Path to Pathology

New Mexico
Supercomputing Challenge
Final Report
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Team #187
Manzano High School

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Abstract

Superbugs are a rising threat to modern society. Superbugs are bacteria that have infected a living organism that are immune to antibiotics. Our research analyzes how to treat superbugs using an unconventional method, the use of bacteriophages to treat superbugs. We decided to research superbugs because we saw it as a rising issue for the future. Currently, superbugs are most commonly found in hospitals due to their frequent overuse of antibiotics causing bacteria to develop immunity to the drugs. Our goal is to try and stop superbugs using bacteriophages.

Figure 1: Bacteriophage visualization of the phage entering the bacteria.

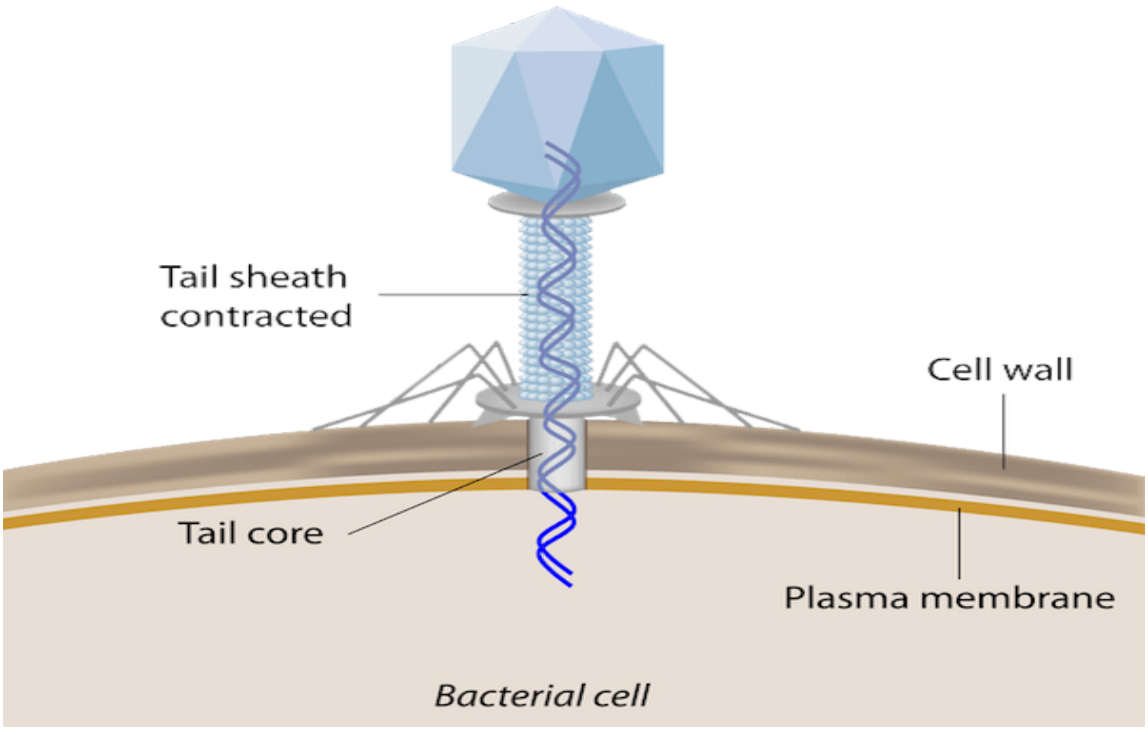
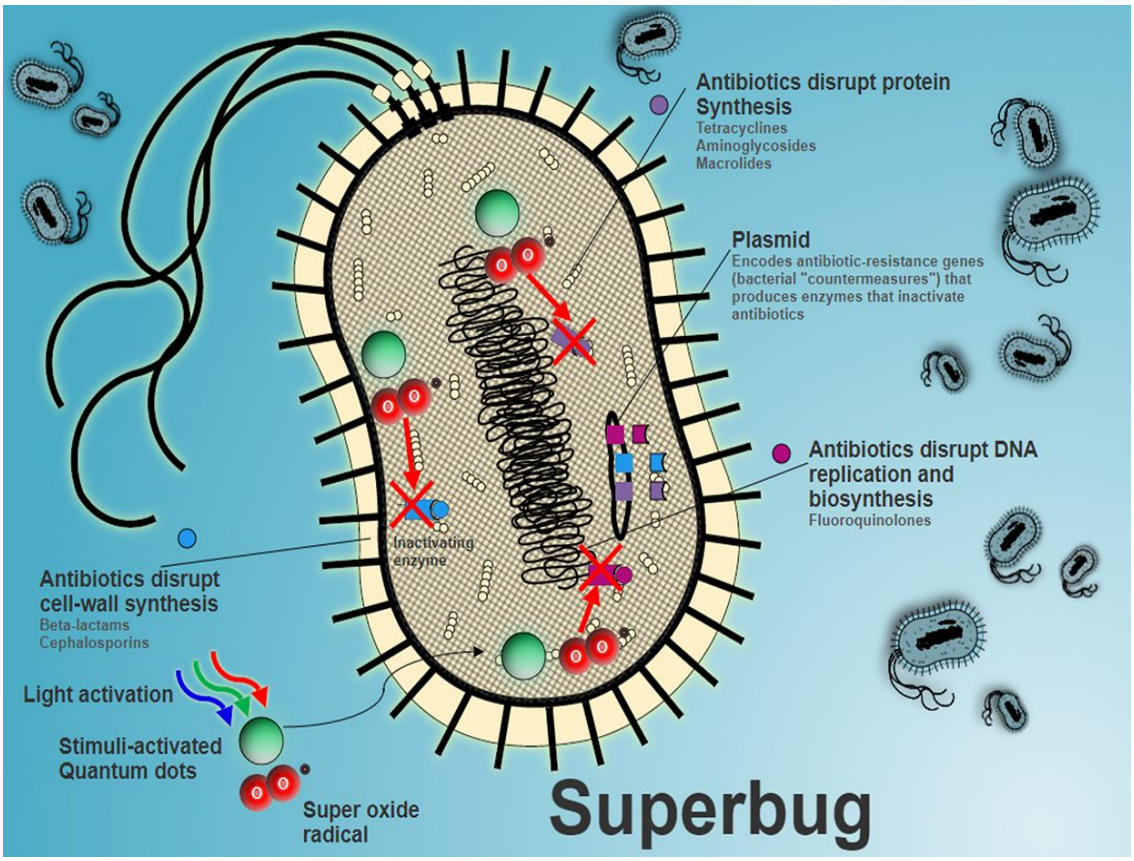


