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| Delft, University of Technology |
| Programming Life 1 |
| Introduction to molecular biology: The Nucleic Acid World |

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| Programming Life – Group 2  2/20/2013 |

# Chemical Structure

***Deoxyribonucleic acid*** ( DNA ) contains **genetic information**. All DNA in an organism is called the **genome**. DNA encodes for all **proteins** needed to live. DNA molecules are linear polymers where each monomer is comprised of a phosphate group, a **nucleotide**, bound by sugar. The monomers only differ in their nucleotide, which is called the **base**. In DNA the sugar is **deoxyribose** and the bases ***guanine*** ( G ), ***adenosine*** ( A ), ***cytosine*** ( C ) and ***thymine*** ( T ). In RNA the sugar is **Ribose** and the base T is replaced by ***uracil*** ( U ).

The structure of the monomers yields a **double-helix form**. Through hydrogen bonding, *T and A* are paired, *G and C* are paired. The opposite sides of DNA are therefore **complements**.  The non-covalent hydrogen bonds can be broken, resulting into two DNA strands, which is necessary for DNA **replication**. DNA strands can be paired with RNA strands. This is called **hybridization**.

# RNA, Transcription and Translation

RNA is usually single stranded and is therefore more flexible, making interactions with itself possible. Some parts of DNA encode for RNA, instead of proteins. A **gene** consists of the region encoding for the protein plus all surrounding *control regions*. To go from DNA to protein, a polymer, the **genetic information** in one of the two strands of DNA is copied[[1]](#footnote-1) through **transcription** to ***messenger RNA*** ( mRNA ); the gene is **expressed**. That strand is called **noncoding strand[[2]](#footnote-2)**. Its complement is the **sense strand**. Genes may overlap, which commonly occurs in **viruses** as a way of packing as much information as possible. RNA encodes for 20 different **amino acids**. Three consecutive bases are called **codons** and encode for one acid. There are multiple encodings for a single acid. Three codons infer a stop signal – or **terminator signal**, which ends of the protein polymer.

***transfer RNA*** ( tRNA ) has a three-base **anticodon** and mediates the addition of amino acids to a protein chain. The enzymatic activity that joins amino acids is due to ***ribosomal RNA*** ( rRNA ). The process of mRNA - with the aid of tRNA and rRNA - to proteins is called **translation**.

# Gene control

Some regions of DNA are **regulatory elements**: control sequences. The control regions where RNA *polymerase[[3]](#footnote-3)* binds to start transcription are called **promotors**. Other controls are **activators** which improve binding of RNA polymerase and **repressors** which do the opposite. Sequential parts of noncoding DNA are called **introns**, protein-coding sequences are called **exons**. **RNA splicing** removes the introns and mends the exons**. Gene regulation[[4]](#footnote-4)** is mainly the cell types within which genes are activated, their timing and magnitude. These are necessary to regulate **gene expression**. Over- and under expression can have devastating effects. In bacteria gene organization allows for **operons**: sequential encoding for proteins without a stop signal, meaning only one control region for several proteins, that are transcribed to a single piece of mRNA. Operons are rarely found in eukaryotes.

# Evolution and mutation

Genes may be changed, added, or destroyed because of **mutations**. Change causes **evolution**. Molecular biologist can *transfer* individual genes between organisms to produce proteins that some humans are missing because of defects.

1. From the ‘3 end to the ‘5 end. The mRNA is then translated from the ‘5 to the ‘3 end. Read: only one direction encodes for the correct codons, thus amino acids, thus actual proteins. You can name the ends, so you can infer the transcription and translation directions. [↑](#footnote-ref-1)
2. Also **anticoding** or **antisense** strand [↑](#footnote-ref-2)
3. Enzyme that unbinds DNA so mRNA can be created from DNA [↑](#footnote-ref-3)
4. By **antisense RNA** ( aRNA ), **small interfering RNA** ( siRNA ) and **small nuclear RNA** ( snRNA ), the latter also to edit mRNA and maintain chromosome tips (telomeres). [↑](#footnote-ref-4)