3]. A stack of 15 raw SIM images (top-left), is reconstructed (top-right) into a final SIM super-resolution image (bottom-right) [5]. The final SIM image has an improved resolution compared to the widefield microscopy image (bottom-left).

Structured Illumination Microscopy is suitable for all common fluorophores, uses several quick recordings with a wide field of view, is incredibly sensitive when using the right camera, and provides a drastic improvement in image contrast compared to wide-field microscopy. SIM's thin sample 3D sectioning capability is suitable for applications that investigate live cells. However, compared to other super-resolution techniques, it provides a smaller improvement in lateral resolution; to obtain high-resolution images, large amounts of processing time are required; and the final result can be seriously harmed by errors in the grating position, system calibration, refractive index mismatch, and/or sample quality [4].

When working with images, it is important to display them for both qualitative and quantitative analysis and be able to manipulate them by processing them using computational methods. ImageJ is a Java-based public-domain scientific image processing program currently developed by the Laboratory for Optical and Computational Instrumentation [2]. Available in desktop and web-based formats, it can operate on 8-bit grayscale and 8-bit, 16-bit, 32-bit, and RGB color images saved in many formats, including raw uncompressed TIFF [2]. ImageJ supports scrolling, zooming, irregular area selections, geometric operations, arithmetic operations, color processing, and displaying multi-image stacks. It also has extensive documentation.

Several derivatives of ImageJ have been developed that add features and make it easier to use and maintain. ImageJ2 is an open-source rewrite of the original program focusing on advanced features and backward compatibility [6]. It has a built-in updater for the program and the plugins, support for larger images and more advanced file formats, and a more powerful script editor. For our study, we used Fiji, an easy-to-install distribution of ImageJ2 and several plugins [2].

FairSIM is a plugin for ImageJ that provides an open-source implementation of a two-dimensional restoration algorithm used in Structured Illumination Microscopy (SIM) [5]. FairSIM uses complex algorithms to process the blurry wide-field image stacks and reconstruct from the raw dataset a sharper super-resolution image as demonstrated in Figure 1 [3].

## Methods

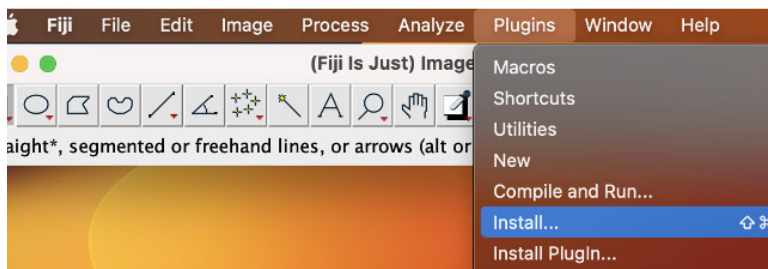
This section describes the tools and other resources used to conduct our study.

### Installing Fiji

On its website, portable binaries of Fiji are provided for the three major desktop operating systems: Windows, macOS, and Linux. Once a Java 8 (or later) runtime is installed, the software can be used on any system. It has no installer – the necessary files and executables are included in the download, which means it can be run from an external drive and easily transferred to another system.

## Installing fairSIM

The ready-to-use JAR file for the fairSIM plugin “fairSIM\_plugin.jar”, can be downloaded from its website and loaded in Fiji, just like any other plugin, from “Plugins > Install...” (see Figure 2), and it can be chosen from the file browser.



**Figure 2.** How to install the fairSIM plugin from Fiji’s menu.

## Dataset

### Opstad data

The dataset used in this paper was created by Opstad et al. [7] using 3D structured illumination microscopy to see how well 3D SIM could be used to examine mitochondria in living or fixed cells. The dataset includes images of lysosomes labeled with LysoTracker in both fixed and live cells. The data is particularly useful for SIM reconstruction because it includes raw 3D SIM data, optical parameters, and reconstructed 3D SIM images for validation.

The data in [7] was captured using a DeltaVision OMX V4 Blaze imaging system with sCMOS cameras and lasers for excitation. It uses sinusoidal illumination patterns to create images with resolution beyond the diffraction limit. The optical resolution of the system is 110-160 nm laterally and 340-380 nm axially. The system takes 120 images for every micrometer in thickness.

Image analysis and processing were performed by Opstad et al. [7] using Fiji. This included converting data format from DV to TIFF image files while maintaining bit-depth and metadata, creating AVI movies by using a maximum intensity z-projection and correcting for photobleaching through exponential fit, and visualizing the images using orthogonal views.

Images of cells grown in two different media types—normal media containing glucose and glucose-free, galactose-adapted growth medium—are presented in [7]. Additionally, for both live-cell and fixed-cell imaging, two different imaging conditions are offered: for alive cells with or without LTDR

labeling and fixed cells chemically preserved with either paraformaldehyde (PFA) or PFA in conjunction with glutaraldehyde (GA). The dataset is hosted on DataVerseNO [7], a national, generic repository for open research data from researchers from Norwegian research institutions. Three-dimensional SIM data of mitochondria and lysosomes in cardiomyoblasts is present under normal and galactose-adapted conditions. Each file in the dataset consists of multiple images (“slices”) contained within a single file (a “stack”). Each two-dimensional slice was taken at different depths ( $z$ ) and at about 1.1 seconds apart, showing the cell at different times and structured illumination angles [7]. The images from the dataset have a time-lapse interval dimension in addition to the three spatial dimensions ( $x$ ,  $y$ , and  $z$ ), hence making it 4D. To access the dataset, refer to Opstad et al. [7].

The “Experimental image”

For our study, we used the file “20210420\_H9C2-dTag\_GAL\_37C\_1520\_sim-fasterer\_016.tif” in the dataset’s RawSIM folder, and its corresponding ground truth “20210420\_H9C2-dTag\_GAL\_37C\_1520\_sim-fasterer\_016\_SIR.tif” in the dataset’s 3D SIM folder of the Opstad data. At just under 900 MB, it is one of the smallest images in Opstad et al.’s data, which was the primary reason we chose this particular image. It is small enough to share with team members and open on lower-speed computers, yet enhancements applied to it were still evident.

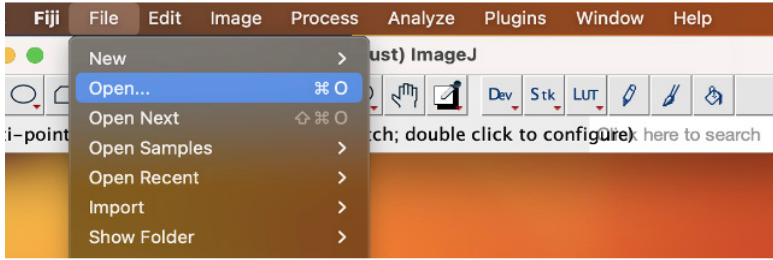
## Exploration

In this section, we show the interesting portions of our exploration of ImageJ as well as the results from this exploration.

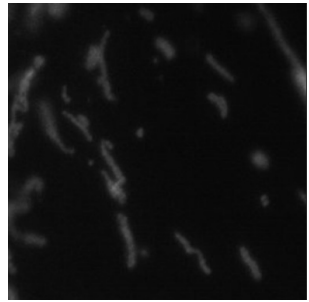
ImageJ tools

Opening an image for display

We used Fiji to open the file used in our exploration (see Figure 3), and all team members could open it and display the image (Figure 4) on their personal computers of varying specs. However, it should be noted that several other images in the dataset are several times larger than the experimental image, so a desktop computer with the largest amounts of CPU and RAM may be required to work with these.



**Figure 3.** An image is opened using Fiji's menu.

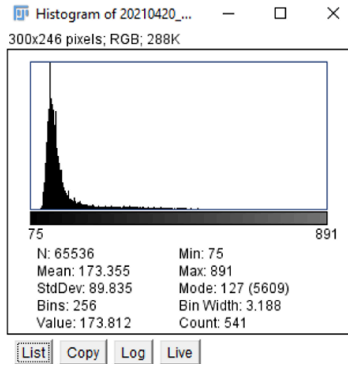


**Figure 4.** The experimental image, "20210420\_H9C2-dTag\_GAL\_37C\_1520\_sim-fasterer\_016.tif". It has a resolution of 256x256x135 pixels and 50 time-lapse intervals (the first x-y-slice at  $z = 1$  from the first-time interval is depicted).

### Histogram

A histogram shows the distribution of pixel intensity values in an image. The "Histogram" feature in ImageJ's "Analyze" menu can be used to create and evaluate histograms. The histogram displays how frequently each pixel intensity value occurs in the image, which can reveal important details about the brightness and contrast of the image as a whole. One can better understand an image's overall brightness and contrast levels by studying its histogram, which can aid in making deft decisions about how to modify these values. The data from the histogram can be used to enhance the methods and algorithms for image processing that are employed in different image analysis applications. The pixel intensity distribution in an image is visually represented by histograms, which can be used to spot patterns and trends in the data. Individuals with little experience with image analysis can use ImageJ's "Histogram" tool because of its clear and straightforward user interface. Overall, using histograms in ImageJ can offer insightful information about an image's composition and aid in image improvement, processing, and analysis.





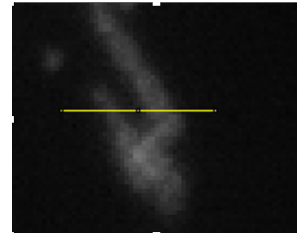
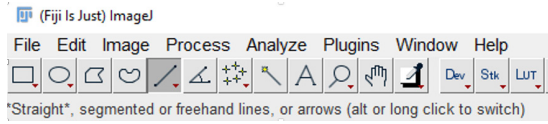
**Figure 5.** Histogram for the image shown in Figure 4

### Brightness/Contrast

When working with any image, our first step will be manipulating the brightness and contrast. In ImageJ, the "Brightness/Contrast" tool, which can be found in the Image>Adjust submenu, is used to change an image's brightness and contrast. Select the desired image and click the Brightness/Contrast option, to use this tool. A dialog box allows the user to change the brightness and contrast settings. The settings can be changed by dragging the sliders or entering precise numbers in the text boxes. Alterations to the image can be applied by clicking "OK". Adjusting the brightness and contrast in ImageJ improves visibility and enables visual inspection of images.

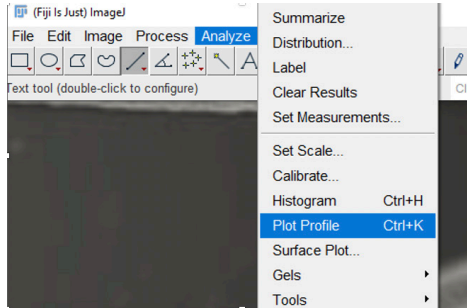
### Intensity Plots

One can plot the intensity profiles of images on ImageJ. General information on image intensity plots can be found in [8]. We demonstrate here intensity plots taken from our experimental image. Figure 6 demonstrates how we use the intensity plot feature of ImageJ to analyze the SIM image. The intensity profile curve in Figure 6 (d) shows how this analytics visualization tool of intensity value versus distance helps us better understand the data quantitatively across a cross-section of our line of interest. This technique is useful for an image reconstruction algorithm researcher when comparing the resolution (which can be estimated from an intensity profile) of an unprocessed raw image with a reconstructed image.

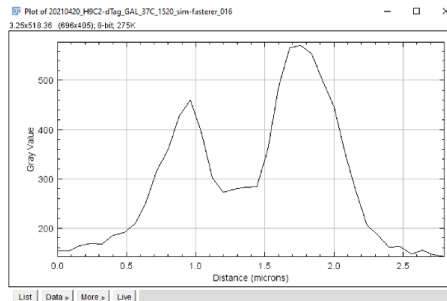


(a)

(b)



(c)



(d)

**Figure 6.** Creating an intensity profile. (a) Select the straight-line segment from Image’s main menu. (b) Drag a line over the RAW SIM image. (c) Go to Analyze in the main menu and select the Plot Profile option. (d) A new dialog appears depicting the intensity profile along the yellow line we set in (b).

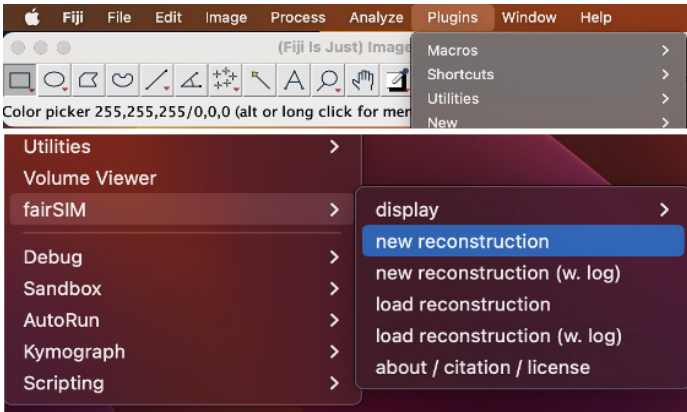
Using fairSIM for image reconstruction.

This section provides the step-by-step process to create a reconstruction with fairSIM. FairSIM is largely an automated tool; it can approximate some input parameters, such as the Optical Transfer Function (OTF) and pixel size, without fine-tuning [9]. A new reconstruction can be started from the

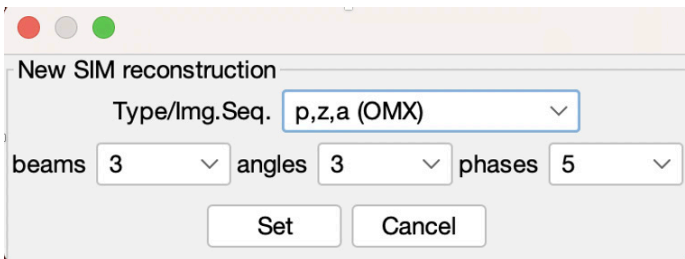
“Plugins” menu (Figure 7). Once this process is initiated, dialogue windows prompt the user for input. In summary, the required steps are:

- Starting a new reconstruction (Figure 7)
- Selecting the image sequence, beams, angles, and phases (Figure 8)
- Importing an image slice (Figure 9, then Figure 10)
- OTF approximation (Figure 9, then Figure 11)
- Parameter estimation (Figure 9, then Figure 12)

We selected the OMX option (Figure 8) for the second step because the dataset was acquired using a DeltaVision OMX V4 Blaze imaging system. We chose 3 angles and 5 phases because of the specification on page 3 of [7]. The number of interference beams was not specified in [7].



**Figure 7.** A new reconstruction is started using fairSIM, at “Plugins > fairSIM > new reconstruction”.



**Figure 8.** New SIM reconstruction dialog box for user input.

We use the default three beams for reconstruction as most 3D SIM datasets in the literature [1] use 3 beams. We clicked on the “Set” button in Figure 8 to display the fairSIM main window (Figure 9). For our study, we are only concerned with the “Load” tab. We chose an image slice from the stack containing multiple slices depicting the same subject at different depths and illumination angles over a time-lapse study.

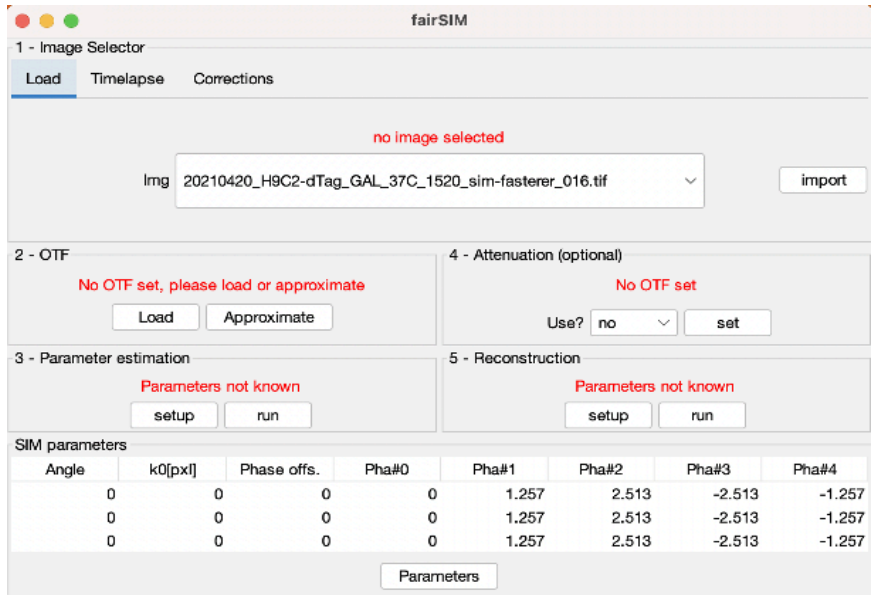


Figure 9. fairSIM main window.

We chose the first slice in the stack (Figure 10), but any slice will work. fairSIM automatically detects the pixel size, 80 nanometers (nm). “Background subtraction” will attempt to remove any background from the image, but this was not used for our study; the test images have a zero background.

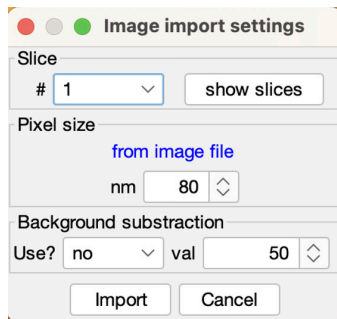
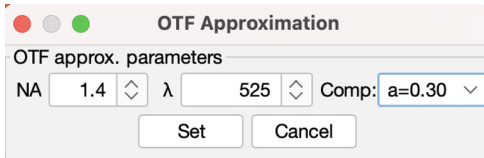


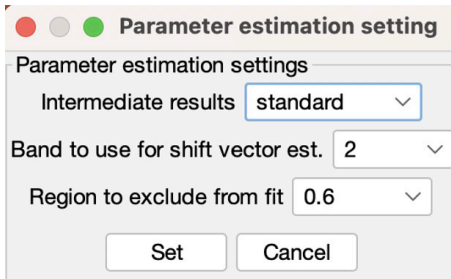
Figure 10. Image import settings.

The Optical Transfer Function (OTF) describes which frequencies are transferred through an imaging system, such as a microscope [10]. It is an indicator of image resolution. FairSIM can either use a given OTF file or (in this study) approximate the function. Attenuation also involves OTFs, but it is optional. The pictured parameters (Figure 11) are fairSIM's defaults, and they worked well on our study.



**Figure 11.** OTF Approximation.

Various parameters involve sub-pixel precision and the display of the fairSIM reconstruction [9]. Again, these default settings (Figure 12) did not require fine-tuning. Finally, the reconstruction was run, and the super-resolution image was generated and displayed (see Figure 13, (d) and Figure 17).

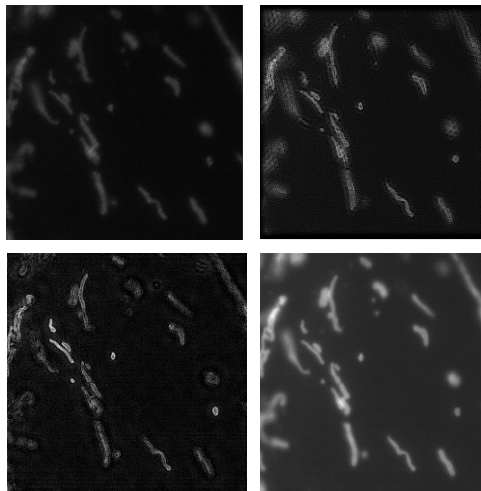


**Figure 12.** Parameter estimation

## Resolution Enhancement

The wide-field image (Figure 13b) has a digital resolution of 1024 x 1024 pixels, while fairSIM's reconstructed image has 2048x2048 pixels (Figure 13d) – it is twice as large, because the optical resolution is doubled through the reconstruction process [1]. Many blurry and grainy details became much sharper after processing with fairSIM; the shapes of the cells are more apparent in the reconstruction (Figure 13d). We see a lot of artifacts in this fairSIM reconstruction because it was performed using default reconstruction parameters estimated by the fairSIM software. These are known to be

residual artifacts due to inaccurate knowledge of the structured illumination pattern parameters. Trying to optimize the input parameters could possibly result in a better reconstruction than what is shown in Figure 13d. It is not quite as sharp as the ground truth image (Figure 13c) provided in the Opstad data, because the two reconstruction methods used to generate these images are different. FairSIM's reconstruction methods are based on two-dimensional processing (instead of three-dimensional processing), but they may be useful as an alternative for researchers who lack more advanced commercial software. Figure 13 qualitatively demonstrates the resolution enhancement we achieved by using the fairSIM plugin in ImageJ. The fairSIM result is a sharp, super-resolution image, twice as large as the experimental raw data image.



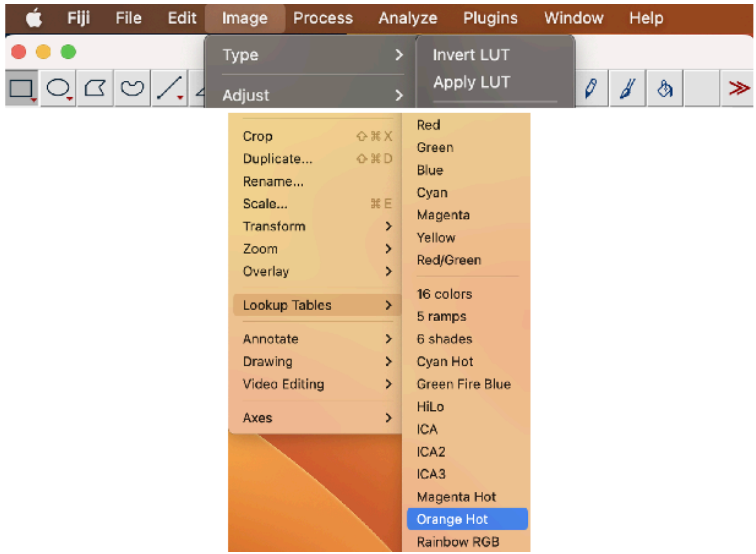
**Figure 13.** Resolution enhancement achieved using the fairSIM plugin in ImageJ. (a) Top left - Raw SIM image (1 out of 135). (b) Top right - wide-field image for depth 1/9. (c) Bottom left - ground truth image for depth 1/9. (d) Bottom right - fairSIM reconstructed image for depth 1/9.

