

Lecture 25A • 06/22/12

DNA – deoxyribonucleic acid – This is a polyester of phosphoric acid. The essential structure of a DNA strand is repeating units of a phosphate group and a sugar. Deoxyribose – deoxy means lacking an oxygen. Back and forth, sugar unit, phosphate unit, sugar unit, phosphate unit – that have these various bases that are attached. [might be able to regurgitate names from high school without having to look] What are the four bases that are in DNA? Adenine, cytosine, guanine, and thymine. And then there is which fifth one that we have in RNA? Uracil. It is the sequence of bases that make up the genetic information that is encoded in both RNA and DNA. Those are attached to sugar units; those are called nucleosides, which then get attached to the phosphate units that make them nucleotides, which then get polymerized together to make DNA or RNA strands. Translation – turning the genetic information into amino acids to turn them into proteins; transcription – the process of replicating DNA or making RNA strands out of it.

There are five bases that are relatives of two simple heterocyclic compounds – they're cyclic and have things other than carbon in the ring. One of the two heterocycles is a bicyclic compound: purine; then, a nitrogenous analog of pyridine – pyrimidine. There are nitrogens all over these compounds, which is why they act as bases. Now, we do some simple substitutions on both of these compounds and we're going to get the five bases that are in DNA [and RNA]. [methyl group on purine, adenine; turn it into an amide, guanine; pyrimidine into cytosine; uracil with another carbonyl instead of amino group; add a methyl group to that, we get thymine. These bases attach to sugars.

[d-ribose][It's the song that's in your heart, it's the song of chemistry, what other song can there be?] In DNA, it is the beta [furanose] form that we end up with. 2'-deoxyribose: what does 2' mean? The fact that we're not changing the carbon at the two position, because technically we would be talking about substitution at carbon, but if we're talking about the things attached to carbon, we can use this prime notation to designate that we're talking about something besides the carbon itself – 2'-deoxy means leave the oxygen out at the 2 position; everything else, however, is still the same. It's technically not a carbohydrate in the rigorous sense since it no longer has the [empirical] formula CH_2O , but it is a carbohydrate derivative.

Why ribose versus deoxyribose? Having that adjoining hydroxy group makes this compound more susceptible to hydrolysis when it's part of its RNA strain. RNA is something that is replicated on a temporary basis. The human genome is comprised of [23] different chromosomes, each of which has two pairs of DNA that form a helix, the famous double helix pattern. These different bases end up making hydrogen-bonding pairs. We normally in DNA talk about base pairs because if, for example, you have guanine, automatically on the other pair, it's other side, you're going to have cytosine. In DNA, if you have adenine, that means automatically thymine is on the opposite side. Just in the structures of the molecules themselves, they have exactly the right shape, along with those different phosphate and sugar groups, that they slowly make that helix as you go from one pair to the next to the next to the next. The DNA information is in the core of each cell, and it's that information that has to survive in order for us to survive. Occasionally, that DNA is split apart and then you make RNA out of it, which is then used to translate into proteins; DNA itself is not used for that purpose, it stays together. In that process of going from DNA to RNA, sometimes there's a chemical reaction that shortens the RNA. There is, in fact, an awful lot of genetic information in DNA that's just garbage, or from what we can tell is just extra information. [outdated: now thought to be more important regions][self-repair] Out of the thousands and millions and billions [?] of different sequences that make up these different DNA molecules, if something goes wrong, that means that something's going to be wrong with us [genetic disorders]. You want DNA to be less hydrolyzable; getting rid of that [hydroxy] group at the 2 position makes it much more robust, much less susceptible to reaction. RNA, since it's replicated and then destroyed, it doesn't need to stay around for as long, so in terms of energy, it's just not invested to first create a structure that's more resistant, nor do you then you need reagents that can power through breaking this apart if and when it's needed. That's the difference between the ribose and the deoxyribose. The deoxyribose is less chemically reactive, which makes for a more permanent structure.

Whenever you take one of these sugars and combine it with one of the five bases, you get a nucleoside. [glycoside] These bases are going to attach at the 1 position of ribose or deoxyribose. You make a glycoside out of a nuclear acid, so you get a nucleoside. If we took adenine, for example, and we were to put it on ribose, we get what is called adenosine. [structure] For the purine-based compounds, it's [this] nitrogen that gets attached to the sugar. Purine's at nine, pyrimidine's at one. [beta] If we made it out of deoxyribose instead, the way that it can be [named] is to call it deoxyadenosine. If we then take phosphate groups and attach, then we get nucleotides – that's phosphate plus a sugar plus a base. It is one unit, you could say, that ends up making the DNA or RNA strand. Phosphate is involved in redox reactions, biologically; you can have phosphate, diphosphate – which is called pyrophosphate – or triphosphate. All three of these combinations can end up in nucleotides. It turns out to be just the monophosphate version that ends up in the polymer chain of DNA itself, but there are other places besides DNA that some of these compounds show up.

