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Bacterial DNA

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DNA is an intriguing topic that has many different aspects that all play a crucial role in the life of every organism. More so, bacterial DNA is a topic that has been studied a multitude of times and there are still many unanswered questions concerning the DNA. Bacterial DNA is incredibly versatile. It can activate immunity in plants[1], the ligase found in bacterial DNA is different from eukaryotic DNA[2], and the topology of bacterial DNA plays a role in infectious diseases[3]. Every day, more and more research is being done by scientists and microbiologists on bacterial DNA which leads to a surplus of academic papers being written on the topic. Due to the large amount of interest bacterial DNA receives, knowledge of the subject is easily gained and can lead to great medical advances in dealing with infectious microbial diseases. Bacteria are a fascinating group of organisms. Regardless of their small sizes, they are very complex in their cellular functions.

Introduction

Bacterial DNA has an amazing extent of properties. Bacterial DNA can activate immunity in specific types of plants[1]. Eukaryotic cells must have special mechanisms to prevent pathogenic organisms from invading the cell and causing disease or death. One such mechanism is the ability of eukaryotic cells to recognize microbe-associated molecular patterns (MAMPS) [1]. Microbe-associated molecular patterns are molecules related to specific microbes that are detected by the innate immune system in organisms, such as plants and animals. In the study of activating immunity of *Arabidopsis thaliana*, it was found that non-methylated MAMPs induced an immunity response whereas methylated MAMPs do not induce an immunity response.

Another astounding aspect of bacterial DNA is the correlation between bacterial DNA topology and infectious disease[3]. It has been found that virulence traits in a pathogen can be looked at as a response to its own changing physiology[3]. The different placements of genes in a bacterial genome (the topology) play a great deal in what genes are expressed in different environments. A great deal of gene expression deals with DNA supercoiling by DNA gyrase. If scientists can figure out how the bacterial DNA is supercoiled in the future, it will become easier to make useful antibiotics that prevent the spread of bacterial infection.

Bacterial DNA is quite different from eukaryotic DNA in some areas. One such area is found in DNA ligase. DNA ligase is used in the process of DNA replication.

It is used specifically in the breaking of phosphodiester chains in DNA so that there is a template strand of DNA for the replication. DNA ligases all follow the same mechanism, but either use ATP or NAD+ as a cofactor[2]. Eukaryotic cells use ATP cofactors, whereas all bacteria use NAD+ as a cofactor but may possess ATP as well. This could have huge medical implications, like the DNA topology mentioned above, in creating more effective antibiotics.

Bacterial DNA is an amazing subject. Like briefly mentioned above, there are at least three large points of bacterial DNA that are truly stunning and can lead to great advances in the medical field especially in treating bacterial diseases and outbreaks. Because it was found that some bacterial DNA can activate immunity in plants, bacterial DNA could be used to activate immunity in other organisms as well, like a vaccine. Certain genes in bacteria, such as *Staphylococcus aureus,* could be flagged to activate immunity in humans to prevent a harsh

Staph infection. Staph infections are especially harmful to the young, elderly, and immune-compromised. If that strain of bacteria could activate immunity against itself in those groups of people who are seriously harmed by it, the mortality rate of nosocomial infections would drop significantly.

Also, virulence in some strains of bacteria is due to the placement of those genes in the whole DNA and how that DNA is coiled. Using topoisomerases on bacterial DNA can influence how tightly or loosely the DNA is coiled and thus could prevent some virulence genes from being expressed. Reverse transcriptase can also be used by viruses on the DNA to prevent virulent gene expression depending on where the gene is placed in the bacterial chromosome. Like the aforementioned example of *S. aureus*, using topoisomerases or reverse transcriptase by viruses to prevent virulent gene expression could lead to the survival rate of those who are affected by these destructive pathogens.

Lastly, bacterial DNA ligase is much different from eukaryotic DNA ligase. DNA ligase is the enzyme used in DNA replication that allows for the template strands to be separated by breaking the phosphodiester bonds and replication to occur properly. If there is already a bacterial infection present in a patient, an antibiotic could be prescribed to target bacterial DNA ligase which then would use selective toxicity to stop the bacteria from replication its DNA properly. If the bacteria are not able to replicate DNA, it is not able to replicate at all which leads to cell death and the eventual end of the bacterial infection.

Recent Progress

Because of the recent advances in studying cell and molecular biology, new technologies and antibiotics are being used and produced in large quantities. It is becoming more and more apparent that the way the bacterial genome is set up and the different mechanisms used within bacterial DNA replication differ from eukaryotic DNA. This allows for more selectively toxic antibiotics to be made that have less harmful implications on the host. Also, the knowledge that some bacterial DNA strands activate immunity in the host leads to a greater understanding of how the innate immune system reacts to infections.

Medical scientists are looking towards making new antibiotics that attack certain things such as bacterial DNA gyrase. They are continually looking into antimicrobials that will disrupt DNA supercoiling and prevent the virulence genes in bacteria from being expressed. They are also looking into antibiotics that will specifically disrupt bacterial DNA replication by preventing NAD+ cofactors from helping the DNA ligase break DNA strands. This is very useful because like was previously mentioned; eukaryotic cells do not use ATP-dependent ligase in DNA replication.

Discussion

The continual study of bacterial cell biology and the new discoveries that are being made every day lead to a huge increase of success in the medical field. The study of bacterial genome topology and its effects on pathogenicity can be used to prevent outbreaks in new wide spread bacterial infections. If scientists and microbiologists can accurately map out the whole topology of virulence genes in a bacterial genome, medical scientists will be able to more effectively create antibiotics that have a great more deal of selective toxicity than the drugs that are currently being used to treat infectious diseases.

Looking at studies that examined how bacterial DNA activates immunity in model organisms, scientists will be able to decide with microbe-associated molecular patterns (MAMPs) are more specifically able to activate immunity in eukaryotic cells. If microbiologists can determine these specific MAMPs, there is a possibility that they can use gene therapy in bacteria to place the specific MAMPs in the bacteria that do not contain them. If this was to happen, the innate immune system in eukaryotic organisms would be able to more effectively stop infections before they became wide-spread.

Lastly, the knowledge that bacteria use NAD+ ligase in replication allows for a great influx in better antibiotics. If antibiotics can be made to prevent NAD+ ligase from beginning DNA replication, the bacterial cell would die due to its lack of replication mechanisms. All three articles I read deal with bacterial genomes and replication. They all allow for advancements in antibiotic treatments and advances in the medical field. There is still a huge amount of unanswered questions dealing with bacteria, but there are small steps being made every day by scientists that will eventually answer these questions. Cell and microbiology is a fascinating subject that will always allow for critical thinking and for microbiologists to further their knowledge of how bacterial cell function.

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