#### Adding pseudo-color with a lookup table

Pseudo-color or false-color is widely employed to display images in many fields of science, including biology. Most scientific-grade cameras used in microscopes record grayscale images. To make it easier for researchers to see details in an image, scientists digitally add colors corresponding to different densities or fluorophores used to stain the sample. The human eye

is more sensitive to color gradations and variations than it is to variations in the tones of black and white [9].

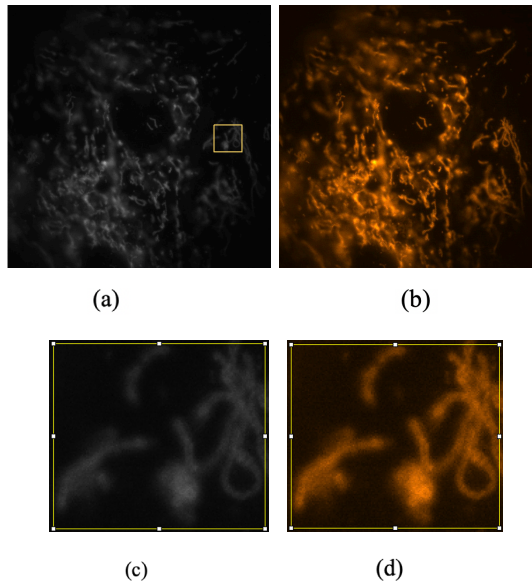
In ImageJ, pseudo-color can be applied to a grayscale image using one of the many built-in lookup tables. Lookup tables (LUTs) are functions that convert shades of gray to shades of another color or color palette. For this study, several different LUTs were applied chosen from those available in the ImageJ menu (Figure 14).



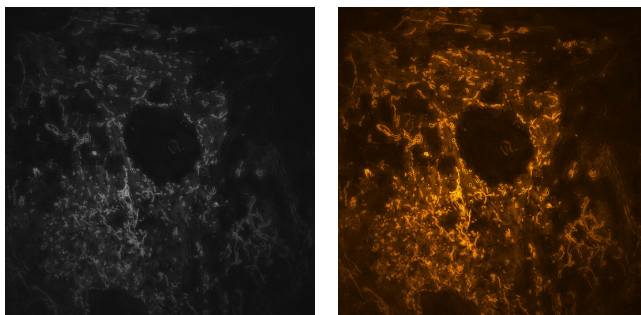
**Figure 14.** ImageJ’s lookup tables menu, with various color options displayed.

### Pseudo-color

In this section we display the images from file “20210420\_H9C2-dTag\_GLU\_37C\_1520\_sim-fast\_005.tif,” of the Opstad dataset using pseudo color. Applying pseudo-color to the raw SIM image was somewhat effective in increasing contrast (Figure 15). Portions of the image that were practically invisible in Figure 15a (mainly the corners) are now much more apparent. Still, the effect of the lookup table is neutered by the low resolution; it cannot make a blurry image sharp. The exact outline of the cell is still difficult to interpret as seen in the cropped images in Figure 15(c & d).

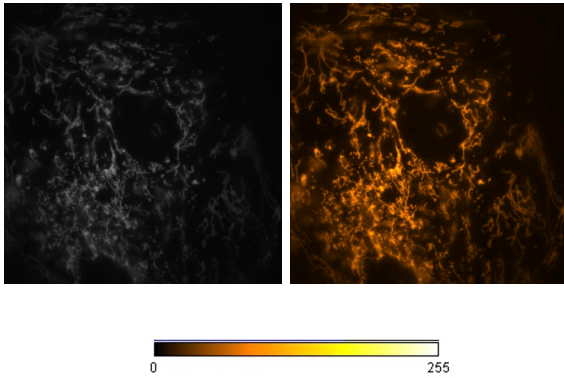


**Figure 15.** Impact of color in visual inspection of an image. (a) Input grayscale wide-field image from file “20210420\_H9C2-dTag\_GLU\_37C\_1520\_sim-fast\_005.tif” in the Opstad data. (b) The same image displayed using the “Orange Hot” LUT. (c) & (d) Cropped zoomed in images for better visualization taken from the yellow box shown in (a) and corresponding area in (b).

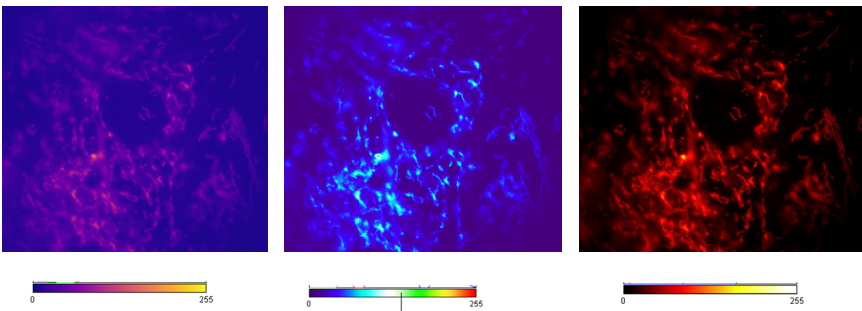


**Figure 16.** Impact of color in visual inspection of an image. Left: The ground truth image corresponding to the image shown in Figure 15. [7]. Right: The same image, displayed using the “Orange Hot” LUT applied.





**Figure 17.** Impact of color in visual inspection of an image. Left: The output reconstruction from FairSIM. Right: The same image, with the “Orange Hot” LUT applied.



**Figure 18.** Impact of different LUTs in the visual inspection of the same image. The name of the LUT in each case is: (a) “mpl-plasma” (b) “Thermal” (c) “Red Hot.”

On the other hand, applying pseudo-color to the super-resolution image helps us see the contrast that is there differently. The differences between the lighter and darker portions of the image are much more visible to the human eye – thin parts of the cells easily missed against the black background stand out more in the color image (Figure 16). The use of this LUT was also effective in visualizing our fairSIM reconstruction (Figure 17), with some portions (bottom middle) being sharper than in the grayscale image. We also compared various LUTs to observe differences in the image due to the different colors used (Figure 18).

## Discussion

ImageJ and fairSIM are useful tools when studying 3D SIM images. Data from super-resolution fluorescence microscopy can be analyzed and visualized using fairSIM and ImageJ as shown in our study. By combining the two software programs, researchers can benefit from the tools offered by fairSIM for SIM data processing and analysis and the extensive capabilities of ImageJ for image analysis and visualization. ImageJ has a user-friendly interface that makes it accessible to researchers with varied degrees of technical skill. While fairSIM offers sophisticated capabilities for SIM image reconstruction, a versatile tool for researchers, fairSIM is compatible with various SIM data types and techniques, while ImageJ has a wide variety of picture file formats. However, the learning curve for ImageJ can be difficult for certain users, and some fairSIM features may be too sophisticated for researchers with little technical competence or lack of knowledge about the SIM imaging technique. For certain users, integrating fairSIM with ImageJ may be difficult, time-consuming, requiring some technical skills. In conclusion, combining fairSIM with ImageJ can result in a complete set of tools for the study and display of super-resolution fluorescence microscopy data. Organizations and researchers must, however, carefully assess potential complexity issues to avoid restoration artifacts and misinterpretation of images.

## Conclusion

In this study, we demonstrate the effective use of ImageJ and fairSIM with a 3D SIM dataset and detailed step-by-step procedures. ImageJ is a free, open-source image processing program for multidimensional scientific images, and fairSIM is an open-source framework for image reconstruction in super-resolution microscopy. Both programs are widely used in scientific communities for image analysis in biology, medicine, and material science. ImageJ can be used to display, edit, analyze, process, and measure images and allows the creation, integration and modification of image macros, while fairSIM enables reconstruction of super-resolution images from SIM raw data. Both programs are written in Java and run on various platforms, including Windows, macOS, and Linux.

## Acknowledgment

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MaKenna Beck is an undergraduate sophomore at the University of Memphis from a rural town in Tennessee that most people have never heard of. She is pursuing a degree in both English and Psychology with a concentration in Creative Writing and takes great pride in being a part of the Helen Hardin Honors College and the English Honors Program. Her hobbies include writing creative fiction, rigorously studying to maintain her academics, and lovingly annoying her family day after day with new bits of acquired knowledge. Everything she has accomplished has been the result of the grace of God and the support of her amazing family.

MaKenna Beck

Judaism forgotten: Steve Stern and the importance of the  
Jewish to the idea of Memphis

Faculty Sponsor

Dr. Courtney Santo



## Abstract

Memphis is known for its foundations in blues and rock music, Ida B. Wells' efforts against racism and in creating the NAACP, and for being the city where Martin Luther King Jr. was assassinated. It has been predominantly characterized by its African American influences on its culture and history. Many, however, are unaware of the rich history of Jewish communities in Memphis. Steve Stern brings this hidden influence into the light. An author who combines details of Jewish and southern culture and identity in stories such as *Isaac and the Undertaker's Daughter*, Stern draws his influences from the Pinch, a forgotten neighborhood that served as Memphis' first business district and the center of a bustling Jewish community. Through his prose, Stern brings the overlooked community into the spotlight, expanding upon the idea of Memphis as he revels in the city's uncelebrated cultural influences. Thus, he should be added to the Memphis canon for works such as *The Pinch* and *The Frozen Rabbi* to create an inclusive list that considers the whole of Memphis' history, not just its prevailing themes.



## Introduction

Resting on the edge of the southwest portion of Tennessee and situated along the Mississippi River lies the famous city of Memphis, known for being the home of the blues and the birthplace of rock 'n' roll, creating delicious bar-b-que, and containing a bustling shipping industry. The city is also known for being "one of the poorest" and most dangerous cities in the United States, an area entrenched in a bloody history of injustice and inequality when it comes to race and class. Noteworthy examples include the Memphis Race Riot of 1866 (in which the white majority attacked the newly freed Black residents), the National Housing Act of 1934 (where Black and low-income neighborhoods were refused mortgages based on racial and ethnic composition), and the brutal deaths of Echol Cole and Robert Walker that sparked the 1968 Sanitation Workers' Strike (World Population Review).

When one thinks of Memphis, one may think of a culturally rich city largely imbued with heavy African American influences. These reflect a war between celebrating Memphis' history of being a birthplace for music and social change and destroying its colorful heritage through ignoring its most blatant issues. However, there is also a Jewish element in Memphis' lively culture. While influences of the religion of Christianity are more prevalent with southern culture and the idea of Memphis, there are neighborhoods, schools, businesses, and places of worship that reflect the presence and history of Jewish communities. Steve Stern and his works provide just one example of how the Jewish southern community has contributed to Memphis culture, art, and literature.

To explain the importance of Steve Stern to the idea of "Memphis as a text", I will delve into the important aspects of Stern's writing that make him stand out from the crowd of typical Memphis authors, as well as his connections to Memphis that ground him in the narrative of the city. One such aspect is his usage of Yiddish folklore (also known as the mythos), which strays from the more dominating narrative of Christian doctrine in southern writing. Other defining aspects are his inspirations gathered from the Pinch neighborhood of Memphis, a once thriving Jewish community centered in the history of the city itself. These two forces combined with Stern's writing prowess, subject matter, and themes will be explored in more detail throughout this paper.

## BIOGRAPHY

Steve Stern was born December 21st, 1947, in Memphis Tennessee. Encyclopedia.com states that Stern was born into "an assimilated household as the son of a grocer and a homemaker, where Stern had "little exposure to any aspects of Jewish culture" during his youth ("Stern, Steve 1947-"; Royal, 139). In the 1960s, he pursued education from multiple institutions, receiving his bachelor's degree from Rhodes College in 1970 and his Master of Fine Arts degree in creative writing program from the University of Arkansas at Fayetteville in 1977 (Royal, 139). Between the years of 1979 and 1986 within Memphis, Stern worked in almost every institution of higher learning as an adjunct instructor until the mid-1980s where he struggled to find steady work and took a job at the Center for Southern Folklore as a transcriber of oral histories (Royal, 139). It was at this job that Stern discovered a location within Memphis known as the Pinch.

The Pinch was an old neighborhood that consisted of "all Memphis land north of Adams Street, playing the role of "Memphis' first business district" (Nickas, "Pinch District"). Nickas states that the Pinch was an area that consisted of numerous immigrants such as the Irish, Italians, Russians, Greeks, and Jewish whose emaciated appearances gave the area a derisive term: Pinch-Gut. Furthermore, Nickas notes that from the 1890s to the 1930s the Pinch was a flourishing and bustling center of activity for Memphis' Jewish community. This changed after World War II when many young families relocated to the eastern parts of the city and their business and commerce followed after them, leaving the Pinch in a deteriorated state until the late 1980s when urban renewal projects set to work in revitalizing the area.

When explaining his muse for his stories, Stern describes his discovery of the Pinch "as strange as discovering the lost city of Atlantis" (Royal, 139). He also states that "much of the Pinch originates in my imagination", a fact that is morphed by historical and cultural significance. He also says that he has "been mining the old North Memphis neighborhood of the Pinch for about three decades now" (Royal 141; Kissileff, "Interview: Steve Stern"). Stern also comments on the connection between the Jewish presence within Memphis and the city's overarching African American cultural background, stating that "there was an interesting symbiosis between African Americans and Jews... where Blacks were barred from shopping at white-owned businesses, they were welcomed by the Jews" (Kissileff). Stern adds that "the Black heritage of Memphis, the city's richest cultural heritage, had from its early inception a lively Jewish element; further accentuating the unknown and

largely unspoken of elements of Memphis' history and culture" (Kissileff).

## Overview

Stern is an author of speculative fiction. His works are set in a world that is different from our own in which imagined elements of grand proportions exist and occur. Stern combines supernatural aspects that stem from Judaism and the worldly basis of the south as the setting for most of his stories. Regarding the influences of his writings, Stern states that

there was very little Jewish content in my growing up. I'm just drawn to Jewish sources and Jewish folklore the same way I seem to be drawn to the damn South. If there's anything that made my being Southern and Jewish necessary and important to my fiction, it's that the combination of the two serves to provide a sense of community" (Dickstein, "Dybbuks in Dixie").

One such story that encompasses these aspects is *The Pinch*, which is set within the very Pinch community that inspires Stern's stories. Its main character, Lenny Sklarew, discovers he is a character in a book titled "*The Pinch*" that tells the history of the area in a work of metafiction.

Stern has won numerous awards over the years. He has won five Pushcart Prizes, an O'Henry Prize and a Pushcart Writers' Choice Award for *Isaac and the Undertaker's Daughter*, a National Jewish Book Award for *The Wedding Jester*, and an Edward Lewis Wallant Award for *Lazar Malkin Enters Heaven* (PenguinRandomHouse, "Steve Stern"). As such, I have chosen three of his works that I believe best demonstrate the influence of Memphis, the Pinch, and Stern's own prowess as a talented writer with a mix of texts that have received awards and recognitions alongside those that have not been celebrated or acknowledged as significant literary explorations of Memphis. These three works are: *Isaac and the Undertaker's Daughter*, *The Frozen Rabbi*, and *The Pinch*.

*Isaac and the Undertaker's Daughter* is Stern's first well known book, a collection of short stories published in 1983. The book consists of seven short stories that follow differing eccentric and eclectic Jewish characters as they live out their lives while dealing with happenings stemming from the mythos of Judaism and strange occurrences. In the book's first story, "Aaron Makes A Match," the main character, Aaron, chooses to use mystical means to summon a husband for his beloved Aunt Esther so that she does not die, but ends up summoning the angel of death, Azrael, to wed her. The belief that she will die comes from the harrowing warnings of the neighborhood's evil genius, W. Cecil Blankenship who states that "unless your Aunt Esther gets penetrated by a male of the species, she will dry up inside and out" (Stern, 8). Another story, "Bruno's Metamorphosis", follows the life of Bruno Katz after his girlfriend dumps him and he finds that his stalled writings upon his typewriter are

being typed for him by a mysterious force in the night. It turns out that his mysterious writer is a little rabbi man who, in another plot twist, turns out to be his future self who breaks into his past self's apartment to write said stories. All the stories approach these bizarre happenings as if they are completely normal, adding to the charm of Stern's stories.

*The Frozen Rabbi* is one of Stern's more recent works, published in 2010. It is a story that follows Bernie Karp, a lazy teenager from an assimilated Jewish family living in Memphis, Tennessee with no discernable motives in life. However, when in search of a slab of meat to recreate a sexual act portrayed in a scandalous novel from the sixties, he discovers a frozen rabbi tucked away within the freezer. When prompting his family about the discovery, his father says that the rabbi is a lucky keepsake, handed down from generation to generation in the family. Life remains relatively normal with the revelation, but all changes when Memphis is hit with a power outage that allows the rabbi to thaw back to life.

Now alive and amazed by the modern world around him with its culture of shame and sexuality, Karp is thrust into the role of caretaker as the rabbi begins his descent into corruption. This descent is juxtaposed by Karp's ascension into piety and becoming a noble man rather than an uninspired nobody. The story states that

...finding an old Jew in the deep freeze did not at first alter Bernie Karp's routine in any measurable way. Overweight and unadventurous, he had no special friends to tell the story to even if he'd wanted, which he didn't... (The Frozen Rabbi).

As stated by Ben Marcus in his article "The Rebbe of Graceland,"

The Frozen Rabbi is a story that follows the Karp family across generations as they seek safety in assimilation, portraying what is sacrificed for safety while promising that the passions of our ancestors are not fully lost, only just needing to be rediscovered.

*The Pinch* is a much more recent work by Stern, published in 2015. It is a story that contains a mythologized Memphis in which the once thriving community of the Pinch has been reduced to one tenant: Lenny Sklarew. Lenny works in a bookstore and peddles drugs on the side, living a wholly uninteresting life until he finds a book called "The Pinch: A History" and finds himself a character in the book.

The book then bounces back and forth between the life of Lenny and the life of the book's author, Muni Pinsker, as he writes the book within an

enchanted day that lasts years. The book also coincides with harrowing events true to real life at the time as Stern delves into the real occurrences of Memphis history like visits from the Ku Klux Klan and the assassination in Martin Luther King, Jr. In his interview with Kissileff, Stern states:

I wanted to address the city's pivotal (even terminal?) historic moment, the garbage strike that preceded the assassination of Martin Luther King. There seemed to me a kind of inevitability in the fact that the so-called urban renewal that destroyed North Main Street coincided with the murder of Dr. King. My dream district evaporated forever with the death of the century's greatest dreamer. (Kissileff)

While Stern bases his stories in a realm of fantastical elements, his works also focus on the real effects of events and people. Drawing on the history of Memphis, Stern employs mystical tools to explore the Pinch and its tangible origins in the same way a ghost story describes a bustling town before a great terror arrives to destroy it. As mythical as Stern may be, inspiration is drawn from real life sources from Memphis, based in the undeniable truth of a bloody history. To tell a story about the Pinch is to tell a story about Memphis itself, and hardly any story about Memphis can ignore the ramifications of the garbage strike and the assassination of Martin Luther King, Jr. on the city's history and development.

## CONTEXT

These reviews of Stern's works highlight many of the strengths of his prose and his capabilities in delving into the more universal themes of literature. Much like Memphis' exuberant culture, Stern possesses a similar flavor as stated in one review that uses the phrase "dynamic inventiveness" to describe Stern's work (Forbes "Review: '*The Pinch*'"). However, these reviews also suggest reasons for Stern's lack of renown within Memphis itself, as when another review states that Stern "doesn't know when to stop" (Fishman, "*The Pinch*"; by Steve Stern"). The excessiveness that Fishman notes can be similarly found from critics of other great Memphis creators, such as Elvis Presley. With such differing commentary on Stern, there is plenty to be said about his works and what they contribute to both literature and the world.

With regard to professional reviews of *The Pinch*, one reviewer calls it "weird and wonderful. [*The Pinch* is] a backdrop to Stern's poignant and antic drama, a playground on which his exuberant, larger-than-life characters can run wild... *The Pinch* is composed of... perfectly calibrated moments, all of which pulse with a dynamic inventiveness" (Forbes). Opposite this praise sits

a review from the *New York Times* that states that "... unfortunately, Stern doesn't know when to stop. There is no era he can't over-research, no scene he can't overimagine, no digression he can resist and no sentence he can't sag with too many words "(Fishman). Kirkus' reviews calls *The Pinch* an "audacious, hilarious, unabashed fiction" and *The Frozen Rabbi* "an ethnic novel with universal implications" ("The Pinch"; "The Frozen Rabbi"). For *Isaac and the Undertaker's Daughter*, Gordish Lish portrays the infatuation felt by many from reading Stern's prose.

Can't recall where it was I first came across "Isaac and the Undertaker's Daughter" and the alliterative no-nonsense monosyllables that gave me the name of its author. Recall only that I straightway made for a typewriter to whip off a love letter. Steve Stern is smart. Steve Stern is eloquent. Steve Stern is knowing. But the best of Steve Stern is the goodly heart whose imprint he impresses onto the page. Here is a mensch-and an artist. (Qtd. in *Isaac and the Undertaker's Daughter* 114)

Similarly, Shoshanna Olidort sings praises for Stern's portrayal of Jewish people in a more contemporary light.

Steve Stern's fiction draws on Jewish folklore in the tradition of great Yiddish writers such as Isaac Bashevis Singer to evoke a magical world populated by flying rabbis and disembodied souls, voyeuristic prophets, and lascivious angels... he presents a closely studied portrait of his subject-the immigrant Jew and his East European predecessor. .. This is what sets Stern's work apart from-and, I would argue, a notch above-much of the literature being churned out by contemporary Jewish writers, many of whom wallow in what Stern has called a "sepia sentimentality" about their ancestral background. ("Steve Stern: Memory Man of the American Jewish South")

In Academic Scholarly Reviews, Derek Parker Royal of Texas A&M University reported that Stern is of a "reserved manner" and that he "is often uncomfortable about discussing his own work, but when he does he brings a healthy dose of self-deprecating-and highly insightful-wit" (140). Derek Parker Royal also conveys the opinion that the "subversion of the possible" is a defining characteristic of Stern's works, an aspect that is similarly found within the works of Hawthorne and Melville (148-149). Michael Shapiro of the University of Illinois at Urbana states that Stern is "less concerned with documenting the immigrant experience and its aftermath than he is with the interplay of the Jewish imagination with Jewish history and Jewish texts"

(131). In relation to the thoughts of Jewish survival, Shapiro muses that, for Stern, "Jewish survival involves remembering and recreating ancient texts, and drawing upon them in the creation of new texts" (133). In another layer of praise, Jay Rogoff proclaims that "Steve Stern has done as much as anyone to further the art of Jewish southern writing" and that his characters "often confront, by choice or chance, their obsession with the forbidden" (xxx-xxxi).