Figure 2: The structure of the Superbug labeled with information about its structures.



Introduction

We started our project with thinking about solving the disease smallpox. After going to the first presentation we realized it was a bad idea due to lack of proper research and data . Judges at the midterm presentation help us realize that and also to fix our mistakes. After realizing our presentation was haphazardly organized we decided to change it alongside the main focus of our project. We started to use NetLogo for our first simulation, we later worked with C++ because of its familiarity. We finally settled with python for machine learning as our computational aspect of our project.

We did research on ebola and later studied on smallpox after we met with Steven B. Bradfute, Ph.D., a Research Assistant Professor in the University of New Mexico Center for Global Health and Department of Internal Medicine. We started to study smallpox and the use of Bacteriophages, viruses made of proteins that trap a DNA or RNA genome and essentially deactivate it, as a form of cure. Since smallpox is a viral infection Bacteriophages would not work. After we discovered that we shifted our attention to using Bacteriophages to cure Superbugs. Superbugs are bacteria that have grown immune to antibiotics.

Our research on smallpox focused on the importance of smallpox and how it spreads. We started with the basics like where it originated and vaccinations. As of writing this paper our group is looking at phage therapy. Phage therapy is the use of bacteriophages for treatment.

Methods

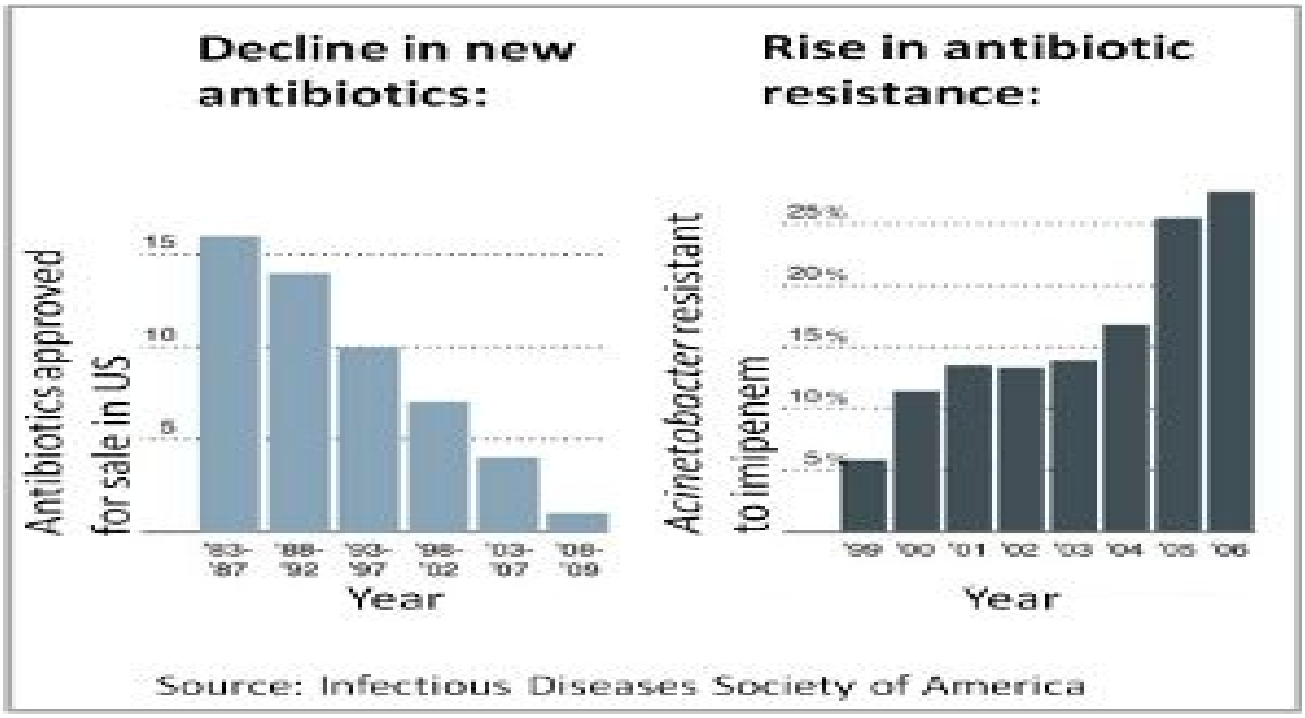
Current methods of treatment

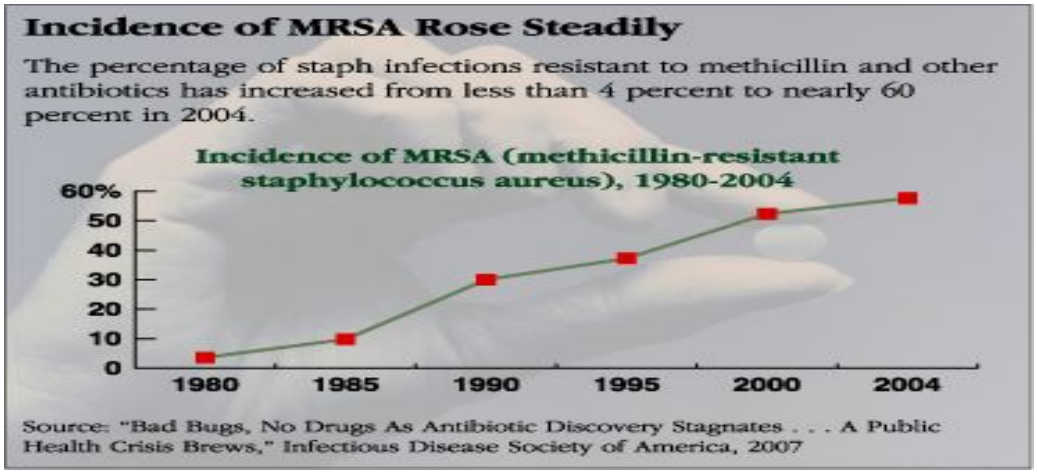
Some of the well known types of superbugs that plague us in the 21st Century are:

- ***Carbapenem-resistant Enterobacteriaceae (CRE)***
- ***Methicillin-resistant Staphylococcus aureus (MRSA)***
- ***ESBL-producing Enterobacteriaceae***
- ***Vancomycin-resistant Enterococcus (VRE)***
- ***Multidrug-resistant Pseudomonas aeruginosa***
- ***Multidrug-resistant Acinetobacter***

There are different forms of treatment for these superbugs, most common of which is to use very strong and last effort antibiotics which the bugs haven't developed immunity to. One major problem with this is that the bugs possibly will eventually develop immunity to these drugs as well. Other forms of treating superbugs is by using viruses (Bacteriophages). There are multiple way to implement this form of treatment, one of them is CRISPR which has been gaining a lot of traction in the medical field because it is has led the way to edit genes within a bacteria. To be clear, bacteria use CRISPR to defend against viruses but it can also be used to edit genes within the bacteria. Another form of treatment is to drink fluid containing bacteriophages, simple yet effective.

Graphs and Charts





This graph show how MERSA has been growing rapidly for the past 40 years. The graph was gotten from CQ RESEARCH.

Our Attempt At A Solution

One major problem with all of the treatments mentioned above are not being cost effective which could be a major problem in hospitals in underdeveloped countries. Our attempt to solve this issue is not the best but it is in an invitation for people to improve it in the future. Our goal is to classify the type of superbug and the best cure possible through software. To be specific, our goal is to use a neural network to identify the superbug. So what is a neural network? It is software that is modeled after the human brain. It works by sending input data into a series of nodes and compares the result to a known value from training data to give an output. Our training data will consist of symptoms and characteristic of a known superbug and second part of our training data will be bacteriophages that are known to work against the mentioned superbugs. We plan to use Google's open source machine learning platform TensorFlow.

Current progress

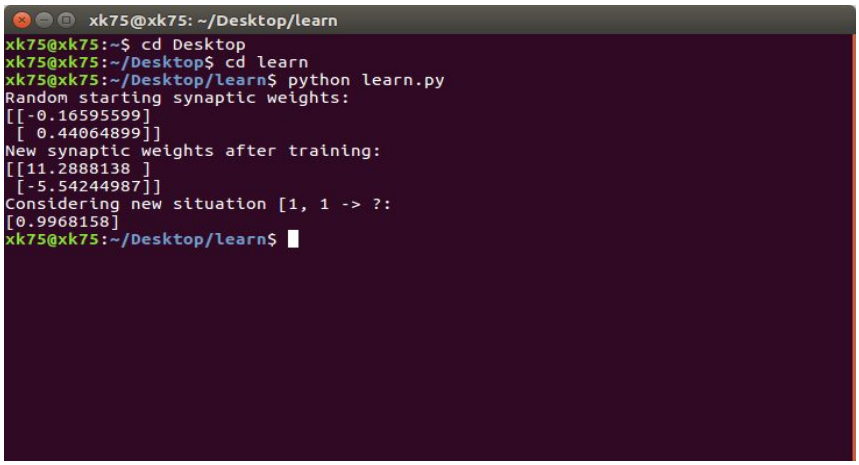
As of now, most of our time has been spent in researching so computing aspect of the challenge has not been a major issue. We are finally starting to shift our attention towards coding and collecting and refining data for the code. We have decided on the structure of the data and it is as follows: description of the superbug will consist of two letters. One of the letters will represent the type of superbug the second will represent the symptoms. The second part of the data will be the value assigned to the name of the bacteriophage that will counteract the bug.

