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DNA Methylation in Context to Memory Formation

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If a cell uses DNA methylation in cooperation for gene expression, genes are passed down from parent cell to daughter cell. Methylation binds to cytosine on DNA. The Regulator protein also binds to DNA and will turn gene expression on or off. This protein attracts the enzyme polymerase and it will initiate transcription. This process will help to manage the amount of cells produced. This is useful throughout the body. Methylation helps cells to remember where their specific cell site is and designated function is. Without methylation cells would have no memory of this. DNA methylation has been found to have an increase in levels of trimethylation and dimethylation of histone proteins found in the hippocampus. This is where memory formation begins, as a result DNA methylation aides in memory.

Introduction

Our bodies are filled with millions and millions of cells, and each cell has their own function. Although every cell has the same DNA make-up, genes in the DNA can be expressed differently depending on the function of the cell. This is called gene expression and it is what makes specialized cells function appropriately. To better understand this process, imagine how each organ in the body has different cells. Each of these tissue cells has different objectives, but as an end result all cells have the same DNA. Gene expression is what makes differentiation of a cell become a liver cell, a white blood cell, or a red blood cell. These are all considered specialized cells because they have different functions. By having this differentiation of cells different RNA and proteins can be made.

Once a cell has become a specialized cell, it will need to be able to pass its exact genome to the daughter cells. During the cell cycle, immediately after replication of the DNA in the parent cell, an enzyme will copy the methylation patterns used and pass it on along with the DNA to the daughter cells. DNA methylation can be found at the cytosine base in the histone tails. A promoter region of a gene will attract DNA polymerase to copy the DNA and the methylation. DNA methylation attracts the regulator protein, which turns off gene expression and makes cell division possible without creating a new gene expression. DNA methylation is used to turn off gene expression, helping the cell to continue to be specialized at a specific region. This can be done without altering the nucleotide sequence of the DNA. DNA methylation is used to turn off gene expression, helping the cell to continue to be specialized at a specific region.

Although there are many types of proteins a very important protein in context to transcription is a regulatory protein, which acts as a repressor or an activator. This protein's purpose for specialized cells is to turn the genes on or off. Thus the names repressor turns off, and activator turns on. The repressor protein is used to decrease transcription and the activator protein aides in transcription.

DNA methylation is critical for eukaryotic cells because it prevents cell death of specialized cells. If DNA methylation were not available for descendants of parent cells, then cells would not know what genes needed to be expressed. DNA methylation helps the cell to continue to pass down the genetic information needed to function appropriately.

By DNA binding to an enzyme and regulatory protein, DNA methylation causes a reaction. This reaction will initiate transcription of the DNA. During activation of transcription enzymes bind to histone protein, DNA methylation can be found attached to the lysine in the histone tails. The Regulator protein will either turn the gene on or off, allowing daughter cells to be transcribed or decreasing transcription.

In company with DNA methylation helping the regulatory protein to turn on or off cells, cell division will occur only when necessary and cells will be made in the appropriate numbers. When cancer invades the body, it begins with a specialized cell creating a mutation in the DNA and then quickly replicating several cells by generating an uncontrollable cell division. Since DNA methylation attracts enzymes, these mutations can usually be cut out of the DNA and the problem will be solved before it replicates. A few bad cells do not harm our bodies, but when an uncontrollable cell division occurs it may become harder to eliminate the bad cells in larger numbers.

DNA methylation is necessary for the memory of all cells. Without DNA methylation cells cannot remember where they have been and what they need to do. Because the cell life is short DNA methylation is extremely important to every cell in the body. Information needs to be transferred on to descendants, and DNA methylation makes it possible.

Recent Progress

To test if DNA methylation is used in context to memory an experiment was performed using fear conditioning. Fear conditioning is a form of learning that involves an uncomfortable shock paired with another stimulus. In this testing experiment the stimulus is a training chamber and a tone. For this experiment mice were used. In the testing environment scientist used training chambers as neutral context, intervals of shocks as a stimulus, and tones associated with the shocks as the neutral stimulus. To test Fear conditioning the mice were grouped by: exposure to context as a control (Group 1), exposure to context plus shock as second control (Group 2), and a naïve group (Group 3).

Two tests were performed in which group 1 and group 2 were put into context chambers and received a series of shocks. Twenty-four hours after the shocks were received both groups demonstrated freezing behaviors. The freezing behaviors the mice displayed could be described as 5 to 10 pauses in any activity. The second test had a series of tones followed by shocks. The freezing behavior was displayed by the mice again immediately after.

Twenty hours after the experiment the mice were put back into the chambers and groups 1 and 2 demonstrated the same freezing behavior, which proved training had been successful. The mice associated the chamber with the previous testing of shocks.

As a result of the experiment it was demostrated that DNA methylation is used in the hippocampus during fear conditioning. To identify whether DNA methylation was altered from the fear conditioned training, histone methylation was extracted and compared to the mice that did not undergo fear-conditioned training and served as a naïve (Group 3).

The group 1 and 2 that experienced the fear conditioned training compared to the group 3, displayed an increase in trimethylated histone levels in lysine found in the hippocampus approximately 1 hour after training. Trimethylated histone at lysine is the site where active transcription occurs. This experiment shows that active transcription occurs during consolidation of a memory in the hippocampus from fear conditioning. As a result we can see the stimulus was stored in long-term memory and confirm that DNA methylation is used to help in memory formation.

Discussion

DNA methylation in context to memory has not been studied long. The possibilities could be endless with further examination. If DNA methylation was further studied, it could possibly aide with cancer patients. The most important function of DNA methylation is helping specialized cells to remember their functions and pass them along to their daughter cells. Without DNA methylation our cells would be lost.

DNA methylation has the ability to pass gene expression onto all of its descendants, therefore cellular memory can be maintained. Since the longevity of a cell is approximately 24 hours, and a memory can last a lifetime; the need for DNA methylation is critical for the conservation of memories.

Peer reviewed studies show that DNA methylation has been found to have increased levels of trimethylation and dimethylation of histone proteins found in the hippocampus. Trimethylation is generally used in active transcription and dimethylation is used in the blocking of transcription; in context both come from methylation that attracts regulator proteins.

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