With regard to authors that Stern is in conversation with, while Stern is seemingly focused upon exploring the human condition through works influenced by Judaism and the Southern lifestyle, he is also in conversation with the history of Memphis itself, the way that Judaism is portrayed in literature, and that of the Southern culture. These conversations also turn into conversations with authors such as William Faulkner, Mark Twain, Isaac Bashevis Singer, and Franz Kafka.

Stern draws upon inspiration from the Pinch within Memphis for his works. By using this inspiration and reanimating the otherwise overlooked ghostly memories of the Pinch, Stern takes a bold step out of the dominant caricature of Memphis' history to shine a light on the forgotten yet important aspects that helped to shape the city, insisting that Jewish people have added to the signature flavor of Memphis' culture.

When speaking upon works involving the Jewish culture, Stern has always noted himself to be bothered by authors (such as Nicole Krauss and Michael Chabon) who use their knowledge of Judaism to "defang a ferocious experience until it's safe for nostalgia," referring to the fact that these authors only use the Jewish culture to infuse their works with an unconventional perspective that serves to further enhance the flavor of their stories than to fully delve into the mysticism of Judaism and its effects on the Jewish person (Royal, 158). He is an author who values honoring the traditions from the past, stating that "if you tug at a Jewish weed in a Jewish story, it shouldn't come out of the ground like an artificial plant... instead, you pull the weed... and up comes an immensely elaborate root system with the culture, history, and myths of the Jews attached" (159).

Such examples can be seen on page five of *The Frozen Rabbi*, in which the Rabbi Elizer's meditations are described with conventional Jewish terms in great detail. Through pages nine and ten, the mentions of giants and fallen angels of Yiddish folklore mingle with reference to the "Babylonian Exile" (referring to when the Israelites were captives in Babylon as punishment for disobedience to Yahweh). Then there are the following vivid descriptions of Jewish oppression in which the inhabitants of Boibicz (the town where Rabbi Elizer resides) suffer the brutal destruction of its buildings and the murder of its citizens by its government: a prevalent theme to the history of the

Jewish. He is of the opinion that, in references to the categories in Kabbalah and Criticism by Harold Bloom regarding Jewish literature, "there's more to a story than meets the eye, or the ear, or the brain, heart... and if the story fails to evoke a felt response in each of these categories, then...it just doesn't matter enough" (Royal, 159-160).

Stern's representations of southern culture and specifically Memphis Mid South culture resist stereotypes and insist on presenting the "South" as complex and full of possibilities for fantasy, as can be seen in *The Pinch* with its descriptions of its "simple" characters (Lenny, a drug peddler trying to win a girl's affections, joins the march for civil rights and focuses on something greater than himself) and its fantastical plot point in which an earthquake creates a flood in the Pinch and strands its denizens in a supernatural time freeze. However, the South is steeped in a folklore of its own that can be expanded upon much in the same way as, according to Millgate, William Faulkner did with his creation of Yoknapatawpha County and its inhabitants (based upon Lafayette and Oxford County, Mississippi, where Faulkner spent a great portion of his life ("William Faulkner"). Much like Faulkner, Stern sees the South as a rich source for storytelling and uses his upbringing to influence his works from character portrayals to settings of prominent themes. As *I Lay Dying*, by William Faulkner, for example, takes place within the fictional Yoknapatawpha County and focuses on the Bundren family undertaking a journey to bury Addie Bundren in Jefferson, Mississippi. In the story, each family member's thoughts and motives (including the dead Addie) are explored in a thrilling psychological narrative of a poor and destitute southern family.

In a similar fashion, in *The Frozen Rabbi*, Stern uses the setting of Memphis as a means of exploring the present-day city and its vices, and its colorful past and population in the Pinch. However, unlike Faulkner, who created a fictional county based on a real place, Stern does not employ fictional placeholders in his works. Instead, he uses the stories he gained from Pinch residents, so much so that Royal reports from his interview with Stern that the surviving tenants of the Pinch sued Stern for a quarter of a million dollars for slander (Royal, 142).

Mark Twain is another southern author similar to Stern. Both authors live in the South, both are talented in their prose, and both heavily deal with creations of a bildungsroman. Stern and Twain often focus heavily upon the seemingly mythical issues the southern adolescent must face in order to grow as people. Both Bernie Karp in *The Frozen Rabbi* and Huckleberry Finn in



*The Adventures of Huckleberry Finn* are presented with herculean challenges that force them to reconsider their current lives and make decisions that fundamentally change them for the better. For Bernie, he must shed his adolescent youth and turn toward his history and faith to grow as a person in order to care for the newly unfrozen rabbi in his care. Huckleberry Finn must escape from his abusive and drunken father and wrestle with the conventions of what is "legally" right and "morally" right as he travels with Jim, an escaped slave.

While not Southern, Isaac Bashevis Singer depicts his own Jewish stories with the same intensity and zest that can be seen in Stern's works. Singer was no stranger to immigration and its effects on the family, which can be seen in his work "Enemies, A Love Story". This work follows Herman Broder, an immigrant from Poland who survived the Holocaust, as he struggles to survive the effects of the traumatic experience and his new life in New York City as he tries to keep his three wives from knowing about each other ("Isaac Bashevis Singer - Facts"). The story reflects human feelings of survival while connecting the Jewish lifestyle with the concerns of mankind. Together, they provide a fascinating narrative of Judaism and its culture. However, Stern is a foreigner to the immigrant experience and writes only from researched accounts and imagination (such as the story of Muni Pinsker in *The Pinch*).

Stern also states he "was weaned on Kafka and Beckett, crown princes of hopelessness", and he is in conversation with them regarding their similar story telling methods (Royal, 150). Both Kafka and Stern are well known for their blending of realism and the fantastical. Kafka is more focused on portraying the struggle against the seemingly futile workings of a world teetering between the edges of nihilism and existentialism. However, Stern focuses upon a world in which the afterlife is a real place. For example, *The Trial*, written by Kafka, follows a man named Josef who is accused of a crime that is never named or told to Josef as he searches for what he could have done wrong, which ends sadly as he is murdered. It is a tragic and absurdist situation that focuses on the desperate attempts of Josef to do right even in a world that fails to help him and constantly confuses what it means to do "right" causing existential doubt.

Stern follows a similar narrative of questioning what it means to do "right" like Kafka does in *The Trial* in his story "Aaron Makes A Match" but where Josef fails to receive an answer from a higher power, a higher power literally shows up to fulfill Aaron's wishes to wed his beloved aunt. Instead, Aaron is left to question the Angel of Death's appearance and affection for his aunt, who is happy, as she is taken from Earth. Thus, it is not a question of whether or not a higher power is watching, but whether or not the characters

will learn from the mythical encounters they face and do something with their predicaments.

Steve Stern is heavily undervalued in the literary marketplace. While he is praised and compared to great writers, his presence is practically nonexistent. Fishman pronounces Stern as "a fellow chronicler of Jewish experience via deeply schooled stories that can't seem to get reviewed without reference to the author being not 'as well-known as he should be.'" This may come from the inability of Stern's works to find a solid foothold in contemporary society due to the nature of his writings and their grounding in Judaism within the predominantly Christian South. Stern himself states that, after having issues with the libel suit previously mentioned, his career was "consigned thereafter to the outer dark, where it has largely remained ever since" (Royal, 143). In total, Stern is widely overlooked despite the awards he has won and the talent that he possesses- an issue that should be rectified.

## MEMPHIS AS A TEXT

Across the world there is a great list of literature deemed vital to being considered "well read". This is known as the literary canon, which serves as the list of essential readings such as *To Kill a Mockingbird*, *The Canterbury Tales*, *The Odyssey*, and many more.

There are debates on what literature is considered "essential" on a grand scale, but smaller literary canons can conceptualize the ideas of smaller geographic regions through texts. For the idea of Memphis as a text, this literary canon consists of works by Memphis born authors or texts based in Memphis. With the canon's more prevalent themes of social inequality on the basis of race and class as well as its focus on music, Steve Stern contributes to the idea of Memphis as a text.

Stern has stated that he has drawn his inspiration from the stories he collected as an oral transcriber of history for a "vanished Beale Street". These led him to find the Jewish element of Memphis "history" and thus discover the buried history of the Pinch (141). Stern reported that the Pinch became a place where his stories, "which had been searching for somewhere to belong; could occur (142). Thus, by being inspired by the Pinch and placing so many of his stories in the fantastical realm of history and myth, he lifts the forgotten ghetto into the peripherals of modern society and has shown that there is more to Memphis than was ever represented.

Stern has a novel called *The Pinch*, which is directly related to the Pinch neighborhood in Memphis. It would seem almost impossible to write a story concerning Memphis and not delve into the racial issues that are so

well known in the city's history. Stern makes no exception with this novel. He uses the history of Memphis and the mythological occurrences in the story to explore racial issues from a perspective unheard of when it comes to the color lines of Memphis: the Jewish perspective. Stern notes that he has "always conceived parallels between the black and the Jewish experience", a perspective that he has often revisited in his works (Kissileff).

*The Pinch* thus serves as a new form of racial narrative for Memphis. It contributes to the racial history of the city and how its most dark days send ripples across all circles of life. This can be seen as Lenny reflects on what he had learned from reading "The Pinch" and his lack of action in the present as he is too preoccupied with the past. He states, "... who cowers in a shop nursing his nebbish ego when history is calling just outside the door? Stop already... and join the struggle for justice and inequality..." (*The Pinch*). Lenny, whose past relates him to the Jewish denizens of the Pinch, co-existed with the African American populace of Memphis. He eventually musters the courage to speak up and defend individuals who look different from him against the same power that aims to eradicate anything that is not white or Christian.

*The Frozen Rabbi* also takes place in Memphis. Set within the average assimilated Jewish family whose only quirks are those that are used to initiate the plot, the novel brings yet another rare perspective to the idea of Memphis that is not entrenched in race. Rather, Stern focuses on the issues of faith, secularism, and redemption that are universal and that intertwine Memphis issues of faith and becoming something from nothing ("The Frozen Rabbi").

Stern's story *Isaac and the Undertaker's Daughter* was heavily influenced by Stern's research and memories of the area. While the stories are not all set in the Pinch like the stories from his book, *Lazar Malkin Enters Heaven*, this novel is undoubtedly the bizarre culmination of the stories Stern encountered since it was published in 1983 while the latter was published in 1986. Along with this, *Isaac and the Undertaker's Daughter* has such wacky elements that the surrounding mythology of Memphis can be warped into even further grandeur. Memphis is a city with its own mythology, ranging from tales of ghosts inhabiting Overton Park and the Memphis Fairgrounds to beliefs that Elvis is still living in Graceland. There is the almost tangible ghost of Martin Luther King, Jr. still hanging around the city (who may not be an actual ghost but still haunts Memphis, and the country for that matter, with his death). It is no stretch of the imagination that Memphis is a city contrived in a rich history of specters and hoodoo practices ("Urban Legends of Memphis"). With Stern's disregard for the possible in *Isaac and the Undertaker's Daughter*, the book creates a new realm for Memphis mythology to expand and tell new ghostly stories with a unique medium that include the Angel of Death whisking away

eligible bachelorettes in "Aaron Makes A Match", fathers returning from the dead to wrestle with their sons in "Rudolph Finkl's Apprenticeship", and versions of 'self' coming from the future to aid in troubling times in "Bruno's Metamorphosis" to name a few examples.

In a broader sense, Stern's contributions can be simply summarized to that of choosing to write about an undervalued part of Memphis. While writers are often urged to write from what they know, to create something considered original means branching away from what is known into the realm of imagination, and create a work in the real world rather than the fictitious one. Many writers are keener to choose the fictitious so that facts pertaining to a location's history cannot be challenged and the laws of the fictional world are of their own making. Stern had been "writing fiction for nearly a decade" before discovering the Pinch, in which he had all the time in the world to write about the blatant themes of Memphis (Royal, 141). However, Stern finds the Pinch and chooses to write about the stories he finds there. Stern could have focused on creating historical texts that unearthed the forgotten neighborhood, but instead chooses to create a new world for Memphians and outsiders alike, bringing everyone back to the place where the stories all began. As Stern has said "it's only natural that some of the narratives dovetail, causing characters who appear in one story to reappear in another." It is then only natural that outsiders who explore the Pinch eventually begin to explore the entirety of Memphis (Kissileff).

And in perhaps the most perplexing method of all, Stern adds to the idea of Memphis as a text by not focusing on Memphis. As paradoxical as it sounds, one of Stern's greatest contributions to the idea of Memphis (past bringing the Pinch back to life) is not focusing his works upon the expected themes that Memphis provides. His works from the Pinch are a "self-enclosed world that has only the barest contact with any larger town", a new perspective that revitalizes what exactly it means to tell a story within Memphis (Dickstein). His stories are unfamiliar and do not scream Memphis in the slightest, but this is how the works aid to reformat the image of Memphis itself and paint a new backdrop for the city to add to its rolling screen of settings. These can be seen in the lack of depictions of blues music, barbeque, or social struggles of Bernie Karp in *The Frozen Rabbi* as he focuses upon a wholly uninteresting teenager rather than a struggling youth who must fight to survive like many other bildungsroman Memphis narratives. His subjects are of a different variety than that of most texts about Memphis,. Stern does not dive into the tried-and-true issues of Memphis and how the city's culture affects his characters, but rather into fantastical situations that force his characters to act in order to reach universal applications regarding the human condition.

The delineation from fact to fiction allows Memphis to be seen in a new way. It also shows other Memphis writers that stories pertaining to Memphis do not have to follow the standard formula so present in Memphian literature.

## PROFESSIONAL REVIEW

Memphis is a city known for its music, its food, and its colorful history. As such, when considering the Memphis canon, it would only be natural to include works that concerned Beale Street, Hurt Village, Elvis, Three 6 Mafia, B.B King, Martin Luther King, Jr., and the Civil Rights Movement. However, the task is to create the whole picture, and while these topics take up a large portion of the canvas that is the Memphis canon, Stern's works colorfully and imaginatively fill in patches to create a fuller picture. Thus, Steve Stern and his works should be included in the Memphis canon due to not only filling in these blank spots, but also for enhancing the Memphis canon with his enamoring writing style.

Stern's writing style is as enthralling as it is humorous, and thus further enhances what can be expected when studying predominant writing styles of Memphis. Verbose and lavish with his descriptions, it is said that "there's nothing Stern can't imagine...the prose can be breathtaking...and above all, Stern is so funny". Stern considers himself "a comic writer" whose intention is to entertain with his stories (Fishman; Kissileff). One such comedic moment can be seen in *The Pinch* when Lenny exclaims that he is a character within a book, to which his boss replies, "this is news?" to antagonize him. Such comedic moments can be found in *The Frozen Rabbi* when Bernie, while searching for a piece of meat to pleasure himself, stumbles upon the frozen rabbi in a bizarrely humorous discovery. This results in a comedic discussion between the family at dinner in which Bernie's father must explain the frozen rabbi as a "keepsake." Stern possesses an "arresting style, which veers between the poetic compression of a Malamud and the vulgar exuberance of a Stanley Elkin," belonging more to the literature of fantasy and horror as he sweeps readers away to his crafted land of fantasy (Dickstein). Adding Stern to the Memphis canon could attest to the influences of Memphis in creating mesmerizing works like *Isaac and the Undertaker's Daughter*, which allow Memphis literature to be known as funny as well as serious.

Secondly, adding Stern's works to the Memphis canon would expand upon the dominating perspectives of Memphis and introduce a new element of fiction while adding new methods in which the human condition can be explored. In the ethical sense, Stern "punishes his characters for their gratuitous cruelty and moral weaknesses," which should satisfy any qualms worrisome readers may have regarding the moral implications of Stern's

work since evil is punished (Dickstein). In *The Frozen Rabbi*, Stern explores “how tragically easy it is, after one generation, to forget the struggles of your forebears, if you ever know about them at all” and the power of faith to transform lowly nobodies into noble somebodies. This is not a new and groundbreaking narrative for literature, but the backdrop where “the Torah trumps the King James Bible” creates a new lens to view the maturation of adolescence through the Jewish lens (Marcus, “The Rebbe of Graceland”; NPR, “A ‘Pinch’ of Magic”).

In the exploration of sociopolitical issues in *The Pinch*, Stern primarily focuses on the (sometimes immigrant) experiences of survival, growth, and the effects of the Jewish culture—things that people do not speak of in the South. Stern does not focus upon the civil war and enslavement but instead focuses upon escapes from Siberian gulags and surviving a supernaturally rendered earthquake and flood that halt the passage of time and death. He focuses on the tangible culture of poverty that surrounds Lenny Sklarew as he lives in Memphis, and how his current reality is shadowed by Muni Pinsker's immigration from Siberia to his accounts of the supernatural events of the Pinch after the neighborhood is stuck in time. But this is a clever method of illusion, tricking readers "into thinking we can relax now and then and leave behind a world of garbage strikes, the Tet Offensive, and the impending assassination of Martin Luther King, Jr.," which comes to slap readers back into reality with the undeniable implications that history has on us all and that no amount of whimsy can escape (NPR). Stern's work serves to remind us that, even in the face of impending change, the most important thing we can do is to live our lives as we choose and to not expect our lives to be written out before us. We must write the narrative ourselves; a powerful message for any reader when reading about Memphis.

Finally, Stern's works should be added to the Memphis canon because he is directly influenced by the real location and history of the Pinch and brings that neglected part of Memphis' history to life, thus expanding upon the idea of Memphis. Not every text about Memphis should be added to its canon, but to refute the Pinch's significance to Memphis would be inaccurate and unjust. The Pinch "served as Memphis' first commercial area", a home to Memphis' earliest immigrant communities, and was "the thriving center of Memphis' Jewish community" that contained real people who interacted and helped shape the culture of Memphis (Nickas). To not include this vital part of Memphis' history would be to give in to the White Anglo-Saxon Protestant narratives that limit our society to exposure of any culture they deem beneath them. Memphis, a city bathed in a bloody history of fighting for change and for the right to be heard and respected, should reject the erasure of its Jewish

narratives from the public sphere and work to actively include them in literary histories and anthologies focused on Memphis writers and writing.

## CONCLUSION

The Memphis canon is in dire need of reexamining what texts it considers to be important to the idea of Memphis as a text. In total, the canon should include works that tell the full story of Memphis, not just its most well known parts. Steve Stern and his works are perfect for beginning to fill in overlooked aspects of Memphis and should be added to the canon. Stern's writing is just one example of important literature that adds a more complete picture and presents the history of the Jewish contributions to Memphis as significant and ongoing.

Stern combines the mythology of Judaism with the familiar aspects of the Southern culture to create his works, revitalizing the existence of the Pinch and the history of Memphis as he brings attention to its hidden past. With his works, which focus on absurdity, morality, and the human condition rather than the well-known idea of Memphis itself, Stern contributes to the idea of Memphis as a text by bringing the ghost stories of the Pinch back to life, enhancing the mythical nature of the city to include a new perspective of the fantastic, giving the city a more complete picture for its history. In the thousand-piece puzzle that is Memphis' history and culture, Stern's works are one overlooked yet vital piece that helps to tie the puzzle together.





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Madison's paper recieved a *QuaesitUM* outstanding paper award.

Madison McMahon

Pietro Cavallini and Mosaics in Duecento Rome: Blending  
the Italo-Byzantine with the Classical

Faculty Sponsor

Dr. Rebecca Howard



## Abstract

In Italy during the Duecento, a group of mosaicists living and working in Rome were influenced by social, political, and religious events, trade and immigration, and the expanding wealth of knowledge throughout Italy. These artists were commissioned to work on many of the same projects around the city. Pietro Cavallini is one of the lesser-known and researched among these Roman mosaicists. New to the medium of mosaics, he received few commissions despite being an accomplished painter, having completed works throughout the city. This paper explores Cavallini's first mosaic commission, a six-panel cycle depicting scenes from the Life of the Virgin Mary, located in Santa Maria in Trastevere. By studying Duecento mosaic processes and analyzing Cavallini's works, this essay determines that Pietro Cavallini was a revolutionary artist who boldly broke away from the dominant Italo-Byzantine style and is responsible for initiating important contributions to the art of Renaissance Italy.

## Introduction

Mosaic art is a creative tradition that has spanned the centuries. From the timeless, tiled floors of ancient Roman palaces to the vibrant, patterned walls of Islamic architecture all the way up to the do-it-yourself garden pavers in many backyards today, mosaics have been an integral and lasting artform in cultures all over the world. Popular examples are the geometric patterned floors and walls of ancient Mediterranean civilizations and the shining, golden expanses of the Byzantine empire's grand architecture and churches, but mosaics are also found in the floors of Mesoamerican temples and variations have been seen on the walls of ancient Egyptian tombs. This medium is unique in its durability. They can be damaged or removed but if left intact, these works remain unaffected by time. Because of the materials used to fabricate mosaic artwork, their colors are unaltered from the day the pieces are installed.

Some of the most remarkable examples of works in this medium are located within churches. In this context, these works serve to transform the architecture and sanctuary into a location that is symbolic of the heavenly realm. This medium has an exceptional ability to transform a space through the use of light, reflection and surface texture. Fresco and painting have an important and recognizable part to play in the decoration of three-dimensional spaces, yet through the use of mosaics the artist can alter the flat plane of a wall in order to create a glowing dimension capable of reflecting light.

During the Duecento in Italy, a handful of artists were known to have been commissioned to create mosaic works for important churches throughout the city of Rome and to have continued this art practice throughout the entire Italian peninsula. This paper will explore the life, works and style of one artist in particular: Pietro Cavallini. This artist's most notable mosaic work is a six-panel cycle, in which is depicted various scenes from the life of the Virgin Mary. This paper will examine the production of mosaic artworks, identify the influences for figural representation and iconographical elements in Pietro Cavallini's works and suggest the important stylistic contributions of this artist's career on the art world of Rome during the Duecento in Italy through the analysis of several panels from the Life of the Virgin cycle.

