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We often think of genes as being a static piece of information in DNA that determines different physical aspects of an organism. I have blue eyes because I have the gene(s) for blue eyes. And while the DNA is important to determining such features, the ultimate ability for a gene to influence such traits lies within proteins. Each gene within DNA is a blueprint for these proteins, the proteins are the functional machines. Given this information, how do we go from DNA to protein, from blueprint to machine. This is particularly challenging as proteins are made in a location separate from where the DNA is stored in a cell. Messenger RNA (mRNA) serves as this intermediate between DNA and protein. You can think of mRNA as a temporary copy of the genic portions of DNA that is single stranded, rather than that familiar double-stranded helix. An RNA molecule is even made up of four bases like DNA: adenine (A), uracil (U), cytosine (C), and guanine (G), and is usually derived from a single gene and therefore contains the blueprint for a single protein, mailed out straight from the DNA post office.

But much like an experience with the postal service, just because something is mailed out doesn't mean it will get there expediently nor is arrival even guaranteed. Much like a mail system has many different designations, airmail, priority, and the 'return to sender' process for unmarked mail, mRNA can be labeled, processed, and shipped for protein production, or destroyed in a variety of ways. Recently, there has been interest in characterizing the role of a small ‘stamp’ that is placed on many mRNAs where a tiny chemical addition is added to a specific location on ‘A’s found within these molecules. This chemical modification known as ‘N6-methyladenosine’ or m6A for short is found in the majority of mRNA molecules, yet what this tag does to regulate the fate of these molecules in plants is still unclear.

In order to answer this question, we took healthy genetically ‘normal’ (wild-type) plants and mutant plants that were incapable of adding this m6A mark to these molecules and sequenced all of the mRNAs in both types of plants. Our sequencing experiments showed us that mRNAs in wild-type plants that contained m6A were far more abundant when compared to these same molecules in mutant plants lacking this chemical tag. When we investigated further, we noticed that in mutant plants these molecules were cleaved right before where the m6A modification should have been, based off our observations of where m6A occurred in normal plants. We were curious to see whether there was a particular set, or sets, of genes that were being cleaved in m6A deficient plants and we found that many genes involved in plant salt response were being mis-regulated in the absence of m6A modification.

This finding led us to hypothesize that m6A may serve to protect mRNAs encoding proteins that allow plants to respond to stressful salt rich environments that would be otherwise potentially fatal to these plants. This is a particularly agriculturally relevant stress that plants encounter, as irrigation brings in not only water but any salt within the water. As the water evaporates, the salt stays behind, leading to an accumulation of salt over time. In order to test whether m6A served to facilitate this plant salt stress response, we characterized the landscape of mRNAs in plants that were watered under normal conditions as well as plants that were subjected to salt stress by watering with saltwater. What we observed was that plants that were subjected to this salt treatment started to add m6A to messenger RNAs that were important to salt stress response. We saw that these molecules were protected from being internally cut and destroyed, presumably leading to increased protein output of these genes. These same molecules, in the absence of salt treatment were not marked with m6A and were thus subjected to internal cleavage and degradation.

In total, over the course of this study we characterized a novel mechanism that plants use to respond to salt stress. When the need arises, plants are able to protect mRNAs important for salt response by adding this small m6A tag, shielding these mRNAs from internal cleavage. In the absence of this stress, these molecules remain unprotected as they are unnecessary. This novel mechanism may provide useful approaches for engineering salt resistant plants that will yield higher crop production in a future with increasingly saline farmland.