### RNA and you

RNA is capable of many types of biological activities. It was the defining molecule during the beginning of life, per the RNA-world hypothesis,^1^ and our genomes contain many functionally important relics of this past. For example, ribosomal RNA (rRNA) makes up a large component of the ribosome and is needed for catalysis; transfer RNA (tRNA) carries the amino acids that are used in protein synthesis. Some RNAs, known as ribozymes, even catalyze chemical reactions like mRNA splicing. Clearly, RNA is a diverse molecule capable of many different chemical activities.^1^

Messenger RNA (\*\*mRNA\*\*) copies genetic information from our genomic DNA through the process of transcription, and then travels to the ribosome, which translates this message into a functional protein. However, the journey from the nucleus to the ribosome is not a simple one. Expression of genes in cells needs to be closely monitored, and one of the ways to do this is to regulate translation of mRNA, restricting the rate at which the mRNA delivers its message. One particularly neat way mRNA does this is using \*\*riboswitches\*\*.

### Proteins lead the way

In fact, RNA and proteins are quite similar despite their differences in chemical makeup. Proteins are linear molecules that fold up on themselves once they are synthesized and can change their shape to be more active or less active. This shape switching property allows proteins to be regulated by other proteins or small molecule ligands, once they bind and alter their conformation. An example of this is the \*\*lac repressor\*\* protein, which regulates the lac operon in bacteria.^2^ The lac repressor binds to lac operon DNA, preventing the transcription of genes that code for lactose metabolic enzymes. However, when lactose is present at high concentrations in the cell, it binds to the lac repressor and alters the conformation of the lac repressor so it cannot bind to the lac operon. This releases the transcription of the lac genes, allowing the cell to metabolize lactose.^2^ Check out this [video](https://www.khanacademy.org/science/biology/gene-regulation/gene-regulation-in-bacteria/v/lac-operon) from Khan Academy if you are interested in learning more about this process.

There are many examples of proteins that are regulated by small molecules like lactose, but they don’t just regulate proteins. Small molecules can also act on mRNA. Often mRNAs fold themselves into a ball to move through the cytoplasm. When they reach the ribosome, they bind to it and translation begins. For many mRNAs, this sequence of events occurs without a hitch and the mRNA message gets translated into a protein. However, certain mRNA structures within the sequence, called riboswitches, can be turned on or off by the binding of small molecules. This acts as a way to regulate the translation of these mRNA.

### Ribozymes do it too

Let’s look at an example: bacteria need to regulate their nickel and cobalt concentrations. Bacteria use these metals for some of their biological functions, but high concentrations of them are toxic.^3^ This poses an important regulatory challenge – one that bacteria have solved using riboswitches. Bacteria absorb cobalt and nickel from their environment using ion transport proteins that are embedded in their cellular membrane. Interestingly, the mRNAs that encode for these transport proteins contain riboswitches. When nickel and cobalt are present in the cell, they will bind to these riboswitches, changing their shape. In this new conformation, the riboswitch-bearing mRNAs can no longer bind to ribosomes, and the transport proteins are no longer made. This keeps the bacteria from taking in toxic amount of metal ions! On the flipside, if metal concentrations are too low in the cell, the transport mRNAs will not be bound by the metals and will be translated into more transport proteins. This way, the cells can increase or decrease their metal ion concentrations as needed.^3^

Cells use ribozymes like these to regulate all types of molecules. There is a diversity of ribozymes that bind metals, amino acids, nucleotide precursors, and protein cofactors, the levels of all of which need to be closely monitored by cells. In these cases, mRNA serves as a \*\*biosensor\*\*, a molecule that can detect the levels of other important molecules. In the example I described, the riboswitch was preventing the mRNA from binding a ribosome, but there are many other ways that riboswitches enable regulation. For example, riboswitches can interfere with transcription, or direct how the primary transcript splices. Since these mRNAs code for the proteins that use the molecules that regulate them, riboswitches create a simple and elegant method of regulation.

### Conclusion

As we have learned, mRNA can be much more than just a messenger between genes and ribosomes. Many mRNAs play an active role in sensing and regulating the various molecules that cells need to survive. RNA is clearly capable of many more actions than we initially thought, and this is important to keep in mind as we continue to study them.

\*\*REFERENCES\*\*

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