Pietro Cavallini was a Roman painter and mosaicist.<sup>1</sup> His birth date is not definitively known to us. However, some scholars place it at some point in the 1240's.<sup>2</sup> He belonged to the Roman school of artists and worked at the same time as contemporaries: Filippo Ruscuti and Jacopo Torriti.

1 Julian Gardner, "Pietro Cavallini," *The Burlington Magazine* 122, no. 925 (1980): 255.

2 *Ibid.*, 256.



He also probably had some contact with Giotto and was likely a source of training and inspiration for the young artist.<sup>3</sup> A contemporary document has revealed to scholars that Cavallini worked for Charles II in Naples in 1308.<sup>4</sup> Documentation by Lorenzo Ghiberti from travels to Rome at the end of the fourteenth century attributes numerous works throughout the city to Cavallini.<sup>5</sup> That list of works includes the six panels depicting the Life of the Virgin, as well as, the exterior façade mosaics of St. Paul's Outside the Walls<sup>6</sup>. Evidence for the work done at St. Paul's is scarce and as such this paper will focus primarily on the Life of the Virgin cycle.

## Embracing a New Aesthetic

Towards the end of the Duecento, and moving into the Trecento, a stylistic shift was occurring within Italian art. A world that had been dominated by the Italo-Byzantine Style was slowly embracing a newer aesthetic approach centered around naturalism. The opulent gold and ornate patterning brought and shared by Byzantine artists had begun to decline in its popularity as artists and patrons alike turned their gaze back in time to the glory days of their own surroundings: Ancient Rome and the Classical sculptures and architecture that populated the very city they walked every day.

This shift in the arts of Rome was occurring simultaneously with a tumultuous migration of political power. The movement of the papacy to Avignon from Rome coincided with a dispersal of artists from Rome to other regions of the Italian peninsula. During this period artists, including Cavallini, left Rome for work in other cities such as Florence, Venice and Naples. There is evidence to suggest that Cavallini also took work alongside Giotto, Torriti and Ruscuti at San Francesco in Assisi<sup>7</sup>. When the papal court left Rome there was a significant, if not complete, decline in mosaic commissions throughout the city<sup>8</sup>. This cessation of work occurred immediately following a period of increased frequency in commissions. The year 1300 was the inaugural Jubilee Year established by Pope Boniface VIII<sup>9</sup>. This event indicated a year long heightened revival of the faith and meant that thousands

3 Stanley Lothrop, "Pietro Cavallini," *Memoirs of the American Academy in Rome* 2 (1918): 78-79.

4 *Ibid.*, 79.

5 *Ibid.*

6 *Ibid.*

7 Carol Ann Hydes, *Italian Mosaic Art 1270-1529* (Sussex: University of Sussex Press, 2017), 86.

8 *Ibid.*

9 Paul Hetherington, "Pietro Cavallini, Artistic Style and Patronage in Late Medieval Rome," *The Burlington Magazine* 114, no. 826 (1972): 7.

and thousands of pilgrims would be traveling through Rome during this time. The work that will be analyzed later in this paper was begun c.1291 and was part of a city-wide explosion of commissions in preparation for this large ecclesiastical affair.

## Mosaics: History, Practice and Use in the Duecento

Before launching into the detailed analysis of the Life of the Virgin cycle, an explanation of mosaic materials and installation processes will provide a fuller understanding of the practice during this period. Since antiquity countless materials have been used to create mosaics: shells, stone, semi-precious stones, pebbles, marbles, ceramics, glass and so on. Early examples of a style of cut glass known as tesserae began to be used by artists sometime around 260 BC<sup>10</sup>.

Tesserae are small cube shaped pieces of glass cut individually by hand. The process of producing tesserae and in turn mosaics, was extremely costly. It has been proposed that the cost of a single mosaic would have been four times as expensive as a fresco by the end of the late Middle Ages<sup>11</sup>. By the Duecento, Italian artists had established glass making and mosaic workshops. The process begins with raw materials like sand, plant matter and minerals. Sometimes local sand could be used but as the techniques evolved better quality sands with less natural impurities were desired. Sand from the delta of the River Nestore or the west coast of Sicily and even imported sand from the Levant were considered the highest quality and had the least amount of impurities<sup>12</sup>. Eventually some artists even turned to finely ground quartz powder<sup>13</sup>. This lack of impurities aided in reducing bubbles and striations in the finished glass.

The two most important basic ingredients in glass were silica and an alkali. Silica was derived from the raw sand. Alkalis were produced by repeatedly burning plant-based materials to produce ash with as few impurities as possible. In Italy, local ferns and a plant called *Salsola kali* became popular choices for alkali production. *Salsola kali* was often imported from the Levant along with high quality sands because it produced a purer alkali<sup>14</sup>. Silica and alkalis were frequently mixed with cullet, broken waste glass and discarded

10 Irene Rousseau, "Mosaic Art: From Pebbles to Pixels," Docslib, accessed December 6, 2022. <https://docslib.org/doc/13250717/mosaic-art-from-pebbles-to-pixels>.

11 Hydes, *Italian Mosaic Art*, 53.

12 *Ibid.*, 36.

13 *Ibid.*

14 *Ibid.*, 39.

tesserae, to encourage the materials to fuse together<sup>15</sup>. Once the glass was melted it would be blown into spheres to form one millimeter thick sheets called cartellina or poured flat to create filati which could then be cut to produce the small tesserae.

Prior to the late fifteenth century, a very limited color palette was used for mosaics due to the inconsistencies in colors that could be made by unreliable chemical processes. It was much easier for artists to form metallic tesserae. Therefore, until this point in history most mosaics are dominated by gold. The process for creating gold tesserae was entirely mechanic so a greater control over the consistency of color could be achieved. Gold leaf was layered between two cartellina until three sheets of glass and two sheets of gold had been attached with a binder, often egg white, and was then fused together in a furnace and slowly cooled<sup>16</sup>. The pieces were then trimmed with an iron tool that was heated and applied to surface to create a small crack that would be manipulated to force a controlled breakage<sup>17</sup>. Millions of tesserae were needed for most mosaic artworks and a process as painstaking and involved as individually hand making glass pieces one square centimeter at a time was a laborious, slow and extremely expensive process.

Once the millions of tesserae were fabricated the process of placing them began. A master would layout a cartoon of the final work, called sinopia, and lesser skilled artists and apprentices would be doing the painstaking process of placing each small piece, one at a time. Plaster was used to bind the tesserae to the wall and large nails would be driven through the surface to help support the immense weight of the millions of pieces of glass<sup>18</sup>. Mosaicists would individually tap each tesserae into two or three layers of plaster and then make sure that the plaster was level with the top most surface of each piece, wiping away any excess and cleaning the surface as they worked<sup>19</sup>.

As the artists worked the choice of the spacing for each piece and angle of the inset must have been decided upon. The choice of spacing and angles in mosaic work are indicators of the periods in which they were made. At the end of the Duecento, mosaicists seem to have preferred to set the tesserae at an angle, rather than parallel to the plaster, which allowed light to reflect off the pieces in many directions and also to place the pieces extremely close together, almost to the point that no plaster could be seen at all. This spacing

15 Ibid.

16 Ibid, 50.

17 Ibid.

18 Ibid, 51.

19 Ibid.

created a crisp and legible image even from a distance, as such would be the view experienced by a lay person sitting at the far end of a nave. These choices in spacing and setting angles are the case for the Life of the Virgin cycle by Cavallini.

### The Life of the Virgin Cycle: A Deliberate Mix of Styles

Though Cavallini's choice of mosaic application was consistent with popular contemporary preferences, I would argue that much of the artist's stylistic choices show a deliberate separation from the previous route taken by artists in this period. Little has been published about Cavallini in his capacity as a mosaicist and of the current scholarship there is only one popular understanding of the artist's style that dominates the recent literature. Many scholars take the stance that Cavallini was a lesser talented artist that often held steadfast to Byzantine influences which resulted in his apparent lack of commissions during his career<sup>20</sup>.

Several arguments have been provided as to why this position is so often favored. Paul Hetherington suggested that much of Cavallini's iconography was borrowed solely from contemporary Byzantine art<sup>21</sup>. Stanley Lorthrop argues that the Virgin in many scenes "preserves the majestic type peculiar to Byzantine mosaics" and that the arrangement of some scenes, most notably the Dormition panel, "strictly maintained" the Byzantine style<sup>22</sup>. Hetherington also stated that "Cavallini clearly rejected the archaizing tastes of both his contemporary fellow artists and of the patrons who could have provided him with more prominent and lucrative commissions."<sup>23</sup>

However, in a compiled listing of works by Cavallini there are more than one hundred and sixty pieces attributed to the artist<sup>24</sup>. This listing clearly demonstrates that Cavallini received many commissions and was not lacking in work. The issue is that many of these artworks are "no longer extant, in bad condition, or have been credited to other artists"<sup>25</sup>. In an article by Catherine Fleck, she suggests that writings of early scholars and the condition of most

20 Gardner, "Pietro Cavallini," 256.

21 Hetherington, "Pietro Cavallini, Artistic Style and Patronage in Late Medieval Rome," 9.

22 Lothrop, "Pietro Cavallini," 81.

23 Hetherington, "Pietro Cavallini, Artistic Style and Patronage in Late Medieval Rome," 9.

24 Gardner, "Pietro Cavallini," 256.

25 Cathleen A. Fleck, "The Rise of the Court Artist: Cavallini and Giotto in Fourteenth-Century Naples," in *Art and Architecture in Naples, 1266-1713*, ed. Cordelia Warr and Janis Elliott (Hoboken, NJ: Wiley-Blackwell, 2010), 38-61.



Figure 1: The Birth of the Virgin



Figure 2: The Annunciation



Figure 3: The Nativity



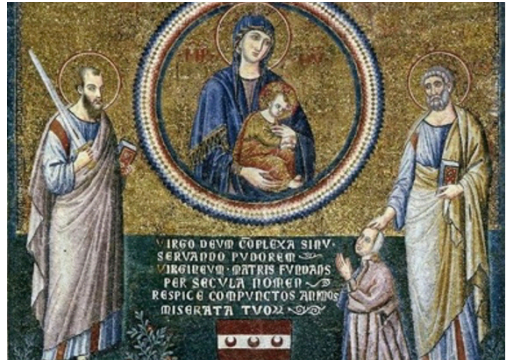
Figure 4: The Adoration of the Magi



Figure 5: The Presentation in the Temple



**Figure 6:** The Dormition



**Figure 7:** Madonna and Christ Donor Panel

of Cavallini's attributed artworks led modern scholars not to pursue the artist as a great master<sup>26</sup>. However, in the first half of the twentieth century a renewed interest in scholarship surrounding Cavallini elevated his standing among artists of the Duecento and Trecento in Italy. It still remains an issue today that few of his works in mosaic have been analyzed on the basis of their stylistic qualities and thus the remainder of this paper will focus on just that.

The Life of the Virgin cycle is located in Santa Maria in Trastevere, a church dedicated to the Virgin Mary in a neighborhood in Rome. The panels were commissioned at the behest of Bertoldo Stefaneschi, a brother of Cardinal Jacopo Stefaneschi<sup>27</sup>. Bertoldo Stefaneschi donated the money for the installation of the mosaics in the early 1290's, possibly for the upcoming Jubilee Year set for 1300. The date often attributed to and most widely accepted for the cycle is 1291.

There are six panels in the cycle along with a donor panel located below the main register, each accompanied by three lines of text. These text below each image are verses of poetry pertaining to the scene above written by Cardinal Jacopo Stefaneschi for Bertoldo to have included in the cycle<sup>28</sup>. The scenes included in the cycle are: the Birth of the Virgin, the Annunciation, the Nativity, the Adoration of the Magi, the Presentation in the Temple, and the Dormition. The panels are located in a thick register immediately below the

26 Cathleen A. Fleck, "The Rise of the Court Artist: Cavallini and Giotto in Fourteenth-Century Naples," *Art History* 31, no. 4 (2008): 460-464.

27 Gertrude M. Young, "Notes on Pietro Cavallini," *The Brooklyn Museum Quarterly* 10, no. 4 (1923): 173-76.

28 Paul Hetherington, "The Mosaics of Pietro Cavallini in Santa Maria in Trastevere," *Journal of the Warburg and Courtauld Institutes* 33, no. 1 (1970): 90.

main apse decoration depicting a scene of the Virgin and Christ enthroned in heaven that dates to the original construction of the church in the early twelfth century. Overall, the cycle is dominated by a large usage of gold tesserae. The background of each image, halos of each saint or Holy figure, and many patches of decoration on clothing and buildings throughout are colored solely by shimmering gold. The entire cycle is aesthetically cohesive, in that, Cavallini chose to employ a similar color palette and compositional layout for each panel. The color palette consists of gold, similar shades of blue and green, red, black and white with a very limited usage of pale yellows and what appears from images to be lavender.

The composition of every work contains a centrally located focal point with the remainder of the space filled by balanced figures and architectural forms, as seen in the Dormition, or left entirely empty, as seen in the Annunciation. Scenes of the Annunciation are extremely recognizable images whose subject matter is widely understood. This is the moment Gabriel announces to Mary that she has been chosen to become the Mother of God. Because of the familiarity with this scene and its subject matter, it will be useful to analyze in order to examine Cavallini's style and influences. The figures of both the Virgin and Gabriel are weighty and full. There is a heavy presence to their bodily forms. The drapery of the figures also conforms to the bodies in a manner informative of the anatomy beneath. The highlight on Gabriel's back side clearly reveals the indication of a torso attached to a muscular thigh that ends at a bent knee on his left side.

Both of the Virgin's knees protrude into space, delineated by large, wide patches of gold at each joint. It may even be observed that, strange as it is considering the Virgin has not yet conceived, there is a full, round, and pregnant belly beneath Mary's garment. The Virgin sits upon a wide, golden throne backed by an architectural structure decorated in a handful of locations with geometric patterns. The throne is depicted in three dimensions though not definitively accurate. Gabriel has beautiful red and green feathered wings and is shown with his left arm outstretched towards the Virgin. The figures rest on a blue-green rocky ground decorated with a smattering of vegetation. Mary is shown seated next to a vase of lilies and what has been interpreted as a bowl of figs<sup>29</sup>.

The second and final image to be closely analyzed here is the Dormition. The Virgin, at the end of her life, sleeps on an ornate, gold bed covered by decorated fabrics. Her head rests on a red cushion and her arms are folded on

29 Livio Pestilli, "Ficus Latine A Fecunditate Vocatur': On A Unique Iconographic Detail in Cavallini's 'Annunciation' in Santa Maria in Trastevere," Source: Notes in the History of Art 20, no. 3 (2001): 5-14.

top of her waist. She is surrounded by a crowd of mourners that contains some of the apostles and various ecclesiastical figures. Above the bed, the figure of Christ, in an orange and red mandorla, flanked by two angels, carries His mother's spirit up to the heavenly realm. The apostles and church officials are in plain, toga style drapery with a few gold accents. The bishops and Saint Peter wear sashes decorated by crosses. The ground is the same blue-green ambiguous, possibly rocky, surface. The background is a wide flat expanse of gold.

The driving impetus for the idea that these works belong within the Italo-Byzantine style is the vast, otherworldly gold backgrounds and the style of dress and patterning used throughout the pieces. To this, I suggest that these stylistic choices made by Cavallini were rather an attempt to unify his newer works with the previously existing decoration that surrounded this cycle from one hundred and sixty years prior. The Italo-Byzantine style flourished throughout Italy in the late medieval period, the same time the construction and original decoration of Santa Maria in Trastevere was begun. Apart from the excessive use of gold and a somewhat frequent application of pattern these works do not overtly bare any further link to the Italo-Byzantine style.

A possible explanation for the amount of gold used is that, as was discussed earlier, gold tesserae were a far more consistent and cost-effective material to produce in this period which would have aided in offsetting the cost of the already exorbitant price of a mosaic installation. Cavallini also appears to have desired to create a cohesive narrative between his own works and those that were already present in the apse, whether of this own accord or on behalf of the patron. The subject matter of the cycle as a whole fits flawlessly into the decoration of a church previously dedicated to the Virgin. The scenes, read from left to right, ending at the dormition lead the viewer across the apse and finally into the conch mosaic above of the Virgin and Christ enthroned.

This last panel in Cavallini's cycle is in direct conversation with the main apse mosaic and a contemporary viewer would have understood that Christ was carrying His mother, body and soul, into heaven to reign as Queen, which is then depicted immediately above. The patterning employed throughout the works is drastically limited compared to contemporary Italo-Byzantine works. Most figures, while displaying some minor gold ornamentation, are clothed in relatively plain garments. The most elaborate patterns are confined to small sections of architecture. There is a genuine attempt at accurately depicting a realistic three-dimensional space. As this work is quite some time before Brunelleschi developed linear perspective, it is on par or even more



advanced than contemporary efforts to show depth within works.

Turning to the depiction of figures themselves, the elongated willowy figures of the Italo-Byzantine style are nowhere to be seen. Cavallini has presented weighty and, for the most part, anatomically correct bodies with a truly voluminous presence. Their feet are firmly placed upon the ground, rather than pointed downward and giving the appearance of hovering over the earth. In the Annunciation, Gabriel's left foot is flexed into a position in which his big toe is pushing off the ground so as to force himself forward in space, creating a realistic sense of movement towards the Virgin. One further unique element of these panels that indicates Cavallini's revolutionary artistic practices is the presence of a signature. He is one of the first few artists to have taken credit for their works. This detail can no longer be seen today after some damage and various restoration but was included in a copy made in 1640<sup>30</sup>.

## Conclusion

Pietro Cavallini was a truly innovative artist who may not have received many major commissions throughout the course of his career. However, it is clear that through more detailed analyses of his works, scholars can come to appreciate this artist for his unique and groundbreaking turn away from the Italo-Byzantine style. This monumental shift towards naturalism, so often associated with Giotto and later artists, owes its humble beginnings to artists such as Cavallini. Elements of the artworks examined here can be identified in Giotto's later works and mature style which he likely was exposed to by Cavallini as young artist. There is much research to continue to be conducted in regard to Pietro Cavallini and it begins with the recognition that this artist was instrumental in laying the groundwork for a full separation from the Italo-Byzantine style, opening the doors for the rise of naturalism and the return to Classical works so loved by future renaissance artists and patrons alike.

30 Young, "Notes on Pietro Cavallini," 176.

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"We are only insisting upon truth and justice for the Southern Confederacy": The United Daughters of the Confederacy, fabricated memory, and lost cause education

Faculty Sponsor

Dr. Michele Coffey



## Abstract

This article analyzes the United Daughters of the Confederacy, a neo-confederate women's organization, and their efforts to vindicate the Confederacy with organized, united action. The Daughters attempted to popularize a revisionist historical mythology called the Lost Cause in order to maintain white supremacy. They accomplished this by engaging in extensive commemoration and monument construction. However, they were particularly impactful instilling their narratives of the Confederacy through their founding the Children of the Confederacy and monitoring school textbooks, fighting to remove any book which they deemed biased or unfair to the former Confederacy.

## Introduction

The United Daughters of the Confederacy is a neo-Confederate women's organization which became a powerful organization in the battle to memorialize and vindicate the Confederacy in order to maintain white supremacy. The UDC sought to rewrite the historical narrative of the Confederacy and what it stood for through organized, united action. UDC members particularly focused on children and public education in the form of textbook campaigns, fighting to remove any book which they deemed biased or unfair to the former Confederacy.

If we are at times apparently contentious," spoke UDC president Rassie White at the 1913 Annual Convention, "we are only insisting upon truth and justice for the Southern Confederacy, for the South, for our noble men, for truth, that we have in the different States UDC text-book committees to see that unbiased histories and unprejudiced readers are used in Southern schools.<sup>1</sup>

By memorializing the Confederacy, the UDC attempted to popularize a revisionist historical mythology called the Lost Cause. The central tenets of the Lost Cause held that the War was fought not to defend slavery, but out of noble love for their homeland. This ideology also erases the brutal legacy of slavery, instead presenting a false picture of an idyllic plantation with kind masters and faithful slaves. This allowed proponents of the Lost Cause to blame racial problems on emancipation and thus call for a return to white supremacy to restore the falsified glory of the Old South. Though the Lost Cause took on many local and regional interpretations to best suit a particular place's needs, one feature remains constant: it is untrue. The Lost Cause was a fabrication intended to promote white supremacy. Historian Adam H. Domby attributes the strength of the Lost Cause to its powerful 'combination of purposeful lying, unquestionably accepting tales that fit into an expected or useful framework, and unknowingly spreading falsehoods.'<sup>2</sup>

An important feature of the Lost Cause is its erasure of anyone who did not fit its idyllic portrayal of the Old South. The mythology focuses on elite whites as its main characters, backed by a supporting cast of loyal slaves. Its white men are all noble and authoritative, and its women are all beautiful and subservient. The Lost Cause has no need for poor whites or

1 United Daughters of the Confederacy, Minutes of the Twentieth Annual Convention (Raleigh: Edwards and Broughton Printing Company, 1914), 17.

2 Adam H. Domby, *The False Cause: Fraud, Fabrication, and White Supremacy in Confederate Memory* (Charlottesville: University of Virginia Press, 2020), 16.



free African Americans because they present a challenge to its main purpose of glorifying white supremacy and patriarchal hierarchy.<sup>3</sup> They do not fit neatly into the imagery of an entirely unified region, all supporting a war fought for these principles. Thus, when the Daughters refer to the South, they solely mean the elite white class. Similarly, their references to the North often simply mean anyone who opposed their pro-Confederate rhetoric, regardless of geographic location. The Lost Cause was built on valorizing Confederate soldiers and making them martyrs for a noble cause, and to do this, proponents needed a monolithic enemy who opposed its brave heroes.

The Daughters' Lost Cause activities were seen as part of their duty to what historian Karen Cox has termed "confederate motherhood." Similar to republican motherhood, this duty endows women with the responsibility of training their children to be good citizens. It is because of this duty that the Daughters focused so heavily on teaching southern children about the history of the region and gave them such an important place in Lost Cause ceremonies. Cox has also posited that, unlike republican motherhood, Confederate motherhood was primarily motivated by fear:

fear that textbooks with a northern bias had already accomplished irreparable damage, fear that their ancestors might not be vindicated, and fear that future generations of white southerners may never know the sacrifices made by their Confederate ancestors.<sup>4</sup>

Thus, their education efforts were an attempt to be sure that their ancestors' legacies would not die out with their generation.

