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Reflective Essay

I wrote “The Secret Life of Bacteriophages: Where Did They Originate?” as my research paper and project for UWP 101 in Winter 2021. The purpose of the project was to focus on an issue that interests me and craft a theoretical lens, while also producing a sound analytical argument in a 2250 word essay. A requirement for this paper was to utilize at least six primary sources. My paper represents a quarter-long project of in-depth research concerning a topic that I knew very little about. Given the opportunity to choose any topic for my paper, I initially felt intimidated by my choice to discuss my own hypothesis about the origins of bacteriophages. However, having access to the grandeur and abundance of the library resources at UC Davis aided in the success of sticking with my topic and writing my paper. By the end of the quarter, I felt more confident and happy with my efforts in learning how to utilize much of the resources available to me.

The idea for the topic of my paper started while I was in my BIS 2C class during Fall 2020. My professor, Dr. Ledford, sat down on zoom with Dr. Eisen and another professor at UC Davis to discuss COVID-19 as part of our Friday playposit lecture. I emailed Dr. Ledford after the lecture and we scheduled a zoom meeting to discuss my questions about the coronavirus and viruses in general. After the meeting, I wanted to learn even more about viruses, so I began studying more about COVID-19 and how the three major hypotheses about the origins of viruses were formed.

For UWP 101, the research project was split into multiple assignments: a proposal, annotated bibliography, and research paper. This enabled me adequate time to become acquainted with my topic and organize how to make use of my resources. For the first writing

assignment, I was required to write a proposal to outline my topic and explore some possible theoretical lenses that I can apply to the topic. To choose my topic, my mind was set on the origins of viruses. However, it soon became clear that focusing on the origins of viruses as my topic was too broad. To combat this problem, I emailed a few librarians from the UC Davis library who specialized in Evolutionary Biology, Biological Sciences, and Microbiology to help me.

In my email, I explained that I was interested in researching the origins of viruses, viral relationships with immune systems in humans and bacteria, and making protein fold comparisons between viruses and bacteria. Sheena Campbell and Ruth Gustafson replied to my email and agreed to aid me in my research. Meeting over zoom, we discussed my topic and narrowed the scope of my paper to bacteria and phage coevolution, and the immune system. I chose to disregard discussing viruses in general and searched for primary sources concerning bacteriophages. When identifying overlapping similarities and information about the subject we were investigating, the library database only found thirteen sources.

Additionally, Ruth introduced me to BIOSIS, Web of Science, and Google Scholar to search for more primary sources. For databases like BIOSIS and the Shields library catalog, she explained that I need to avoid making searches that are broad because the database would provide me with too many sources that may not be relevant to my paper. As a result, Ruth taught me how to use taxonomic restrictions, taxa notes, concept codes, and to utilize keywords to narrow my searches in BIOSIS. For example, a concept code that helped narrow my search on the database was “01500” which was for topics on evolution. I used keywords and restrictions, for instance, *Bacteriophag**, *phage**, and “*Protein fold**”, and a taxa note of Viruses in order to limit the sources to bacteriophages and protein folds. I conducted more searches with restrictions

such as “*Immune System**”, *Bacteriophag**, *phage**, *immun**, *protein**, and *immunoglobulin** to locate studies relating the immune system and bacteriophages. From this search, I uncovered *A Member of the Immunoglobulin Superfamily in Bacteriophage T4* by Bateman et al. This study provided a focus on bacteriophage T4’s capsid (head) and the discovery of an immunoglobulin protein, Hoc, located on it. I used this source to try and answer the authors’ questions of whether T4 could be a late evolutionary invention from eukaryotic genes with my hypothesis. Continuing my search for sources, I removed several restrictions to broaden my search and skim through additional sources for general information about bacteriophages.

Removing a few restrictions allowed me to come across an article that tied in bacteria-bacteriophage coevolution with immune cells. In the source, *Bacteriophage and the Innate Immune System: Access and Signaling* by Amanda Carroll-Portillo and Henry Lin, I learned that there is evidence of bacteriophages regularly interacting with immune cells of the innate immune system. I sought to think about an explanation for this. I began by thinking that immune systems or defense mechanisms must contain information that defines and recognizes abnormal behaviors and mechanisms that would cause harm to a cell. I believed that it might be possible that a virus or mutation got ahold of this information to learn harmful behavior. This idea is what led me to mention in my hypothesis that bacteriophages were a negative mutation of early bacterial defense mechanisms.

Furthermore, I wanted to focus my paper on recent studies within the last ten to fifteen years for my research. I decided that if I used a source older than that, I would do my best to locate a study that builds off the findings of the original study. I felt that this was a fundamental and useful way to inform my readers of new discoveries regarding older studies. In office hours, Professor Bradley Sekedat discussed my topic and encouraged me to focus on more recent

studies as they would be more relevant to today's knowledge and research. My professor also motivated me to approach and write my paper in a manner that those who are unfamiliar with the topic of viruses would be able to understand my paper. Thus, I made a strong effort to add footnotes to words or phrases that I believed would be unfamiliar to most people and include a definition.