If we take adenosine and add a triphosphate group to it [structure]... it turns out it's at the 5 position or – technically because it's on the oxygen, not the carbon itself – the 5' position that the phosphate or pyrophosphate or, in this case, the triphosphate group is attached. Triphosphate is an anhydride of phosphoric acid. Notice we link one phosphate through a common oxygen to the next phosphorus, which links to the next one. This is a nucleotide.

Because it is adenine that we used, then we'll abbreviate it with A. We do not put a little d in front of it; if you put a little d in front of it, that's an abbreviation for if we had used deoxyribose instead. We have a triphosphate, instead of a mono- or diphosphate. Adenine, since it's part of a sugar, now: adenosine triphosphate, or ATP. [summary]

[diagram of two base pairs][DNA dolls –it's the perfect thing to give your little one- or two-year old to learn the nuclear acids at an early age.][molecular jewelry] Thymine pairs up with adenine. Here is that hydrogen bonding; they're just the right shape to have a really good interaction with each other. This what holds the two DNA strands together, not necessarily covalent bonds; it's just the fact that you have millions [?] of these pairs of bases that all perfectly line up with each other in terms of hydrogen bonding. [cytosine & guanine][substitution at the 1 position for pyrimidine derivatives and 9 for purine][structure] How is this different from RNA? RNA's single-stranded; it doesn't have the double helix. During transcription, which is where you copy ...

Translation. The DNA strand gets split apart and then replicated to make the initial RNA. Sometimes this RNA strand is chemically modified from just the simple bases that are there and get split off into different kinds of RNA. There tRNA, transfer RNA. There are three [bases] that are at the bottom of this that form what's called an anticodon. A codon is a sequence of three of these bases that get[s] interpreted to be the different amino acids. This 3' and 5' have to do with which direction along the DNA chain that you're reading, kinda like going from the amino end to the acid end of a polypeptide. There's 64 combinations (4 bases * 4 bases * 4) [matrix showing which amino acid gets generated]. Or, there are three combinations that say stop the process. You go from one end of the [RNA] to the other; each group of three of bases, each one of these codons, corresponds to an amino acid. You have these transfer RNAs that carry the amino acid on the top of them [diagram]. You then you have the complimentary set of these bases that would be at the bottom of the tRNA, so that once you get the RNA, these line up with the RNA, and then you have the amino acids, therefore that are line up with each other. There are enzymes that come along zip each one of these amino acids to each other, and that's how you grow a chain of amino acids – in other words, that's how you make a protein. [what is role of proteins] Messenger RNA is the subset of RNA that carries the codons that get turned into amino acid polymers, turned into the polypeptides. [ribosomal RNA? is that where the action of transcription occurs?][rRNA – factory; mRNA – plan; tRNA – parts] That's translation. [diagram]

[Uracil versus thymine]There's a tautomerization that can happen with cytosine that eventually, through chemical reaction, can get us to uracil. In the process of transcribing DNA, [somehow cytosine can turn into uracil – self-correcting mechanisms convert uracil back into cytosine][energy conservation].[describing diagram][summary] The bases are attached to [two] different sugars. Those sugars can attach to phosphates which then make a polymer chain. That polymer chain has sets of bases which are interpreted in groups of 3 once they make it to RNA. From DNA to RNA, some of that genetic information is thrown away. Once you get to the messenger RNA that actually contains the real coded information, in groups of three, those are translated into amino acids, which get linked together to make proteins. [final review]

DNA – Deoxyribonucleic acid

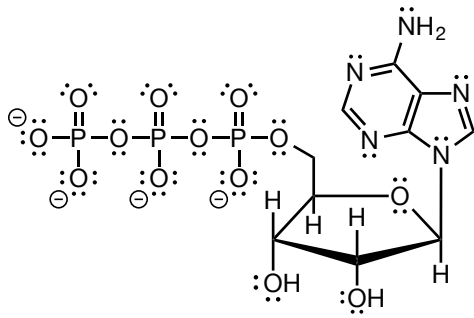
Nucleoside = sugar + base

adenine + ribose → adenosine

nucleotide = phosphate + sugar + base

Structures (remaining structures identical to lecture 24B)

06/22/12 lec • 1



adenosine-5'-triphosphate
ATP

06/22/12 lec • 2