Most historians of the UDC have primarily dedicated attention to their monument building efforts. Caroline E. Janney's *Burying the Dead but Not the Past: Ladies' Memorial Associations and the Lost Cause* (2008) and William A. Blair's *Cities of the Dead: Contesting the Memory of the Civil War in the South, 1865-1914* (2004) examine the UDC's origins in Ladies' Memorial Associations, which were formed in order to honor the Confederate dead.<sup>5</sup> These associations set the precedent for public involvement for women's groups and inspired the UDC to use monuments as a method for Confed-

3 Ibid., 65

4 Karen L. Cox, *Dixie's Daughters: The United Daughters of the Confederacy and the Preservation of Confederate Culture* (Gainesville: University of Florida Press, 2003), 123.

5 Caroline E. Janney, *Burying the Dead but Not the Past: Ladies' Memorial Associations and the Lost Cause* (Chapel Hill: The University of North Carolina Press), William A. Blair, *Cities of the Dead: Contesting the Memory of the Civil War in the South, 1865-1914* (Chapel Hill: University of North Carolina Press, 2004).

erate vindication. Adam H. Domby's *The False Cause: Fraud, Fabrication, and White Supremacy in Confederate Memory* (2020) analyzes the political motivations behind the UDC's commemoration efforts, but this analysis is largely limited to their monuments.<sup>6</sup>

Similarly, many historians who study Lost Cause education have primarily studied men's organizations, such as the Sons of Confederate Veterans. James McPherson's "Long-Legged Yankee Lies: the Southern textbook crusade" (2004) discusses organized efforts to ensure schools were teaching pro-Confederate material but does not examine the UDC's textbook crusades.<sup>7</sup> Karen Cox's *Dixie's Daughters: The United Daughters of the Confederacy and the Preservation of Confederate Culture* (2003) is one of the few works which analyzes the UDC's emphasis on children and education, though monument building continues to be the primary focus.<sup>8</sup> Combining both fields of study to analyze the UDC's education campaigns in the context of the broader Lost Cause education crusade reveals that the UDC played a crucial role in training children to uphold the Lost Cause.

## Origins and Early Work

The United Daughters of the Confederacy emerged as an official organization in 1894. The organization's official aims were

educational, memorial, literary, social, and benevolent; to collect and preserve the material for a truthful history of the war between the Confederate States and the United States of America; to honor the memory of those who served and those who fell in the service of the Confederate States, and to record the part taken by Southern women, as well, in untiring effort after the war in the reconstruction of the South, as in patient endurance of hardship and patriotic devotion during the struggle; to cherish ties of friendship among the members of the society, and to fulfill the duties of sacred charity to the survivors of the war and those dependent upon them.<sup>9</sup>

Though there had been previous women's organizations dedicated to restoring the glory of the Old South, the UDC added a new dimension to

6 Domby, *The False Cause*,

7 James McPherson, "Long-Legged Yankee Lies: the Southern textbook crusade," in *The Memory of the Civil War in American Culture* ed. Alice Fahs and Joan Waugh (Chapel Hill: University of North Carolina Press, 2004),

8 Cox, *Dixie's Daughters*.

9 United Daughters of the Confederacy, *Minutes of the Fourth Annual Meeting* (Nashville: Print of Foster and Webb, 1898), 51.

the Lost Cause. Instead of just memorializing those who died in the War, the Daughters wanted to vindicate them. As shown in their official goals, the desire to control the narrative of history played a significant role in the UDC. This was, in part, due to the end of Reconstruction. Without federal troops there to suppress it, the Lost Cause was free to publicly take hold.

Another cause for this shift toward vindication was the changing demographics of these organizations. As the war became more and more distant, some members did not have firsthand connections to it as the founders. Thus, their mission became less about memorializing the individual dead and more about promoting the Confederate way of life as a whole. The Old South envisioned by many of the Daughters was an idealized mythology in which they, as elite whites, were still in total control. According to historian Karen Cox, the Lost Cause promoted “a version of the southern past based on a belief in the superiority of their race and class.”<sup>10</sup> Thus, the Daughters were creating a rhetorical, sentimental, plantation paradise in order to justify that for which their ancestors had fought.

The UDC had assistance from male groups with similar missions. For men, the United Confederate Veterans (UCV) and the Sons of Confederate Veterans (SCV) provided ample opportunity to work toward glorifying the Lost Cause. These men’s organizations have long been some of the most recognized for their work, as they were the ones in the most publicly visible roles. The Daughters themselves often overtly deferred to men, reflecting traditional gender roles which they claimed to uphold. Yet, behind the scenes, it was these women who were often in control. The Daughters were the ones fighting to build monuments, take care of aging Veterans, and host Memorial Day celebrations. In doing so, they carved out a niche for women in which they could be “natural leaders” without defying social norms.<sup>11</sup>

Indeed, the work of these women came to be seen as an extension of their duties as moral guardians, protecting the honor of their Confederate ancestors. This argument successfully veiled the Daughters in enough tradition that their political and ideological work went unquestioned. The work of the UDC was also set apart by their insistence on honoring both the men and women of the Confederacy. The women, the Daughters argued, suffered and did their part in the war as did the men, and thus they also deserved to be remembered.

The UDC grew quickly in the early twentieth century. Founded as just a small group of women in Nashville, Tennessee, within ten years

10 Cox, 12.

11 Ibid., 20.

membership had grown to almost 30,000.<sup>12</sup> Its members were from both the first and second generations removed from the Civil War. Older members remembered the war firsthand and had likely been a part of Ladies' Memorial Associations prior to joining the Daughters. The younger women, who made up a greater portion of UDC membership, grew up during Reconstruction and had been raised on Lost Cause mythology.<sup>13</sup> Though few of the women had personal memories of it themselves, they fought for a return to the culture of the Old South as they imagined it.

Reconstruction was often regarded as a low point for white Southerners, their darkest days. The Lost Cause imagery of the peaceful plantation, in which white masters controlled their faithful slaves and women are protected from all harm by their fathers and husbands, was much more appealing than the realities of the actual situations. As Cox argues, for these younger members of the UDC, "myth had replaced reality."<sup>14</sup>

The most prominent work of the UDC was their monument building. Nearly every city in the South has a monument to Confederate soldiers, placed there by the local chapter of the UDC.<sup>15</sup> These monuments served (and continue to serve) as public proof that the Lost Cause was alive and well, conveying the message that the white South was still devoted to Confederate principles and the men who died for them.

Domby argues that the monuments were intended to build up the false narrative of Confederate glory and played a key role in "justifying and defending [the continued] white hegemonic control of southern politics."<sup>16</sup> These monuments became rallying points for white southerners, and unveiling ceremonies were major public events. The Daughters themselves took center stage at these events, a solid reminder that these women were leading the creation the Lost Cause. One such monument ceremony in Opelousas, Louisiana in September 1897 was covered in the UDC's official newspaper, the *Confederate Veteran*, which praised the Daughters' work: "We look to you, ladies, whenever any movement of great moment is undertaken... We may try by ourselves, but without your assistance we never succeed."<sup>17</sup>

As the most public of the UDC's activities, monument building became one of the most important tools for advancing the narratives of the Lost

12 *ibid.*, 29.

13 *ibid.*, 37

14 *Ibid.*, 38.

15 *Ibid.*, 51.

16 Domby, 26

17 "Daughters at Opelousas, LA," *Confederate Veteran* (Nashville, TN), September 1897.

Cause. These monuments, placed in civic spaces, signified that Confederate values had not been reconstructed but were still shaping the present. The unveiling ceremonies were a rallying cry to Daughters in other chapters, inspiring them to mobilize their resources in their own communities.<sup>18</sup> These ceremonies were dramatic affairs, often featuring parades through streets adorned with Confederate flags. Confederate veterans led the parades, and

18 Adam Chamberlain and Alixandra B. Yanus, “Monuments as Mobilization? The United Daughters of the Confederacy and the Memorialization of the Lost Cause,” *Social Science Quarterly* 102, no. 1 (Jan. 2021): 136.



**Figure 1:** UDC members pose in front of a monument to a Confederate general <sup>20</sup>

any visible war injuries only added to the heroic imagery.<sup>19</sup> The Daughters responsible for the entire event took center stage alongside prominent politicians and these veterans. In fact, a key point in the nearly every ceremony was a Daughter presenting the monument to a Confederate veteran followed by his acceptance and appreciation<sup>20</sup>. This visible partnership between the UDC and the veterans gave legitimacy to the Daughters as protectors of the white, Southern masculinity. White men had been entrusted with the fate of the Confederacy during the war, and it was white women who were entrusted with its subsequent legacy. Figure 1 <sup>21</sup>shows UDC members standing near a

19 Cox, 61.

20 Domby, 25.

21 Monument to Gen. John H. Morgan and his men, and some of the members of the U.D.C.

monument to Confederate general.

Children also played an important role in the creation of Lost Cause culture, especially in these monument ceremonies. They were often a central feature of the monument unveiling, symbolizing a link between the past and future generations. Children's choirs were common, performing patriotic songs like "Dixie" for the adults<sup>22</sup>. These ceremonies were important for the effect they had in instilling Lost Cause values and Confederate pride in Southern, white children, but also for the message they visibly portrayed. Crowds of children, all dressed in Confederate colors and embracing their Confederate ancestors symbolized a promise that the Confederate tradition would live on. The North had not succeeded in reconstructing white Southern youth just as it had failed to change their mothers and fathers.

The monuments erected by the Daughters have continued to be some of the most visible reminders of the Confederacy. Placing these statues in almost every town across the South was a way of publicly honoring Confederate soldiers, making their image more associated with valor and heroics than treason and rebellion. The Daughters, to be sure, made a lasting name for themselves as well by performing this work, a legacy which has extended into the 21st century. However, the UDC also realized that statues alone were not going to be enough to vindicate the Confederacy and her defenders. The powerful symbolism of children clad in Confederate memorabilia perhaps served as inspiration for the Daughters' new mission: they would have to expand their work to shape the living along with the dead.

## The Children of the Confederacy

"To the Children of the Confederacy you must consign your work, and it must be their task to keep the fires of patriotism burning bright upon our country's altars," declared Etta Putnam Johnson, leader of the Julia Jackson chapter of the Children of the Confederacy, to the 1908 UDC Convention<sup>23</sup>. The Daughters were just beginning to realize the potential of public education in pursuing aims, but schools were not the only place where they would carve out a niche. The UDC's official auxiliary children's group, the Children of the Confederacy, would become yet another way for them to indoctrinate Southern youth into the glory of the Lost Cause ideology.

The Children of the Confederacy (CoC) was first created in 1896, but it did not become a uniform auxiliary organization until 1917.<sup>24</sup> Before that

22 Cox, 64.

23 United Daughters of the Confederacy, *Minutes of the Fifteenth Annual Convention* (Opelika, Alabama: Post Publishing Company, 1909), 18.

24 Kristina DuRocher, *Raising Racists: the Socialization of White Children*

point, chapters were primarily the responsibility of the local UDC chapter and did not have a standardized curriculum to follow. Membership was open to both boys and girls who had Confederate ancestry, a requirement which was occasionally limiting for those who could not provide proof. Some children were enrolled in the CoC as early as the day they were born, as Daughters were often eager to enroll their children and grandchildren<sup>25</sup>. Most children did not become active members until they were at least six,

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in the Jim Crow South (Lexington: The University Press of Kentucky, 2011), 88.

<sup>25</sup> Cox, 136.



**Figure 2:** A chapter of the Children of the Confederacy with their leaders

however. The CoC grew rapidly as the Daughters began to dedicate more time and effort to its educational efforts. Figure 2 <sup>26</sup>demonstrates children and leaders of Confederacy.

Chapters of the CoC met monthly to study Confederate history, sing patriotic songs, and study the Confederate catechism. Figure 2 shows a CoC chapter proudly posing with their leaders clad in Confederate dress. The chapter has on display both a Confederate flag and an American flag, meant to establish patriotism for both the Confederacy and the United States. This was not, in the minds of the UDC, a contradiction, for they saw the Confederacy's secession as the highest act of patriotism to the United States

<sup>26</sup> Children of Confederacy, 1/19/24. Photograph. N.P., 1924, <https://www.loc.gov/pictures/item/2016848591/>

Constitution.<sup>27</sup>

Part of their Lost Cause narrative insisted that secession was a legitimate and reasonable response to federal tyranny in keeping with the response of the founders of the United States to the colonial tyranny of England. Thus, the American flag played a significant role in the indoctrination of these children. Another item of significance within the Confederate Children was the Confederate Catechism. The catechism was a book of questions and answers designed as a call and response activity. This format retains a rhetorical power based on its religious undertones, as the catechism format was developed and used by the Christian church.<sup>28</sup> This association gives the catechism unquestioned authority, enhanced by its contents, in which the concept of truth is repeatedly reinforced.

One North Carolina CoC catechism had the leader ask, “What does your leader teach you?” followed by the response “The truth, and Confederate history.”<sup>29</sup> The repetition of this ritual, which was performed at every meeting and delivered by an authority figure, likely cemented the children’s belief in and understanding of the Lost Cause.

The content of the Confederate Catechism primarily centers around four themes: slavery, secession, the Civil War, and Reconstruction<sup>30</sup>. Many of these questions reinforce common Lost Cause themes that were already being incorporated into school curricula, but some take a more passionate stance than a school textbook would. One question asks, “Were our Confederate soldiers and our relatives who fought in the Confederate army traitors?” and expects the children to answer “No! No! No!”<sup>31</sup> This particular exercise trains children to respond with ardor and intensity upon hearing these accusations of treason levied at the South and their ancestors.

Other questions are designed to instill pride in Confederate soldiers, such as when the leader asks, “Did we kill many Yankees?” and the children respond “yes, thousands and thousands of them.”<sup>32</sup> The use of the term “we” in this question creates a connection for the children, drawing them into the War on the side of the Confederacy and strengthening the “us versus them” mentality in framing the North and the South while also valorizing

27 Cox, 65.

28 Amy Lynn Heyse, “The Rhetoric of Memory-Making: Lessons from the UDC’s Catechisms for Children” *Rhetoric Society Quarterly* 38, no. 4 (2008): 419.

29 J.P. Allison, *Confederate Catechism for Young Children* (Concord, North Carolina: n.p.), 8.

30 Allison 7

31 Allison, 7.

32 Allison, 6.



their ancestors. The rhetoric contained within this catechism was another powerful method of impressing the Lost Cause onto children in an effort to preserve these values for future generations.

Mildred Lewis Rutherford, who involved herself with the projects related to the UDC's historical mission, published monthly programs for the CoC while she served as historian-general. This pamphlet served as a way to standardize CoC curriculums, creating a more uniform understanding of Confederate history that lined up with the UDC's own historical program. Each month centers around a particular theme, such as Robert E. Lee, Confederate Memorial Day, or the Merrimac and Monitor<sup>33</sup>. The pamphlet also includes a matching program for local UDC chapters to follow. UDC meetings and CoC meetings were often held at the same time, so this encouraged conversation between mother and child, ensuring that their Confederation education was taking place at home, school, and club meetings.<sup>34</sup> Thus, the Lost Cause became an inescapable part of life for many southern children.

Through the Children of the Confederacy, the Daughters modeled the society they hoped to restore with this generation. Their regular meetings immersed children in Confederate history, teaching them that the Old South and plantation life were a more idyllic past. A past that they should be striving to rebuild. The Confederate Catechism trained the children to question their school teachings unless they came directly from white southerners. This organization created a group of children who deeply understood the Lost Cause and would fight for the future the Daughters wanted.

## The UDC and Pro-Confederate History

the Daughters were not content to just educate the children who joined the CoC. In order to come closer to their goal of creating an entire generation steeped in Lost Cause mythology, they began to take an interest in public schools. At the sixth annual meeting of the UDC, held in Richmond in 1899, Annie Booth McKinney, president of the Knoxville chapter, proclaimed that the group was working toward establishing a fund for educating local orphan children. This, she said, was because the chapter "prefers educating the living to raising monuments to the dead."<sup>35</sup> Though the UDC was already heavily involved in monument work at this point, Mrs. McKinney's statement is one of the earlier signs that the UDC's mission was shifting. Of course,

33 Mildred Lewis Rutherford, *Monthly Programs* (Athens, Georgia: n.p.)

34 Heyse, 410.

35 *United Daughters of the Confederacy, Minutes of the Sixth Annual Meeting*, (Nashville: Print of Foster and Webb, 1900), 7

“educational” work had been in the UDC’s constitutional objectives from the very beginning, but over time, this would become one of their most impactful missions.<sup>36</sup>

The Daughters saw a need to combat the narrative that Confederates were rebels and traitors, for this contradicted their mission of vindication. Adelia Dunovant, historian of the Texas UDC division, delivered a passionate address to the 1898 annual convention on the importance of combating what she termed as the “perversion of facts, omission of events, and adoption of Northern opinions.”<sup>37</sup> In it, she lashed out at certain textbooks for referring to the war as the North “putting down the rebellion,” lamenting that “instead of furnishing the children of the South draughts from the pure fountain of truth, it supplies surface water from about the fungus growth of popular opinion.”<sup>38</sup> Clearly, by the Daughters’ standards, any interpretation of history required a pro-Confederate stance.

Some of the most common narratives the UDC sought to combat were the assertion that the war was fought to defend slavery and that Confederates were traitors to the United States. According to the Lost Cause mythology, the war was fought over states’ rights, and thus Confederate soldiers were defending their homes, not their right to own other human beings as property. The Daughters also insisted that their ancestors were not defectors and rebels, but patriots of the highest caliber who fought to defend the Constitution from federal encroachment. This sentiment extends from the assertion that the war was fought over states’ rights, for the Confederates were, according to the Lost Cause, fighting to uphold their Constitutional right to self-determination which had been violated by the federal government’s attempts to interfere with slavery and the election of Abraham Lincoln as president.<sup>39</sup>

In order to enforce this falsified Lost Cause version of history, the UDC established a historical committee in 1897. The creation of such a committee followed a drawn-out debate regarding the Daughters’ responsibility to educate the children and grandchildren of Confederate veterans. Rebecca Felton, a Georgia Daughter and wife of Representative William H. Felton, questioned the UDC’s priorities with their memorial work:

36 United Daughters of the Confederacy, *Minutes of the Fourth Annual Meeting* (Nashville: Print of Foster and Webb, 1898), 51.

37 United Daughters of the Confederacy, *Minutes of the Fifth Annual Meeting* (Nashville: Print of Foster and Webb, 1899), 72.

38 *Ibid.*

39 Cox, 96.

If the dead soldiers could revisit earth during one of the great general reunions of the present time; if they could come down to us in long, shining lines, and tell us what they desired, and what would be most gratifying to parental love and genuine patriotism, do you suppose they would be asking for soldiers' homes or a refuge for survivors, when they now occupy homes "not made with hands, eternal in the heavens?" Would they ask you for monuments to "keep memory green," when they have already a place in your hearts more enduring than brass or marble? Do you imagine they would clamor for flowers on Decoration Days or any other days, if their orphaned daughters or granddaughters were ragged, homeless, and illiterate?<sup>40</sup>

Thus, the establishment of the Committee on History shows an organized push in a new direction for the UDC. Educating white, Southern children was not only about benevolence, but also about ensuring that the next generation would be indoctrinated into Lost Cause mythology. They were, in effect, establishing a younger cohort of future Daughters and Sons to one day take up their mission.

With the guidance of the national convention's Committee on History, local chapters were encouraged to provide for the education of local children, especially those who were descended from Confederate veterans, elect their own chapter historians, and write their own essays on the history of the Confederacy. Male organizations like the UCV and SCV were also engaging in historical writing, but while they were writing stories of battles and military tactics, the Daughters were writing about life on the home front and their vision of Confederate culture, which primarily centered on elite whites and their plantations.<sup>41</sup> They told Lost Cause stories of benevolent masters caring for friendly slaves and valiant wives managing plantations while their husbands were away. They often emphasized the peaceful domesticity of Southern plantation life.

The Daughters intended to contradict the notion that slavery was cruel or inhumane with narratives like that of "an old black mammy who cared for us" or "a faithful old negro man, who remained our 'right hand' until death claimed him."<sup>42</sup> Of course, they saw no issue with these claims coming mostly from white women who had very little experience with plantation life. These 'histories' were fixated on the white elites and their loyal slaves; poor whites

40 United Daughters of the Confederacy, Minutes of the Fourth Annual Meeting, 35-36.

41Cox, 103.

42 Kate W. Moore, "Tribute to Our Faithful Slaves," Confederate Veteran (Nashville, TN), July 1905.

were almost entirely excluded from the narrative.

By 1908, these historical efforts had become so key to the UDC that the national office of historian-general was established.<sup>43</sup> This position would quickly become one of the most powerful within the UDC. Virginia Morgan Robinson was the first woman to hold this office, and she was highly influential in establishing its duties and organizing chapter historians in order to pursue a united rhetorical path for vindication. She implored each chapter to begin collecting “papers, books and documents of every kind, relating to Southern history” so that the Daughters would be well equipped with primary sources for their historical writing.<sup>44</sup> Robinson’s work set the precedent of unifying the Daughters in a single historical effort, one which would be far more powerful than the local chapters writing on their own.

Mildred Lewis Rutherford, Robinson’s successor as historian-general, soon rose to prominence as one of the most notable influences on the UDC’s historical aims. Elected in 1911, Rutherford was already known for traveling the country to give lectures about her version of history, as well as her many essays and pamphlets defending the mythic image of the Old South popularized by the Lost Cause. This “vindication crusade,” as Cox calls it, placed Rutherford firmly at the center of the UDC’s fight to control the historical narrative.<sup>45</sup> In her first year as historian-general, Rutherford published an astounding eleven volumes and 3 scrapbooks, all regarding the history of the Confederacy, as well as the clubs dedicated to its memory, like the UDC and UCV.<sup>46</sup> This was intended to encourage even more Daughters to take up the pen themselves, as Rutherford saw their essays as one of the most important pieces of work being done by the UDC.