Machine Learning with numpy on python, proof of concept before tensorflow created using Siraj Raval's guide .

xk75@xk75: ~/Desktop/learn

```
from numpy import exp, array, random, dot
class NeuralNetwork():
    def __init__(self):
        random.seed(1)
        self.synaptic_weights = 2 * random.random((2, 1)) - 1
    def __sigmoid(self, x):
        return 1 / (1 + exp(-x))
    def __sigmoid_derivative(self, x):
        return x * (1 - x)
    def train(self, training_set_inputs, training_set_outputs, n
umber_of_training_iterations):
        for iteration in xrange(number_of_training_iterations):
            output = self.think(training_set_inputs)
            error = training_set_outputs - output
            adjustment = dot(training_set_inputs.T, error * self
.__sigmoid_derivative(output))
            self.synaptic_weights += adjustment
    def think(self, inputs):
        return self.__sigmoid(dot(inputs, self.synaptic_weights)
)
if __name__ == "__main__":

    neural_network = NeuralNetwork()
                                                    1,1           Top
```



Output

Conclusion

Our research and hypothetical implementation of bacteriophages prove to be a possible future for medicine and disease containment. The bacteriophages infect and replicate inside a bacteria until the disease is fully contained. Bacteriophages are not only versatile but also effective. The bacteriophages can be adapted and mutated to combat specific diseases and can be mass produced. Using bacteriophages would allow for an overall more effective way to control those diseases that are antibiotic immune and would be efficient at containing those disease completely and quickly. Our main focus would to be combat superbugs with bacteriophages. These superbugs are in fact becoming more and more antibiotic resistant and much more common. The uncleanliness and nature of hospitals cultivates these superbugs which could become a serious issue in the future. With bacteriophages, the only flaw in using it to combat disease is the current lack of cost efficiency. Bacteriophages are expensive in production but still very effective for this task. Overall, with superbugs becoming a more potent threat and considering the overall effectiveness of bacteriophages, we see that using bacteriophages will become very important and useful in the future against the war on disease.

Acknowledgements

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We would like to thank our sponsor EC-Council for helping out with the funding that our group needed to improve research on our topic and for helping us get in the competition. Thank you, EC-Council.

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Steven B. Bradfute

We would also like to thank Mr. Bradfute, a Ph.D. and a Research Assistant Professor in the University of New Mexico Center for Global Health and Department of Internal Medicine, Mr. Bradfute helped us narrow down ideas what diseases we needed to focus on in order to have an efficient research and presentation. Thank you, Mr. Bradfute.

Sharee Lunsford

Of course, we would like to thank Ms. Lunsford. Ms. Lunsford has been at our meetings every time. She has provided us crucial strategies and help of proofreading on our powerpoint slides and research paper for our topic. Thank you, Ms. Lunsford.

Karen Glennon

We would like to thank Ms. Glennon for supporting us in a crucial way. Ranging from providing snacks to reminding us of deadlines for the presentation and research paper to helping us proofread our paper to providing us materials, Ms. Glennon was a huge support and our group gladly appreciated her help. Thank you, Ms. Glennon.

Kurtis Griess

Lastly, we would like to thank Mr. Griess for giving us ideals and for suggesting EC-Council as a possible sponsor for our group. Mr. Griess has also helped us with editing our presentation and research paper. Thank you, Mr. Griess.

Individual Significant Achievements

Jerrel White: What I learned and got out of this program is that research can be hard if you don't have the right kind of research. Research is important because you need research to help with determining the code.

Seth Griffin: I learned from this whole experience that teamwork and cooperation is vital and collaboration is key to success. But I also find that individual work, individual study, is the most important thing for self-improvement and self-learning. Using those two things are what got me through this whole experience and left me smarter and more knowledgeable.

Torrey Luong: I learned that communication is very crucial and without it, this team would fall into pieces. Our teamwork was good and helped us become better people. It helped me get along with other people and to communicate to people more properly. This experience also helped me improve on my researching skills.

Manoj Subedi: During the project I learned that communication is key to team work. The challenges that arose during the competition got our group to learn more and research better. Personally, I am grateful to the competition for forcing me to learn more python.

Nigone Phommachack: It was clear that our group required large amounts of work which then requires teamwork that had to be really efficient. But efficient teamwork also meant efficient communication skills amongst myself and the members of the team and I was glad that I learned how to utilize these skills in order to contribute to our team's project.

Danny Luong: What I have acquired from working in this group is that if you want to accomplish anything you have to work for it and not wait for other people to do it for you. Doing the super computing challenge has taught me how to manage my time better.

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