

Methylation in Space

Mission Objective

Scientists in training will gain an understanding of how the environment of space may affect the expression of the DNA.

Background

Every living thing from single-celled bacteria to human beings have DNA which contain the instructions for the structure and function of organisms. The study of the actual structure and sequence of the DNA code that makes up a gene is genetics. The sequence of the DNA we are born with does not change during our lifetime. However some environmental factors, such as the amount of sleep or nutrition can cause a specific change around the DNA. These changes are not changes to the genetic code, but rather to how it is read or expressed. The study of these changes in organisms is epigenetics. Methylation is a form of epigenetics where a methyl group (-CH₃) is attached to the structure making it unable to be read or expressed.

Methylation is a type of epigenetic modification (change to the DNA) where a methyl group (-CH₃) is attached to the DNA. These methyl groups can attach to the DNA at CpG sites. A CpG site is anywhere in the DNA sequence where a C is followed by a G. In the figure below, everything highlighted in red is a potential site of DNA methylation.

CTCATT**CG**TAGCAT**CG**TCCTAGG**CG**GGAG**CG**TCATCATGATGAG**CG**ATTAGCAT

- 1) Methylation causes a DECREASE in the transcription or reading of a gene decreasing the expression and the amount of that protein that will be made in an individual cell.
- 2) Lots of things can affect methylation – What you eat, where you live, who you interact with, when you sleep, how you exercise, even aging– all of these can eventually cause changes around the genes that will turn those genes on or off over time.
- 3) Methylation makes everyone unique – since methylation is separate from our DNA sequence it can also produce a large amount of variability within a population. It might be why some people like the taste of broccoli but hate the taste of chocolate.
- 4) Methylation is reversible – Since it does not directly affect your DNA those methyl groups can be added or removed throughout your lifetime! It is not permanent, as your lifestyle and environment changes so will the epigenetic profile of your DNA!

Epigenetics in Space

Recently astronaut Scott Kelly spent 1 year in space to allow scientists to study the effect of long-term space travel on the body (it can take over 6 months to get to Mars). Luckily, Scott Kelly has a twin brother who is also an astronaut so they were able to compare between identical subjects (Mark Kelly as the control on Earth and Scott Kelly the experiment on the ISS). Reports show that 7% of Scott Kelly's DNA *expression* (due to a change in methylation) was affected by his 1 year in space, likely due to changes in



his environment (like microgravity), his sleep (he saw 16 sunrises and sunsets everyday) and what he ate (astronauts have to eat healthy while they are in space). It is important to remember that the order, or sequence of base pairs does not change, but how it can be read or expressed may change. Ongoing experiments are being conducted to determine what genes were changed.

Materials

Methylation activity board sheet
Dice
Environment cards
Dry erase markers

Methods

- 1) Select a sequence for a trait.
- 2) Begin to read the sequence. When a CpG site (anywhere on your sequence with a CG) is reached, draw an ISS situation card.
- 3) Roll to determine if that site is methylated based on the selected ISS environmental card.
- 4) If that site is methylated, draw a methyl group (CH₃) on it and start reading again at the next DNA base pair.
- 5) Count the number of methylation sites and determined the condition or phenotype.
- 6) Select a new sequence and repeat until all phenotypes have been determines.

ISS Environmental Cards

1) Solar flare (Add methylation if you roll a 2, 3, 4, 5, 6)
2) Family video chat (no change)
3) Experiment went poorly (Add methylation if you roll a 2, 3, 4, 5, 6)
4) Heat systems failed (Add methylation if you roll a 2, 3, 4, 5, 6)
5) New cosmonauts arrive on station (Add a methylation if you roll a 1)
6) Sleep changes (Add methylation if you roll a 3, 4, 5, 6)
7) New exercise regime (Add a methylation if you roll a 1 or a 2)
8) Cargo delivery with fresh fruit (no change)
9) Look out and see the Earth (remove 1 methylation)
10) Experiment went poorly (Add methylation if you roll a 4, 5, 6)
11) EVA (Add a methylation if you roll a 1, 2 or a 3)
12) Finished tasks and have more free time (Add a methylation if you roll a 1)
13) Capsule reentry – Add methylation if you roll a 2, 3, 4, 5 or 6