The women of the UDC had previously established a committee on education in 1909. However, these early iterations of the committee were quite moderate in comparison to the ambitious body which would later rise up as they pertained more to individual children than the public school system as a whole. Its early aims were less a desire to control the education of children across the South and more a reflection of the UDC’s mission to care for Confederate soldiers and their families. In the committee’s first annual report, they assert that their mission was “to help the descendants of Confederate Veterans to hold their places in the great struggle of life. We want to preserve Confederate history, and honor the Confederate soldier, and we

<sup>43</sup>Cox, 102.

<sup>44</sup> United Daughters of the Confederacy, *Minutes of the Sixteenth Annual Convention* (Opelika, Alabama: Post Publishing Company, 1909), 100.

<sup>45</sup>Cox, 103.

<sup>46</sup> United Daughters of the Confederacy, *Minutes of the Nineteenth Annual Convention* (Jackson, Tennessee: McCowat-Mercer Press, 1913), 144-145.

can find no better way than by training his children and grandchildren to be useful and honorable citizens of these United States.”<sup>47</sup> Thus, while this first committee was focused primarily on caring for Confederate descendants, their purview would soon expand to encompass all the children of the South.

What caused this pivot toward education? It was, in part, a reflection of the UDC’s desire to vindicate their Confederate ancestors, a mission which was not being achieved solely through erecting monuments. Historian James McPherson posits that the professionalization of history as a subject and the rise of standardized, public-school curriculums played a significant role.<sup>48</sup> These schools needed textbooks, and the publishing industry that rose up to meet this need was primarily based in the North. This, as McPherson calls it, was “the serpent... in the Confederate Garden of Eden,” for these books tended to espouse a viewpoint that reflected the growing nationalism of the North following the Union’s victory.<sup>49</sup>

In addition to all their work with the children of the South, the Daughters also sought to expand their sphere of influence beyond the former Confederacy. They recognized that schoolteachers played a large role in determining how friendly lessons would be towards the Confederacy, and therefore decided to establish essay contests at Northern universities where large numbers of teachers were being trained.<sup>50</sup> Leonora Rogers Schuyler, the chairman of the committee responsible for the essay contest at Columbia University, addressed the 1908 convention: “It is the teacher who guides and directs the thought of the coming generation, and with a wider vision, which comes with fuller knowledge, soon the whole land will echo the words that we feel expresses so well our sentiments, ‘Lee and the South be represented, constituted the real patriotic riches of the nation.’”<sup>51</sup> By encouraging students to write about essays about the Old South and the Civil War with the boon of prize money, the Daughters were hoping to grow the influence of the Lost Cause beyond the former Confederacy. This seemed like a mutually beneficial situation for the UDC, for they would get new pro-Confederacy essays to publish while influencing a new audience, and a student would be

47United Daughters of the Confederacy, Minutes of the Sixteenth Annual Convention, 259.

48James McPherson, “Long-Legged Yankee Lies: the Southern textbook crusade,” in *The Memory of the Civil War in American Culture* ed. Alice Fahs and Joan Waugh (Chapel Hill: University of North Carolina Press, 2004), 67.

49 Ibid.

50 Cox, 112.

51 United Daughters of the Confederacy, Minutes of the Sixteenth Annual Convention, 263.

rewarded with prize money and would hopefully remember the donor once they became a teacher.

However, the UDC was naive in thinking that they could bring about a pro-Confederate shift simply by encouraging a study of history which lined up with their views. They would soon discover that their ideas on truth and bias were not nearly as universally true as they believed them to be. The winner of the 1907 essay contest was Christine Boyson, who was selected by a committee made up of academics and Daughters alike for having the best essay on the topic of “the South’s part in the War between the States.”<sup>52</sup> Each year of the contest, the winning essay was published in the official UDC newspaper, the *Confederate Veteran*, but Boyson’s essay was published with a disclaimer, stating “the *Veteran* is unwilling to make such a record of it without protest against several statements.”<sup>53</sup> Indeed, this essay, while very complementary of Robert E. Lee, directly contradicted the manufactured image of the Old South that was so key to the Lost Cause. Boyson’s essay was met with widespread outcry from the UDC and readers of the *Veteran*, especially for statements such as, “Intellectually the South was practically dead. Most of the people were densely ignorant.”<sup>54</sup> It is likely not a coincidence that the failure and embarrassment of this UDC effort was followed by attempts to standardize a core set of principles for the Daughters’ Lost Cause narrative, particularly in schools and textbooks.

## The Battle for Textbooks

As time passed and the Civil War became more and more distant, the Daughters of the Confederacy’s missions began to once again shift. The Daughters had witnessed how their personal ties to their Confederate ancestors grew weaker, and thus they wished to systematically instill Confederate values in children since family ties would no longer be enough to accomplish this. Knowing that there was strength in their numbers, the Daughters organized to have a voice in public schools and the books they were using. Their campaigns fought against any book deemed unfair to the South, meaning it contradicted the fabricated Lost Cause narrative the Daughters were fighting to establish as fact, and it would have a long-lasting effect on public education.

Mildred Lewis Rutherford was certainly aware of an issue with textbook publishing. In her 1912 address as historian-general, she proclaimed, “We

<sup>52</sup> “Robert E. Lee—A Present Estimate,” *Confederate Veteran* (Nashville, TN), December 1908.

<sup>53</sup> *Ibid.*

<sup>54</sup> *Ibid.*

cannot in the South compete with the North in publishing houses... We must not blame the manufacturer of books at the North because he is pushing his interests in the matter of his books. You would do it and I would do it.”<sup>55</sup> In this statement, Rutherford is not only laying blame at the feet of the South for doing enough to combat the Northern publishers, but also acknowledging that these books did indeed function as a way to push their own agenda. Though much of the Daughters’ historical work was often veiled as the search for unbiased history, this serves as a clear reference to the reality that the Daughters recognized themselves to be fighting an ideological war. They were campaigning for a bias in their favor in order to treat this narrative as fact. By placing this narrative in textbooks, they were effectively legitimizing their Confederate mythology and attempting to turn it into the accepted history. Here, the women of the UDC traded the muskets and bayonets used by their ancestors for schoolbooks and pens.

Rutherford was exactly the person needed to take the reins for the UDC’s historical and educational crusades. She was a passionate advocate for the Lost Cause ideology and, according to historian Fred Arthur Bailey, “the UDC’s most articulate interpreter of the South’s past.”<sup>56</sup> Rutherford, perhaps more than any other Lost Cause proponent of the time, saw their historical work for what it was: a chance to control the narrative and return to the white Southern elite some of the power which they had lost during the Civil War. She recognized that history did not have to be just chronological dates and military battles, but, as she argued, “some human event, some social movement... and all the circumstances attending it, and the motives of all the people connected with it.”<sup>57</sup> She pressed other Daughters to fight for their version of history and would not rest until the South had been restored to its imagined glory.

Rutherford’s role as historian-general gave her the power to set standards for what defined a true, unbiased history from the UDC perspective. These standards “demanded unrelenting censorship of textbooks and library materials” which did not match the portrayal these Confederate groups deemed acceptable.<sup>58</sup> Rutherford’s 1914 essay “Wrongs of History Righted” was an early attempt to mark the exact problems she found in school textbooks. “The responsibility is yours, mothers and fathers,” she declared, “to know the training your children are receiving; to know by whom taught,

55 Mildred Lewis Rutherford, *Address* (Athens, Georgia: McGregor Co., 1912), 8.

56 Fred Arthur Bailey, “Mildred Lewis Rutherford and the Patrician Cult of the Old South,” *Georgia Historical Quarterly* Vol. 78, No. 3 (Fall 1994): 516.

57 Rutherford, *Address*, 13.

58 Bailey, “Mildred Lewis Rutherford,” 530.

whether true or false to all we hold dear. Only in this way can we stem the tide of falsehoods that have crept in, and are still creeping into the newspapers in our homes, into the books in our libraries, and into the text-books that we are allowing to be used in our schools.”<sup>59</sup> This placed the responsibility on the Daughters to be watchdogs in their own communities as part of their duty of Confederate motherhood to ensure their children were not being taught a history the UDC found unacceptable.

The deadliest sin a textbook could commit, according to Rutherford, was portraying slavery in a negative light. Far from being a cruel institution, she insisted that “slavery was no disgrace to the owner or the owned.”<sup>60</sup> She disputes the use of the term “slave,” stating that the term was a tool used by abolitionists to make slavery seem worse than it was. “They were our servants,” she insisted, “part of our very home, and always alluded to as the servants of a given plantation.”<sup>61</sup> Rutherford promoted this paternalistic view in which slavery functioned as a civilizing tool and was therefore a positive good. She even argued that African Americans should “give thanks daily that they and their children are not today where their ancestors were before they came into bondage.”<sup>62</sup> This defense of slavery doubles as a defense of white supremacy. By expounding on the merits of slavery, Rutherford is reiterating the benefits of white supremacy. She uses plantation life to exemplify what proper race relations should look like: black submission to white control. Rutherford hoped to see this structure in effect once more and thought that impressing this upon children was an effective method of reaching this end.

Another major fault Rutherford saw in many textbooks was the negative labeling of the South’s secession as a rebellion. This was, of course, a longtime tenet of the UDC, for even their monument work had been dedicated to countering the labels of traitor and rebel. Rutherford reasoned that the South had been justified in the decision to secede, for they had experienced “nothing but continued violation of the Constitution by the North.”<sup>63</sup>

The South, she argued, had clearly not been seeking a war when they seceded, for it was the North that was in control of the military resources like Fort Sumter. What portion of these resources the South had fought for had not been for war preparation, but simply taking “possession of the

59 Mildred Lewis Rutherford, *Wrongs of History Righted* (Athens, Georgia: McGregor Co., 1914), 3-4.

60 *Ibid.*, 14.

61 Mildred Lewis Rutherford, *The Civilization of the Old South: what made it: what destroyed it: what has replaced it.* (Athens, Georgia: McGregor Co., 1916), 3.

62 Rutherford, *Wrongs of History Righted*, 16.

63 *Ibid.*, 11.



things which were rightfully hers.”<sup>64</sup> By justifying secession as a response to Northern encroachment on the South’s Constitutional rights, Rutherford is echoing the Lost Cause sentiment that the South’s position was not one of treason, but actually a high act of patriotism. This idea frames secession as a defensive action by the South done simply to defend the principle of states’ rights. Though they may have lost this battle, it was indeed a great moral mission according to Rutherford’s history.

Of course, Rutherford and the UDC were not alone in their fight. The UCV and SCV were also interested in fighting against this perceived anti-Southern slant in education. Rutherford was a speaker at the 1919 Grand Reunion of the United Confederate Veterans, and in her speech, she stressed the importance of eliminating anti-Southern sentiment from school textbooks. She urged the UCV to dedicate more of their time and effort to this mission which the UDC had already been fighting for over a decade. Her address was met with rapturous applause, and the UCV immediately adopted a resolution to establish a committee consisting of five members from each of the UCV, SCV, and UDC.<sup>65</sup> This committee was named the Rutherford Committee in recognition of her contributions to the cause.

One of the committee’s first acts was publishing uniform standards for schoolbooks. Of course, Rutherford had long been writing essays for the Daughters on what was unacceptable, but her “Measuring Rod For Text-Books” signified a united, uniform approach that could be used by any of the three organizations involved. Whereas before, it had been more up to interpretation of what constituted anti-Confederate bias, this pamphlet laid out eleven clear statements, treated as fact, and the violation of any one of them was grounds for protest. The committee was truly drawing a line in the sand with this pamphlet, stating that “all library authorities in the Southern States are requested to mark all books in their collections which do not come up to the same measure, on the title page thereof, ‘Unjust to the South.’”<sup>66</sup> If the fight for textbooks had been a battle before, this was the committee readying the troops.

The Daughters quickly put the Rutherford Committee’s standards to work in their own local communities. The North Carolina division of the UDC became the center of one of the most notable controversies over Confederate history in textbooks. At their 1920 state convention, the state

64 Ibid.

65 “The Reunion in Atlanta,” Confederate Veteran (Nashville, TN), July 1919. ,

66 C. Irvine Walker, foreword to “A Measuring Rod to Test Text Books, and Reference Books, in Schools, Colleges and Libraries” by Mildred Lewis Rutherford (Athens, Georgia: n.p., 1919), 3.

historian noted that the North Carolina State Board of Education had adopted the use of David S. Muzzey's *An American History* for use in public schools. This was met with widespread protest by the North Carolina Daughters. "It is unfair to the noble traditions of the South from beginning to end," one Daughter proclaimed. "Our children should know the truth about their Southland and not be taught to feel his ancestors were fools and traitors."<sup>67</sup> The convention then voted to form a committee dedicated to fighting this book which "smacks with such unfairness."<sup>68</sup>

Muzzey's *American History* failed nearly every single test laid out in Rutherford's "Measuring Rod." The only standard which it did not fail, the treatment of prisoners of war at Andersonville Prison, was simply because that topic is not mentioned at all by Muzzey.

Rutherford's first two standards state that the Constitution was a compact and was not perpetual nor national, and therefore secession was not a rebellion since the North had reneged on their end of the deal.<sup>69</sup> Muzzey, however, stated, "Until a revolt is successful it is 'rebellion...'" and the authors of it and participants in it are, in the eyes of the law, traitors."<sup>70</sup> He acknowledged that the people have a right to revolt but questions the justification behind the South's secession. Rutherford's next standards argued that the North was fully responsible for the Civil War, that the party of Lincoln was hostile to the South, and that attempts to coerce the South to stay were unconstitutional.<sup>71</sup> Muzzey again disputed the UDC reasoning behind secession. He ardently rejected the notion that Abraham Lincoln's election was, in any way, a provocation to the South. "To call the election of such a man with such a program an invasion of the rights of the South, a violation of the Constitution, or 'an insult that branded the people of the South as sinners and criminals' was absurd," he wrote.

He also rejected the assertion that Congress did anything that would warrant the South's ire, saying that they "gave the South as little provocation for secession" as did Lincoln's election.<sup>72</sup> Contradicting the notion that the North was fully responsible for the War takes away a major component of the Lost Cause, which held that the Confederacy was completely justified in

67 United Daughters of the Confederacy North Carolina Division, *Minutes of the Twenty-Fourth Annual Convention* (Charlotte, North Carolina: Queen City Printing Co., 1920), 41.

68 *Ibid.*, 42.

69 Rutherford, "Measuring Rod," 6-7.

70 David S. Muzzey, *An American History* (Boston: Ginn and Company, 1911), 468.

71 Rutherford, "Measuring Rod," 8-13.

72 Muzzey, 463-465.

their response and had little choice but to fight. If Southern children were to learn that this was untrue, their entire view of their Confederate ancestors could collapse.

Muzzey also contradicted Rutherford's idealization of plantation life in the Old South. Another of her standards maintained that slavery was not a cruel institution.<sup>73</sup> Muzzey, on the other hand, held that "the existence of the coarse slave driver and the callous slave trader testified to its cruelty."<sup>74</sup> Casting slavery in this light contradicted all of the work the Daughters were putting in to make the Old South seem like a lost paradise, which also directly contributed to the legitimization of white supremacy. Muzzey also strongly and repeatedly violated Rutherford's standard attributing the cause of the war to states' rights instead of slavery. He wrote

the only "right" for which the South was contending in 1860 was the right to have the institution of slavery recognized and protected in all the territory of the United States. Whether or not the Constitution gave the South this right was exactly the point of dispute. It was not a case of the North's refusing to give the South its constitutional right, but of the North's denying that such was the constitutional right of the South. It was a conflict in the interpretation of the Constitution; and slavery, and slavery alone, was the cause of that conflict. To say that secession and the Civil War were not caused by slavery, therefore, is to say that the thing for which a man is fighting is not the cause of the fight.<sup>75</sup>

This combination of arguments, asserting that slavery was both barbaric and the cause of the war, once again targeted the valor of the Confederate cause.

The Muzzey textbook's final "crimes" come from its treatment of the Civil War itself. Rutherford's standards insisted that the Union army was responsible for destruction of property during the War and that the South was constantly seeking peace while the North refused.<sup>76</sup> Muzzey did not directly deny the charge of Northern property damage but simply failed to mention it. His account of Sherman's March to the Sea was rather straightforward and did not detail any of this military engagement activities beyond the path it took.

This, in the Rutherford Committee's eyes, was a glaring omission of

73 Rutherford, "Measuring Rod," 10.

74 Muzzey, 481.

75 Muzzey, 467-468.

76 Rutherford, "Measuring Rod," 14-21.

wartime atrocities committed by the North. The fact that it was not mentioned at all was, to them, evidence of a Northern bias. Muzzey fought back against the claim that the South was always seeking peace by first placing them as at least partially responsible for the breakout of war, and then discussing their fervor to win. Far from wanting the war to end, the South was “more confident than ever” in 1863.<sup>77</sup> Perhaps the most publicized excerpt from the entire controversy is Muzzey’s comment on the end of the war: “It is impossible for the student of history today to feel otherwise than that the cause for which the South fought the war of 1861-1865 was an unworthy cause, and that the victory of the South would have been a calamity for every section of our country.”<sup>78</sup> Rutherford herself used this quote in her pamphlet “Truths of History” as an example of the former Confederacy’s mistreatment in literature.<sup>79</sup> However, it is worth noting that Muzzey was not nearly the anti-Confederate crusader that Rutherford and the Daughters portrayed. This excerpt which had so strongly offended Rutherford was immediately followed by an acknowledgement of Confederate heroism in Muzzey’s work: “But the indomitable valor and utter self-sacrifice with which the South defended that cause both at home and in the field must always arouse our admiration.”<sup>80</sup> By this point, even this admission that Confederates were, in their own way, heroes was not enough to stem the tide of protest which met Muzzey’s *American History*. Full submission to the Lost Cause was mandatory to escape the ire of the Rutherford Committee.

To fight against Muzzey’s book being used to educate impressionable Southern children, the Daughters once again turned to their greatest weapon: their pens. At the 1921 North Carolina UDC convention, the chair of the textbook committee reported that each local chapter president had been asked to write a protest to every member of the State Board of Education and the State Text Book Committee. Protests were also sent to 55 high school superintendents whose schools were known to be using Muzzey’s book in their curriculum.<sup>81</sup>

In addition to this overwhelming letter campaign, some Daughters took to the press to wage their war. Virginia Crowell, a North Carolina Daughter, wrote a passionate letter to the *Monroe Journal* explaining the UDC’s

<sup>77</sup> Muzzey, 500.

<sup>78</sup> Muzzey, 517.

<sup>79</sup> Mildred Lewis Rutherford, “Truths of History” (Athens, Georgia: n.p., 1920), 110

<sup>80</sup> Muzzey, 517.

<sup>81</sup> United Daughters of the Confederacy North Carolina Division, *Minutes of the Twenty-Fifth Annual Convention* (Charlotte, North Carolina: Queen City Printing Co., 1921), 61-62.

criticisms of the book and appealing to Southern pride to gain support. “If Muzzey’s History should be taught in our Southern schools, then the U.D.C. as an organization should disband,” she wrote. “‘Loyalty to the truth of Confederate history is our motto.’ Can we be true to such a motto and teach Muzzey? No!”<sup>82</sup> The Daughters’ work did eventually pay off as in 1922, the State Board of Education did not renew its contract with Muzzey’s American History, and North Carolina classrooms were free from all but histories that supported the UDC’s vision of the Confederate South.<sup>83</sup>

## Conclusion

The Daughters’ fight to preserve white supremacy left its mark on the South. Under the guise of tradition and history, these women carved out a new role for themselves as Confederate mothers, taking an active part in publicly memorializing the Confederacy. The Children of the Confederacy and its catechisms trained children to instinctively defend the Confederacy and insist that their ancestors were heroes. The Daughters’ textbook crusade ensured that generations of Southern students exclusively learned Lost Cause history. These efforts contributed to the reign of Jim Crow in the South by creating a new cohort of Daughters and Sons ready to employ Lost Cause rhetoric, even once the original Daughters were no longer around to fight. Indeed, the generations educated with UDC-approved textbooks would continue to espouse white supremacy in the face of the Civil Rights Movement. It is, perhaps, no surprise that the region continues to struggle with its legacy of racism and inequality, particularly in school curriculums—a legacy which the Daughters of the Confederacy helped create.

<sup>82</sup>Virginia Crowell, “Muzzey’s History is Unjust to the Southland” *Monroe Journal* (Monroe, NC), August 26, 1921.

<sup>83</sup>United Daughters of the Confederacy North Carolina Division, *Minutes of the Twenty-Sixth Annual Convention* (Charlotte, North Carolina: Queen City Printing Co., 1922), 47.



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Monument to Gen. John H. Morgan and his men, and some of the members of the U.D.C. Committee that built it. Lexington Kentucky, ca. 1911. Photograph. Library of Congress, <https://www.loc.gov/item/91787584>.

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Kyle Lam is a physics major at the University of Memphis, graduating in the Spring of 2023. He hopes to attend graduate school in the Fall of 2023. Kyle has conducted research in chemistry, biology, and physics. At the University of Memphis in the summer of 2022, he participated in an NSF-funded research experience. Kyle is very thankful for the opportunity, where he learned many, new techniques in the field and made connections that he hopes to maintain in the coming years.

N.K. Lam  
Synthesis of transition metal sulfides via low-pressure  
chemical vapor deposition

Faculty Sponsor  
Dr. Shawn Pollard



## Abstract

Transition metal sulfides are in a unique position to replace the roles of many existing materials currently used in renewable energy technologies. They can be more conductive and have better electrocatalytic activity than their oxide counterparts while also being cheaper and safer to use and synthesize than their telluride and selenide counterparts. However, traditional synthesis routes of transition metal sulfides are inefficient, taking several hours to produce products that are too thick to be used. Low-pressure chemical vapor deposition can avoid many of the issues of wet chemical methods. However, the morphology of transition metal sulfides synthesized using LPCVD is not well understood. Here, an evaluation of the synthesis of nickel, copper, and their molybdenum sulfides using low-pressure chemical vapor deposition is presented. The resulting growth was then characterized using SEM, EDX, and XRD. Temperature and precursor concentration have clear effects on the morphology and the density of sulfide growth.