For the next portion of my research project, I needed to write an annotated bibliography. I was required to compose a bibliographic entry and an annotation that comprised a one-paragraph summary and a one-paragraph evaluation for each of the six scholarly sources I have chosen. Sheena had followed up with me over email and found additional sources that I can use as background information in my paper. These additional sources included *Multiple origins of viral capsid proteins from cellular ancestors* by Mart Krupovic and Eugene V. Koonin; *Do Viruses Exchange Genes across Superkingdoms of Life?* By Malik et al.; *"I will survive": A tale of bacteriophage-bacteria coevolution in the gut* by De Sordi et al., along with additional articles. *Do Viruses Exchange Genes across Superkingdoms of Life?* provided my paper with the background information to confirm whether or not viruses perform exchanges across different domains of life. I made use of the evidence and perspectives confirming cross-superkingdom exchanges as support for my hypothesis. From this source, I was also able to provide questions to my reader to allow them to follow not only my thought process, but to engage their thinking. For example, I asked how is it possible that viruses are making cross-superkingdom exchanges and what does this say about their origins? I placed several questions after every few paragraphs to engage my readers before I attempted to provide an answer with my own hypothesis.

When it came to writing my research paper, I wrote two drafts before submitting my final draft. When I reached my professor's minimum of six scholarly sources, I felt my paper was still

lacking and I wanted to explore my topic further. I sought to stray away from making my research paper seem like a scientific report. I wanted to find my own voice. To help me do this, I discussed the three major hypotheses that are being considered to explain the origins of viruses. I used this to guide my reader in understanding the other viewpoints and to also introduce my own hypothesis since neither of the major three have been universally accepted. Another method that helped me search for more sources was finding common sources that included similar authors and skimming through the citations used within the articles that I had chosen for my paper. I was able to find similar and more recent studies about the topic.

Due to COVID-19, I was working from home and unable to visit the UC Davis library to gather the sources. Instead, I downloaded the Library's VPN (Pulse Secure) to access the databases and the articles I needed. I spent several days searching for articles and studies that would support the topic of my research. One particular strategy that helped me was using a biochemist approach. In my BIS 102 class (Winter 2021), I learned how biochemists approached problems. For example, if they wanted to learn to understand how a car functions, they would take it apart to learn about each component and the pathways within the car. Then, they would put it all back together. I used this approach in both my thinking and to find sources. For the bacteriophage, I took the entity apart and began focusing on certain structures. For the purposes of my paper, I chose to study the capsid and "legs." I pondered about what other entity on Earth at the microscopic level had "legs." I adjusted my searches on BIOSIS and found a study proving that bacteriophage T7 "walks" on the surface of *E. coli* and "scans" for the injection site. To tie in bacteriophages with the immunoglobulin protein found within its capsid, I discovered that white blood cells also use "legs" to "walk" and "scan" for a location. These sources were extremely valuable for my hypothesis.

As I continued to alter the phrases of my searches in the UC Davis library, I found additional articles that opened my eyes to new ideas that I had not thought of to tie in with my topic. One article of much interest was *The Origins of Phagocytosis and Eukaryogenesis* by Yutin et al. From this source, they described how eukaryotic cells acquired bacterial endosymbionts such as the mitochondria. This led me to formulate an idea to answer how bacteriophage T4 contains an immunoglobulin protein whereas bacteriophage T2 does not. If a bacterial cell that contained the mutated mass of proteins was engulfed by a eukaryotic cell, then it was able to hijack the immunoglobulin protein and become a different virus. From the resources provided by the UC Davis library and the librarians, I was able to discuss various ideas, studies, and perspectives throughout my paper.

Today's events with the COVID-19 pandemic have also further contributed to my interest in this topic. In real time, I am able to observe the behavior of a virus and its rate of mutations and infections in real time. Viruses are stealthy and in order to create my hypothesis about the origins of bacteriophages, I needed to think about their behavior and what they would do. With viruses behaving stealthily and able to take over the functions of cells in secret, I decided to voice my thoughts on bacteriophages beginning as an abundance of proteins that mutated and would hijack proteins from within the cell. Then being replicated, engulfed, and passed to other cells to one day create viruses that affect other domains of life. Moreover, the question of how viruses have originated still puzzles scientists today. Many of the studies I read in my search for sources mentioned the limits of their findings due to a lack of understanding about the biology of viruses. I hope that one day my claims can be investigated and tested, and encourage others to continue uncovering more mysteries about viruses.

Despite the lack of confidence I initially felt about my topic, Ruth Gustafson, Sheena Campbell, Professor Bradley Sekedat, and the resources of the UC Davis library provided me with the knowledge to write my paper. I was given the unique opportunity to explore the ideas I had in mind through this research project, and further uncover the valuable information provided by the library to support my hypothesis. I was also given the wonderful chance to work with the librarians to understand databases such as BIOSIS, Web of Science, Google Scholar, and how to navigate the Shields library catalog. I am confident that I can employ the new skills I learned from utilizing the UC Davis library in the future and know that I can trust the library staff to always point me in the right direction.