**Genomics 101 transcript: What is the difference between DNA and RNA?**

**Clare Kennedy**

**Naimah:** What is the difference between DNA and RNA? Today, I’m joined by Clare Kennedy, who’s a Clinical Bioinformatician here at Genomics England, who’s going to tell us more.

So first of all, Clare, what is DNA?

**Clare:** So, DNA stands for deoxyribonucleic acid, and although this is quite a mouthful, DNA is essentially an instruction manual for our body on how to function, and a copy of this manual is stored within almost every cell of the body in a structure called the nucleus. So, our DNA essentially comprises all of the genetic information we inherit from our parents, and this information is contained within two long strands of code, and we inherit one strand of code from our mother and one from our father, and both strands combine and they form a twisted ladder like structure that we call the DNA double helix. So, each strand is made up of small units called nucleotides, and these nucleotides, they differ based on their chemical composition. They can either contain a molecule of adenine, guanine, cytosine or thiamine, and this is why we often see our DNA sequence represented by the letters A, G, C or T. And in total, our entire DNA sequence consists of three billion of these nucleotides.

So, as this DNA instruction manual is quite long, it needs to be broken up into smaller sections that the body can read, and that’s where genes come in. So, a gene is a segment of the DNA and it contains a particular set of instructions, normally on how to make a protein. So, proteins are essential for life and they’re involved in almost every process within our body, and that is why we have around 20,000 protein coding genes in our DNA.

**Naimah:** So then can you tell me, what is RNA and how does this differ from DNA?

**Clare:** So, like DNA, RNA, which stands for ribonucleic acid, is an incredibly important molecule that encodes genetic information, and it’s found in all cells of the body. So, RNA consists of only a single strand of nucleotide units, and just like DNA, RNA can be represented by four letters that reflect the chemical composition of each nucleotide. These four letters do differ slightly though, because RNA contains uracil instead of thiamine, so you can distinguish a DNA sequence from an RNA sequence by the presence of the letter U and the absence of the letter T. So, while we think of the DNA as the instruction manual for the body that contains all of our genetic code, RNA is the reader of this instruction manual, and it helps the cell to carry out these instructions, so the proteins can be made.

**Naimah:** So, can you tell me a bit more about this protein production, and how are DNA and RNA involved?

**Clare:** So, protein production all starts in the nucleus with the DNA. So, if we want to make protein, we must first read the portion of the DNA or the gene that contains the instructions to make this protein. So, because DNA is so long, it’s really tightly packed into our nucleus, and the

region we’re interested in might not be accessible, so we first need to open this region out. So, molecules and enzymes help us open this region of the DNA, and once the gene is accessible, they start to read it, and they start to transcribe the instructions that are encoded within the gene into a type of RNA called messenger RNA. So, as the name suggests, messenger RNA is the communicator of the instructions contained within our DNA, and this process is called transcription.

So, the messenger RNA then leaves the nucleus and enters the main body of our cell, which is called the cytoplasm, and messenger RNA is transported to the ribosome. Now, the ribosome is a piece of machinery which will build the protein, and it’ll use the instructions that are encoded by the messenger RNA. But we need materials to build the protein, and that’s where a type of RNA called transfer RNA comes in. So, transfer RNA is instructed to hunt down the building blocks or the amino acids that we need to build the protein, and it brings these back to the ribosome. And then we have a third type of RNA that gets involved called ribosomal RNA. So, ribosomal RNA helps the ribosome assemble these amino acids into proteins in a process known as translation.

So, it really is a group effort between the messenger RNA, the transfer RNA and the ribosomal RNA. And once the protein has been assembled, it might go through some more processing steps, and it’s eventually exported by the cell to where it’s needed.

**Naimah:** Okay, so apart from their roles, are there other key differences between DNA and RNA?

**Clare:** So, as we touched on earlier, the main difference between DNA and RNA is in their structure. So, we have, DNA is in a double stranded helical structure, whereas RNA is single stranded. And because of DNA having this double standard helical structure, it’s actually much more stable than RNA, which is more susceptible to degradation by enzymes and other molecules. As DNA contains our genetic code, it’s much longer than RNA, and you can only find DNA in the nucleus of the cell as it’s much too large to leave the nucleus, whereas you can see RNA in the nucleus and in the cytoplasm. RNA and DNA also differ in the type of code or the lettering they use, so they both use the A, G and C letters in their code, while DNA’s is the T lettering and RNA’s is the U lettering, and this is due to the differences in the chemical compositions of the nucleotides that make up DNA and RNA.

And the nucleotides in DNA also contain different types of sugars from the nucleotides used in RNAs. So, in DNAs, you would have a deoxyribose sugar, whereas an RNA uses a ribose sugar. That’s where we get the deoxyribonucleic acid and the ribonucleic acid.

**Naimah:** So Clare, we’ve talked about the difference between DNA and RNA, but why are these important in clinical care?

**Clare:** So, we can use DNA and RNA to diagnose illness and to also develop therapies against these illnesses.

**Naimah:** Can you give me some examples of where DNA and RNA are used for diagnosing conditions?

**Clare:** Absolutely, so an excellent example is in the diagnosis of cancer. So, the majority of cancers are caused by mistakes in the genetic information encoded within our DNA, and result in the production of malformed proteins. So, we can normally look at the DNA and we can identify certain genetic mutations that cause the cancer. So, examples are breast cancer, ovarian cancers, lung cancers, essentially all types of cancers that you can think of will have genetic mutations associated with them. But then there are cases where no problem with the DNA can be identified, but then when we look at the RNA, we do see a problem. So, a particular example was recently shown in breast and ovarian cancer, where a gene that encodes for a protein called BRCA1 was not shown to have any genetic mutations, however when we looked at the RNA produced from that gene, we could see there are problems with that RNA and essentially identify a genetic cause for that cancer.

**Naimah:** Could you also give me any examples of where RNA or DNA are being used in therapies?

**Clare:** So, absolutely. So, most of us will have heard of RNA vaccines in recent times, such as those that were generated against COVID-19. And essentially how these vaccines work is they deliver small messenger RNA from the virus into the body. The body can then make a protein from this messenger RNA, and the immune system recognises this as an invader and destroys it. So, this low level of viral exposure essentially trains your immune system to respond in the event of an infection, and really the success of the MRNA vaccines against covid has really paved the way for the use of MRNA vaccines against cancer. So, it’s believed that we can stimulate an immune response that would destroy a cancer cell using MRNA vaccines, and there are now some studies that are looking at developing messenger RNA vaccines against cervical cancer in particular.

So, DNA therapies can actually target genetic mutations and correct them to prevent illness, and one such example is a gene editing treatment that has been developed for the treatment of blood disorders, such as sickle cell anaemia.

**Naimah:** That was Clare Kennedy explaining the difference between DNA and RNA. If you’d like to hear more explainer episodes like this, you can find them on our website at www.genomicsengland.co.uk. Thank you for listening.