## INTRODUCTION

As the world's energy demands and consumption increase, so too does its need for more efficient and inexpensive energy storage and conversion materials. Sustainable energy is a large and still growing field of interest. Current projects include improved efficiency of current power sources like capacitors or lithium-ion batteries along with improved fuel generation methods like hydrogen evolution reaction (HER) and oxygen evolution reactions (OER).<sup>1-3</sup>

A growing body of research has been focused on two-dimensional (2D) nanomaterials for efficient energy storage and conversion. 2D materials also have the added benefits of high specific surface area, many sites for electrochemistry, and high mechanical flexibility.<sup>4</sup> Unlike their 0D, 1D, and bulk counterparts, 2D materials also have the flexibility to be synthesized using either a top-down or bottom-up approach.<sup>5</sup>

2D transition metal chalcogenides (TMCs) and hybrid metal chalcogenides are promising materials. 2D-TMCs have been studied for their photovoltaic, thermoelectric, semiconducting, superconducting, nanosensing, and electrocatalytic applications.<sup>6,7</sup> 2D-TMCs have also demonstrated potential in 2D spintronic devices, which open up avenues of research in not only renewable energy but also in quantum computing and new physical phenomena.<sup>8,9</sup> 2D-TMCs are able to preserve electron spin for more than 3 ns at 5 K under certain conditions, and their valley polarizations can be controlled to some extent.<sup>10-12</sup> In particular, nickel, copper, and molybdenum sulfides have been studied extensively.

For HER and OER, the standard electrode material is RuO<sub>2</sub> and IrO<sub>2</sub> due to their high electrical conductivities and low overpotentials. However, these materials are expensive and corrode easily, which produces toxic, metal ions. Nickel and copper sulfides have shown promise as possible replacements. Nickel and copper are abundant, relatively safe to work with, and cheap. They also exhibit low overpotentials, and one method to increase their conductivity is to use foams.<sup>1,2,7,13-16</sup> Nickel and copper foams have the benefit of being highly conductive and increasing surface area, which leads to more efficient electrodes and electrocatalysts.

However, current research on transition metal sulfide synthesis is lacking. Conventionally, nickel and copper sulfides are synthesized using hydrothermal methods. However, these processes can take several hours or even days to produce the sulfides. The sulfides also potentially suffer from nonuniformity and uneven thickness, or the process cannot reasonably be scaled up or down. An alternative synthesis pathway is through chemical

vapor deposition (CVD). Products produced through CVD can be made much more quickly than through solvothermal processes, and because of the tight control over the entire process, the sulfide can be finely tuned. Gas flow rate, temperature, the distance between precursors, the concentration of precursors, etc. can all affect the product made and the morphology of the product.

Nickel and copper sulfides can be produced on nickel and copper foams, respectively, using CVD.<sup>2,17</sup> However, there is little to no data on how low-pressure CVD (LPCVD) or plasma-enhanced CVD (PECVD) affects the growth and morphology of nickel and copper sulfides. There is also little on how the accessibility of growth sites, such as those on 3D foam, influences the polymorphs of the transition metal sulfides or their morphologies. While the surface growth may be of a singular phase, the phases of the foam areas that are harder to access or even the layers immediately below the surface growth are not well-characterized.

Furthermore, binary metal sulfides suffer from a similar deficit of knowledge. Although it is known that polymetallic compounds can have higher electrical conductivity and that they could be instrumental in the performance increase of supercapacitors or the creation of battery-supercapacitor hybrid devices, no study has been done on the synthesis of nickel or copper and molybdenum sulfides via LPCVD.<sup>18-20</sup>

As previously described, CVD has a breadth of control points, such as distance between the substrates or flow rate. Because this area has not been well explored, however, the driving variables here are primarily temperature and precursor concentration on sulfide growth. Here, an evaluation of the synthesis of nickel, copper, and their molybdenum sulfides using low-pressure chemical vapor deposition is presented.

## MATERIALS AND METHODS

### Synthesis

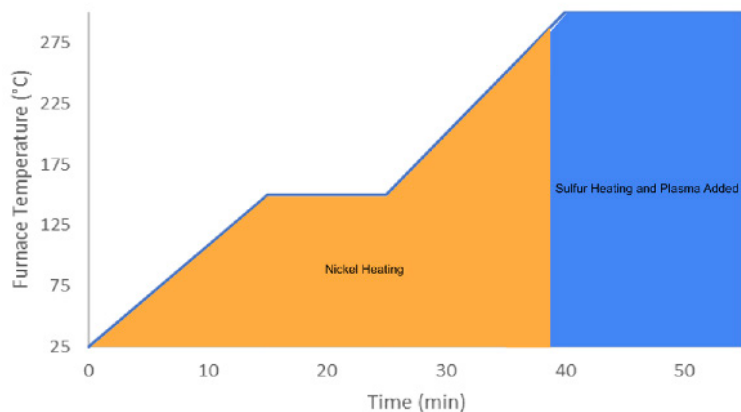
#### Nickel Sulfide

Sulfur powder (Alfa Aesar, 99.5% purity) and nickel foam (MTI Corporation) were used to synthesize nickel sulfides. The nickel foam was prepared into roughly 3 cm<sup>2</sup> rectangles and pre-cleaned using isopropanol and DI water under sonication for five minutes each.

The appropriate amounts of sulfur and the closest edge of the prepared nickel foam were placed in crucibles in a quartz tube about 13 cm apart in the furnace (MTI Corporation OTF-1200X-80-II-4CV-PE-SL). The furnace



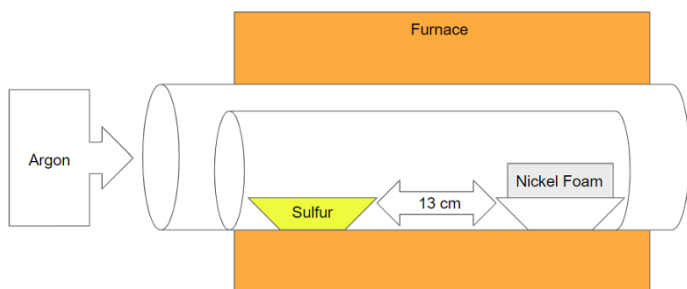
was programmed to heat up to 150°C in 15 minutes, stay at that temperature for an additional 10 minutes, heat up to the target temperature at a rate of 10°C per minute, stay at the target temperature of either 300°C or 400°C for 15 minutes, and then stop. Figure 1 shows the heating programming. The quartz tube was placed under a vacuum, and then argon with a flow rate of 50 sccm was introduced.



**Figure 1.** Heating profile of temperature program for furnace. This program is for PECVD and a target temperature of 300°C. The furnace starts at SATP. After staying at the target temperature for 15 minutes, the furnace turns off, and the product cools naturally.

The nickel was preheated to 150°C for 15 minutes by the furnace with the sulfur just outside of the furnace's range. About 20°C before the furnace reached the target temperature, the sulfur was also placed within the furnace's range, and plasma was added. The plasma was generated at 100 W and introduced 45 cm from the sulfur powder. Figure 2 shows a schematic of the CVD setup.

After the furnace reached the target temperature and both substrates were heated for about 15 minutes, the product cooled naturally, still under vacuum and with an argon flow rate of 20 sccm.



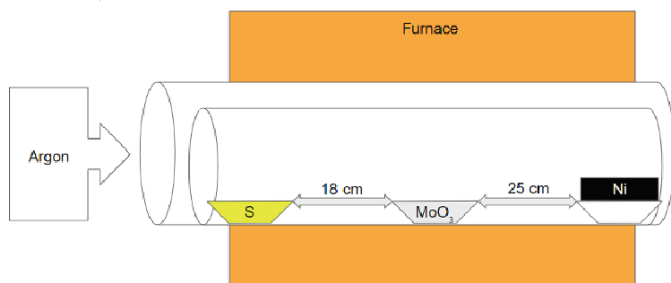
**Figure 2.** Schematic of PECVD setup. About 20°C before reaching the target temperature, the furnace was moved to encompass both sulfur and nickel, and plasma was added, if necessary.

### Copper Sulfide

The synthesis of copper sulfide followed the same procedure as the nickel sulfide synthesis. However, the copper foam (MTI Corporation) was cut into 3.6 cm<sup>2</sup> rectangles to prevent the foam from falling inside the crucible during loading. Plasma was also never introduced during the synthesis of copper sulfide.

### Nickel-Molybdenum-Sulfur Complex

The preparation of the nickel foam and sulfur followed the same procedure as the nickel sulfide synthesis. 25 mg of molybdenum (VI) oxide (Sigma-Aldrich, ≥ 99.5% purity) was placed between the sulfur and nickel foam. It was 18 cm from the sulfur and 25 cm from the nickel foam. Figure 3 shows the setup.



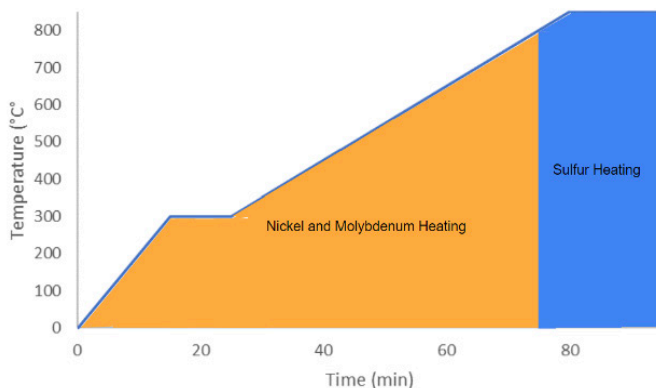
**Figure 3.** Schematic of LPCVD setup for synthesis of nickel-molybdenum-sulfur complex after reaching target temperature.

After placing the reactants under vacuum and then introducing argon at 50 sccm, the furnace was programmed to heat up to 300°C in 15 minutes, stay at that temperature of either 750°C or 850°C for 10 minutes, increase to the target temperature at 10°C per minute, stay at the target temperature for 15 minutes, and then stop. Figure 4 shows the heating program.

The sulfur was kept just outside of the furnace. At about 20°C before reaching the target temperature, the furnace was moved to encompass all substrates. Because of the distance between the substrates, the furnace was moved, so the sulfur was on the thermoblock and not directly in the heating zone.

#### Copper-Molybdenum-Sulfur Complex

The synthesis of the copper-molybdenum-sulfur complex followed mostly the same procedure as the nickel-molybdenum-sulfur complex. However, instead of placing the molybdenum (VI) oxide in a crucible between the sulfur and copper, it was placed directly underneath the copper foam. The copper foam was placed to cover about half of the MoO<sub>3</sub>'s area. The sulfur and the copper foam were set 18 cm apart.



**Figure 4.** Heating profile of furnace programming. About 20°C before reaching the target temperature, the furnace was moved to encompass all substrates.

## Characterization

X-ray diffraction (XRD) was carried out using a Bruker D8 Discover XRD to identify and characterize the crystalline structure of the sulfides and complexes on the transition metal foams. The XRD scanned the samples at 0.48 degrees per second from 10° to 80° at 20 kV.

Scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDX) were carried out using a Hitachi S-4700 to identify the morphologies and elemental composition on the foam surface.

## RESULTS

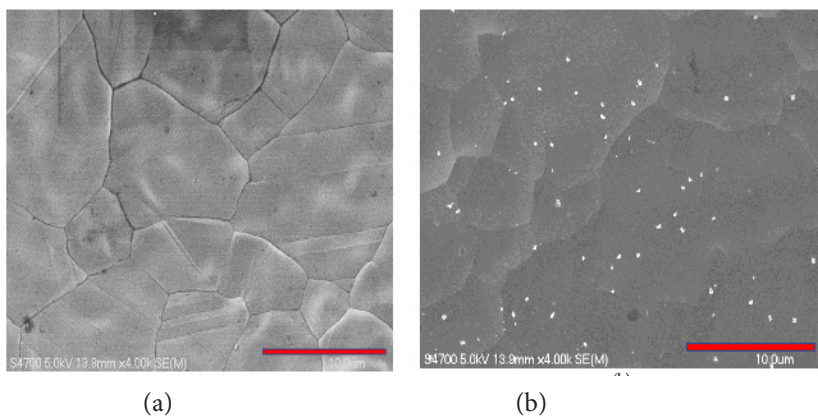
Figure 5 shows plain nickel and copper foams for reference.

### Sulfides

#### Nickel Sulfide

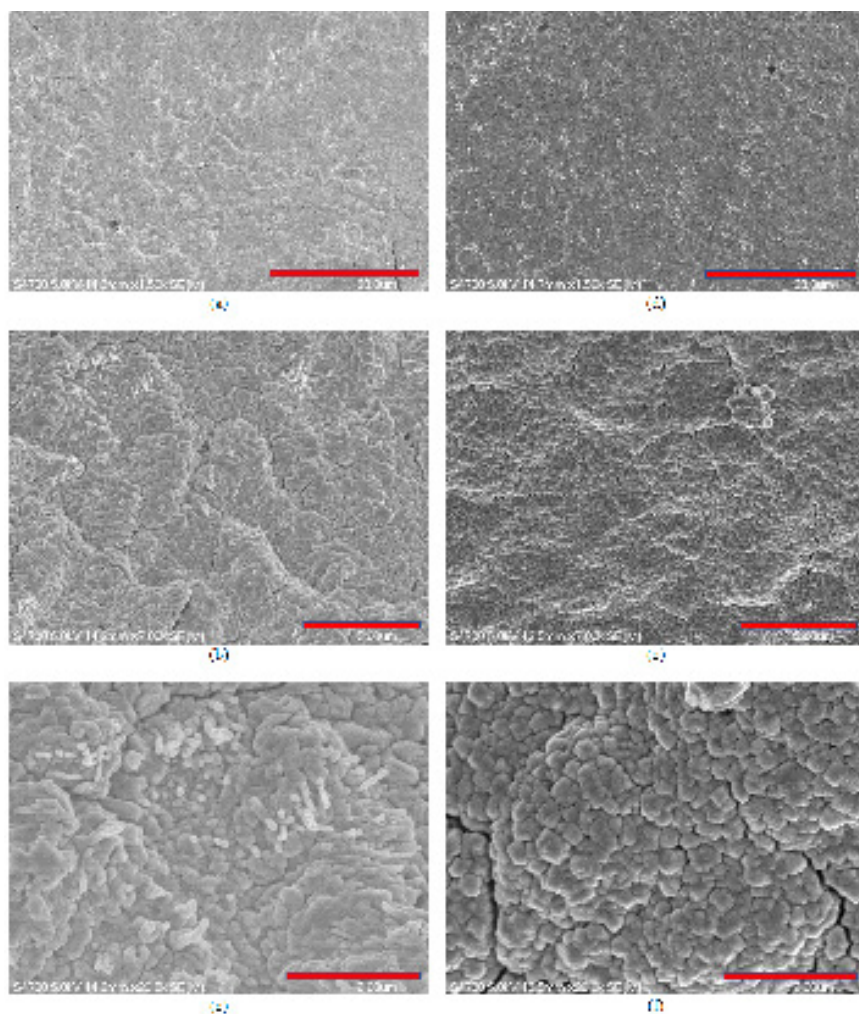
At low concentrations of sulfur and in the presence of plasma, the sulfide growth is more uniform in texture with fewer or less pronounced peaks or branches visible in Figure 6b and Figure 6c.

The thickness of the sulfide growth is greater in the presence of plasma as shown by the crosssection in Figure 7b. At high concentrations of sulfur, however, the differences are not noticeable. The growth is evenly spread and shaped with and without plasma as seen in Figure. 8. The thickness of the growth also is equivalent.

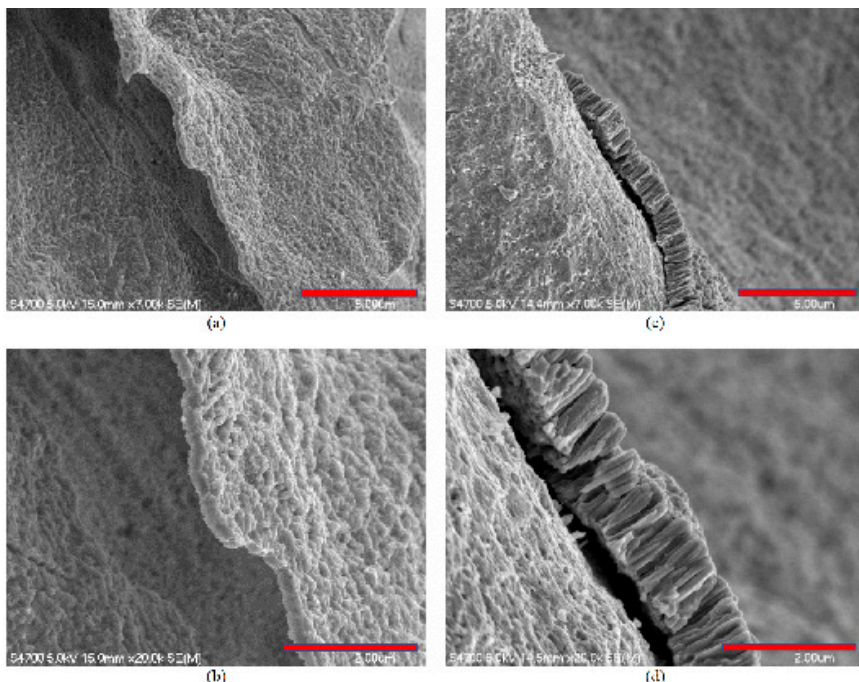


**Figure 5.** (a) Unaltered nickel foam. (b) Unaltered copper foam.

All XRD spectra are normalized with respect to the largest nickel peak around  $45^\circ$ . Figures 9 and 10 show many overlapping peaks, so it is very difficult to characterize the peaks as coming from a single species.



**Figure 6.** SEM images of nickel sulfide deposited on nickel foam with 1 mg S (a-c) without plasma and (d-f) with plasma.



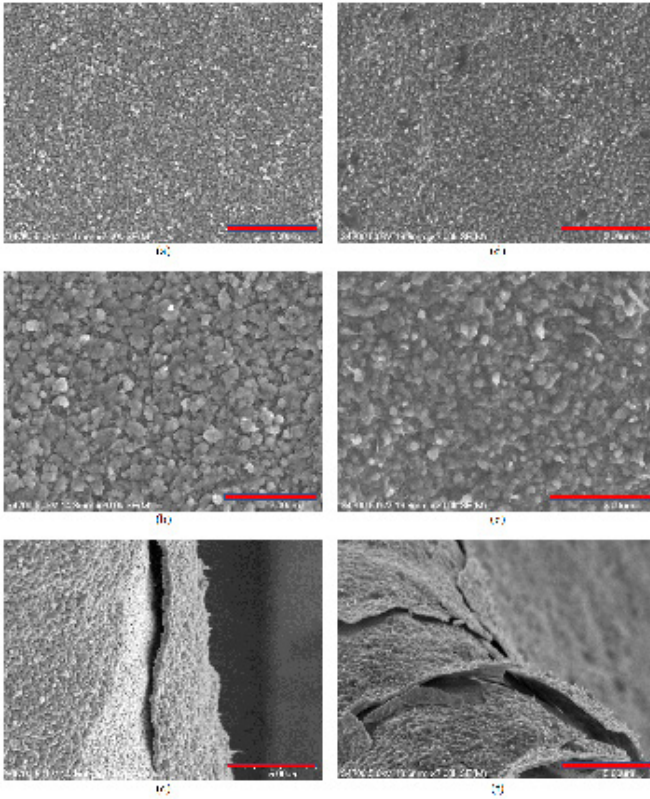
**Figure 7.** SEM images of nickel sulfide deposited on nickel foam with 5 mg S (a,b) without plasma and (d,e) with plasma.

### Copper sulfide

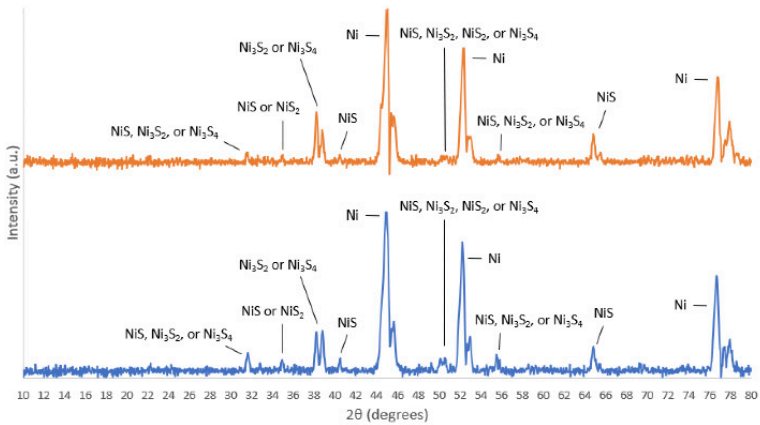
Figure 11 shows sulfide deposited on copper foam. Copper sulfide grown at higher temperatures has more even growth with fewer small grains being seen at high temperatures.

The thickness of the growth also changes substantially as shown in Figure. 12. Not only is the growth thicker at higher temperatures, but the cross-section is smoother than the column-like cross-section of the lower temperature growth. Small grains can be seen on the surface of the smooth cross-section. Increasing the initial concentration of sulfur shows similar results as increasing the temperature. The growth is more even with fewer, large grains interspersed, which is consistent with previous work.

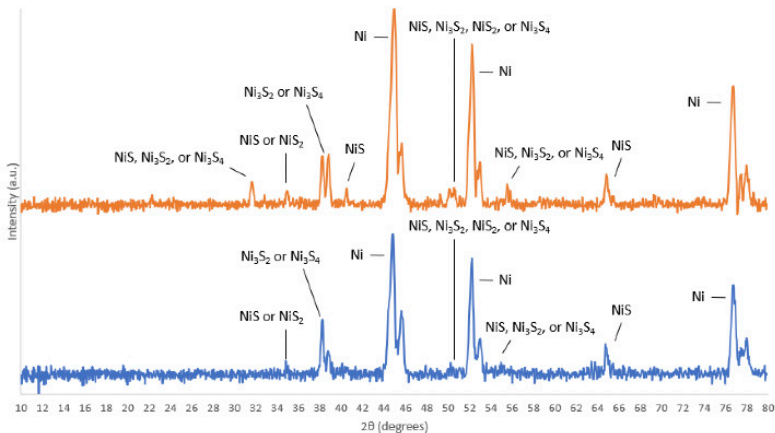
Looking beyond the surface and at lower levels of the copper foam, the growth at each layer is different, as shown in Figure 13. At lower levels, the copper foam beneath is more easily seen, and the sulfide grains are farther apart and smaller. All spectra are normalized with respect to the largest



**Figure 8.** SEM images of nickel sulfide deposited on nickel foam with 100 mg S (a-c) without plasma and (d-f) with plasma.



**Figure 9.** XRD spectrum of nickel sulfide on nickel foam with 1 mg S. Blue is without plasma; orange is with plasma.



**Figure 10.** XRD spectrum of nickel sulfide on nickel foam. Blue is the sample grown with 1 mg S; orange is the sample grown with 100 mg S.

copper peak around 44 degrees. The spectra in Figures 14 and 15 show that the initial concentration of sulfur does affect the species of copper sulfide synthesized. Like with nickel sulfide, there is much overlap between the samples, which makes it difficult to characterize the peaks as coming from a single species.

### Transition Metal-Molybdenum-Sulfur Complex

#### Nickel-Molybdenum-Sulfur

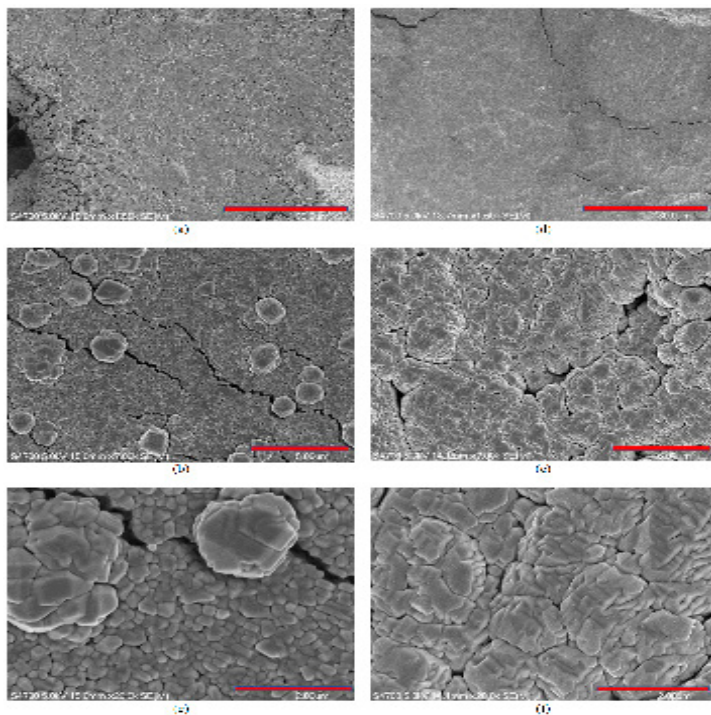
The SEM images in Figure 16 show that the nickel-molybdenum-sulfur complexes grown at different temperatures have clear, morphological differences. The samples grown at 750°C had more globular growth while the samples grown at 850°C had nonuniform growths.

For the growth at lower temperatures, the XRD spectra in Figure 17 suggest the presence of many different crystalline structures within the sample. For the growth at higher temperatures, however, the XRD spectrum has significantly fewer peaks.

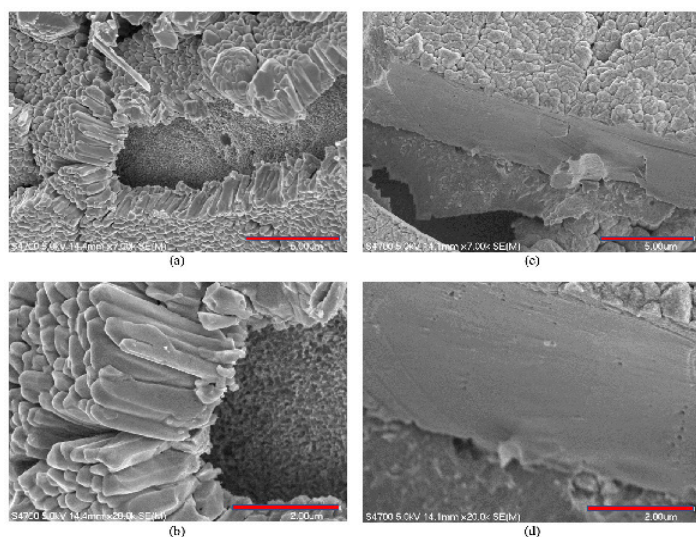
#### Copper-Molybdenum-Sulfur

The samples grown at lower concentrations of sulfur in Figure 18 show larger, more uniformly shaped grains while the samples grown at high concentrations of sulfur are less uniform in shape. The growths appear to be melted together. The morphologies at different temperatures also differ.

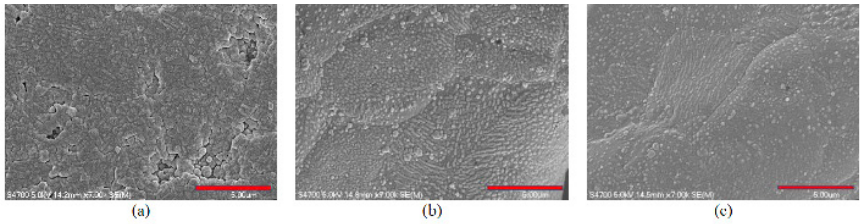




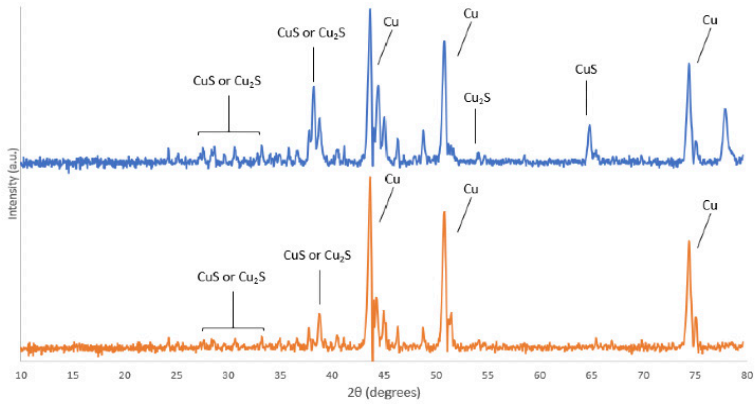
**Figure 11.** SEM images of copper sulfide deposited on copper foam with 1 mg S at (a-c) 300°C and (d,e) 500°C.



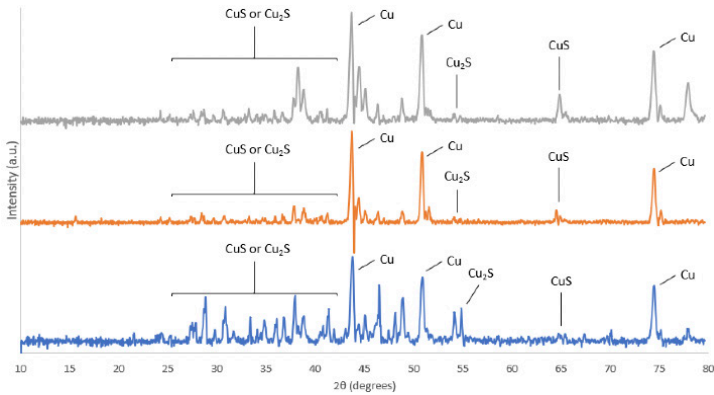
**Figure 12.** SEM images of copper sulfide deposited on copper foam with 5 mg S at (a-c) 300°C and (d,e) 500°C.



**Figure 13.** SEM images of copper sulfide deposited on copper foam with 5 mg S (a) one layer below the surface (b) two layers below the surface (c) three layers below the surface.



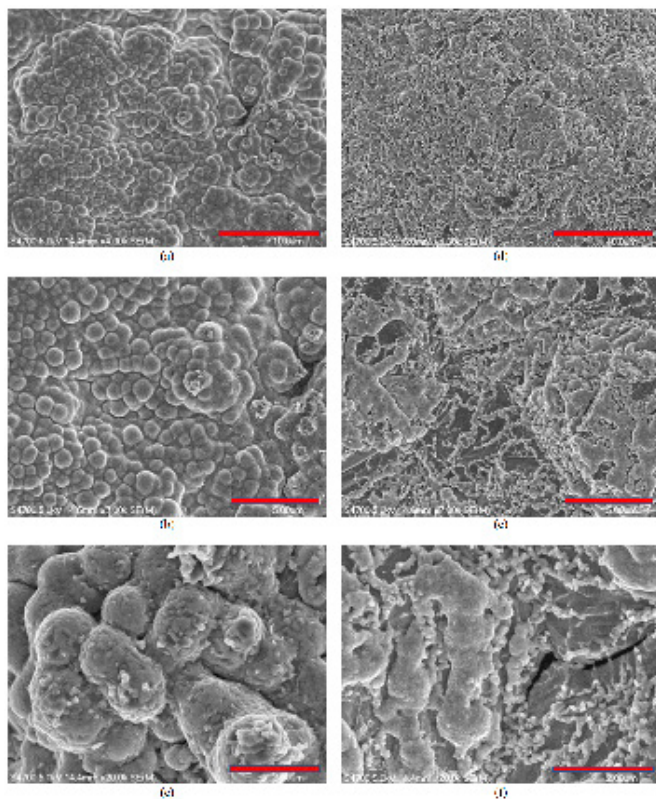
**Figure 14.** XRD spectra of copper sulfide on copper foam at 300°C. Blue is the sample grown with 1 mg S; orange is the sample grown with 5 mg S.



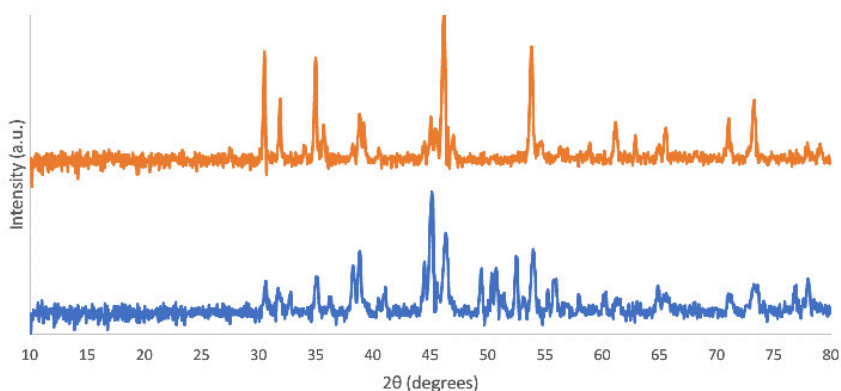
**Figure 15.** XRD spectra of copper sulfide on copper foam. Samples were grown with 5 mg S at (gray) 300°C, (orange) 500°C, and (blue) 750°C.

The sample grown at a higher temperature has sharper, more well-defined structures than the sample grown at a lower temperature as shown in Figure 19.

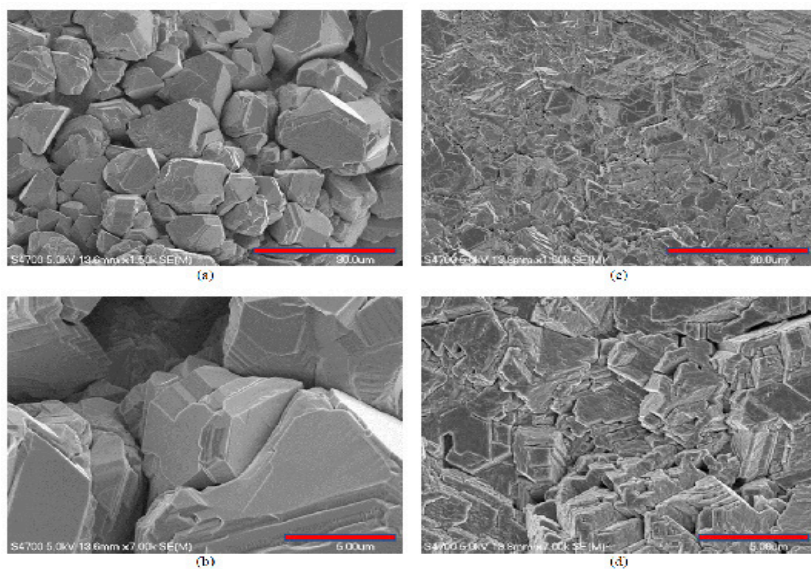
Looking beyond the surface and at lower levels of the copper foam in Figure 20, the growth at each layer is different. At lower levels, the copper foam beneath is more easily seen, and irregularly-shaped growths start to appear. All spectra in Figures 21 and 22 were normalized with respect to peaks around 38 degrees. Like with the nickel-molybdenum-sulfur complex, the spectra suggest the presence of many different crystalline structures.



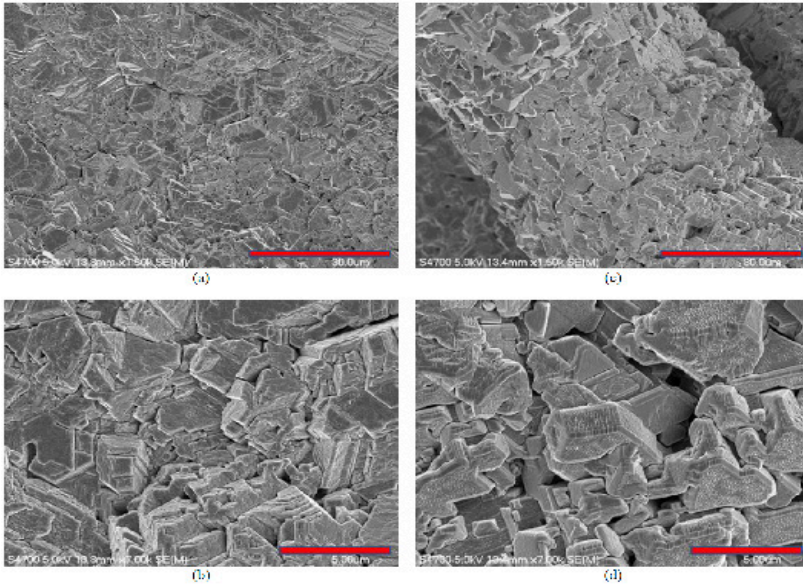
**Figure 16.** SEM images of nickel-molybdenum-sulfur complexes. The samples were grown with 500 mg S and 25 mg MoO<sub>3</sub> at (a-c) 750°C and (d-f) 850°C.



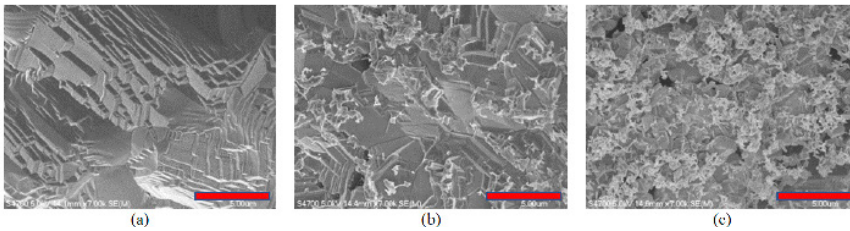
**Figure 17.** XRD spectra of nickel-molybdenum-sulfur samples grown with 500 mg S and 25 mg MoO<sub>3</sub>. Blue is the sample grown at 750°C; orange is the sample grown at 850°C.



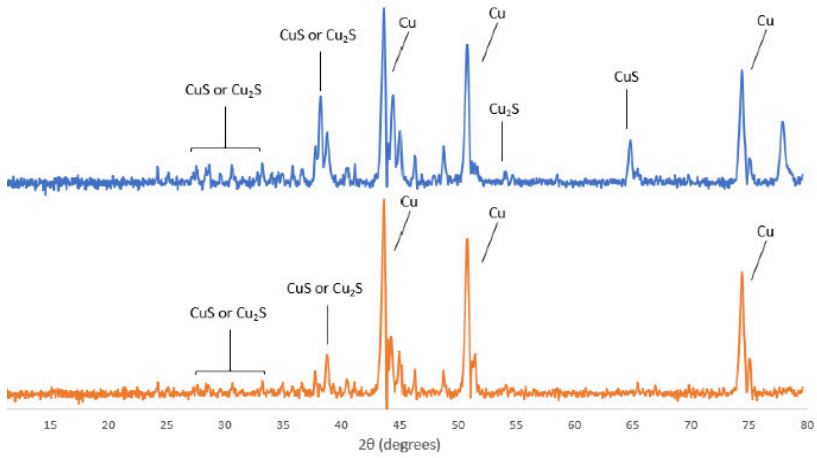
**Figure 18.** SEM images of copper-molybdenum-sulfur complexes. All samples were grown with 10 mg MoO<sub>3</sub> at 750°C using (a,b) 50 mg S and (c,d) 500 mg S.



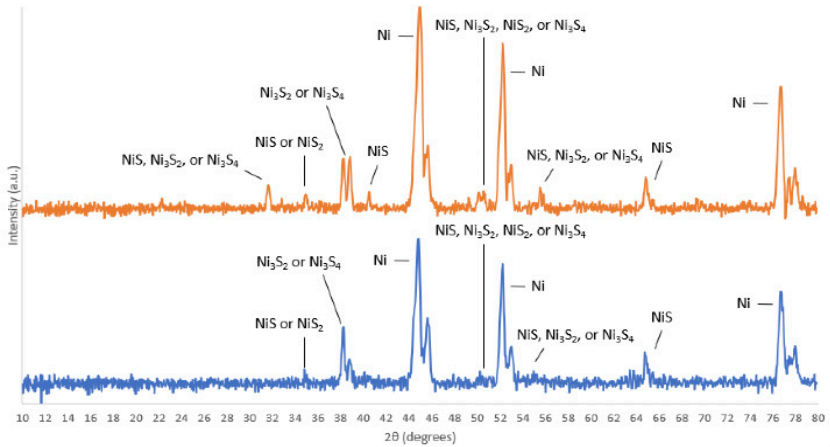
**Figure 19.** SEM images of copper-molybdenum-sulfur complexes. The samples were grown using 500 mg S and 10 mg MoO<sub>3</sub> at (a,b) 750°C and at (c,d) 850°C.



**Figure 20.** SEM images of the copper-molybdenum-sulfur complex growth (a) one layer below the surface (b) two layers below the surface (c) three layers below the surface.



**Figure 21.** XRD spectra of copper-molybdenum-sulfur samples grown with 500 mg S and 10 mg MoO<sub>3</sub>. Orange is the samples grown at 750°C; blue is the sample grown at 850°C.



**Figure 22.** XRD spectra of copper-molybdenum-sulfur samples grown at 850°C with 10 mg MoO<sub>3</sub>. Orange is the sample grown with 50 mg S; blue is the sample grown with 500 mg S.

## DISCUSSION

### Transition Metal Sulfides

#### Nickel Sulfide

The presence of plasma affects the surface morphology of the nickel sulfides with the plasma making the growth more uniform in size and density up to about 5 mg of sulfur. At high concentrations of sulfur, such as in the 100 mg samples, the surface morphologies and thickness were about the same.

Sulfur concentration and plasma do not affect the crystallinity of nickel sulfides produced as shown by the XRD spectra. Based on the XRD spectra, it seems that the temperature has a greater effect on the crystallinity than the concentration, but both affect the morphology. The XRD fitting software suggests that there is a mix of species of roughly the same stoichiometric coefficients, such as NiS<sub>1.3</sub> and NiS<sub>1.17</sub>. The non-uniformity of the foam's geometry may have also influenced the XRD spectra.

#### Copper Sulfides

Temperature and sulfur concentration have noticeable effects on the growth of copper sulfide with increasing temperatures and concentrations producing larger and more uniform grains. The accessibility of nucleation sites also affects growth. The less accessible fourth layer of copper foam has higher copper content, and what little sulfide has grown on the surface is much smaller in size and density than the easily accessible top layer.

Like nickel sulfide, the crystallinity of copper sulfides remains constant at low concentrations of sulfur and over a wide temperature range. The crystallinity changes significantly only at 750°C.

### Transition Metal-Molybdenum-Sulfur Complexes

#### Nickel-Molybdenum-Sulfur

The nickel-molybdenum-sulfur complex was successfully synthesized. First, nickel oxide was synthesized more quickly than the complex, which led to the nickel foam melting. However, by placing the MoO<sub>3</sub> in a separate crucible 25 cm away from the nickel foam, nickel oxide was not able to outpace the growth of the complexes.

Temperature has a significant effect on the morphology and crystal structure of the complex. At higher temperatures, the growth appears to have melted together or conglomerated into larger structures. It is possible that, like the nickel and copper sulfides, there are more phases present at 750°C than at 850°C.

Like with copper sulfide, temperature and sulfur concentration have effects on morphology and crystal structure. At higher concentrations of sulfur, the growth loses its smooth, well-defined structures and develops a rougher, denser growth pattern. However, the structure appears to become more separated and well-defined again at higher temperatures.

The accessibility of nucleation sites also affects growth with the first layer being the outermost surface and subsequent layers closer to the center of the foam. The less accessible fourth layer of copper foam has higher copper content, and unlike the higher, more accessible levels, the growth does not have relatively smooth and sharp morphology. Instead, there are randomly shaped and oriented growths.

Unlike the transition metal sulfides or the nickel-molybdenum-sulfur complex, the XRD spectra for the copper-molybdenum-sulfur complexes remained complex regardless of temperature or sulfur concentration.

## Conclusion

The presence of plasma seemed to have little effect on both the morphology and the crystal structure of the resultant transition metal sulfide. Temperature and sulfur concentration had significantly more effect, but while sulfur concentration influenced only morphology, temperature impacted both structure and morphology. The results match previous work.

## FUTURE WORK

In addition to further investigation on the relation between concentration and temperature on surface morphology and crystal structure, future projects will focus on the electrocatalytic activity of the transition metal sulfides and binary metal sulfides. The application of these materials in electrodes for HER or OER is promising but has not been fully explored.

In these experiments, the temperature and precursor concentrations were the driving variables in morphology and crystal structure because the relation between these factors on the growth on foam was not well understood. Other work can also include the other variables that come with CVD, such as the addition of plasma or the effect of flow rate differences. The activity of the other chalcogenides, selenium and tellurium, should also be evaluated.



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All submitted text is to be the sole creation of the author(s) with the exception of correctly cited paraphrases and properly indicated quotations. In cases where undergraduate students have conducted research with faculty or graduate students, papers should represent the student's contribution to the larger project.

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