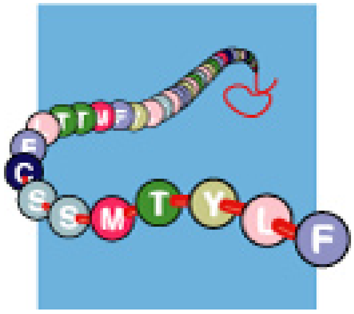
DNA, genes and genomes - Detailed

Genes: DNA’s instructions

Specific sections of DNA carry the instructions to make other molecules, usually proteins. These lengths of DNA are called genes. To interpret the DNA code, the cell first makes a copy of the DNA segment to be read. The copy then travels to another part of the cell, where the code is used to assemble a chain of protein subunits.



These processes are called transcription and translation.

Transcription: copying the code

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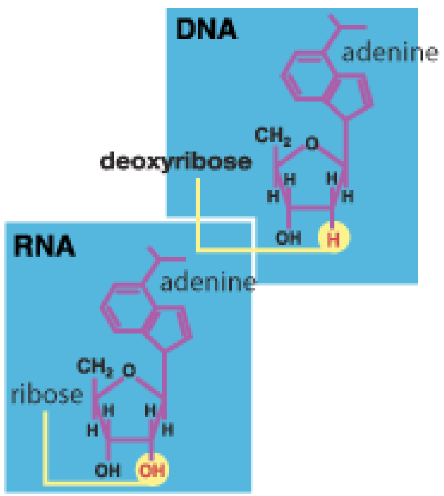
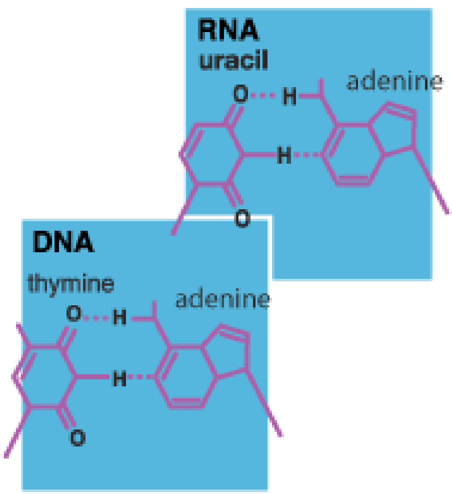
These processes are called transcription and translation.

More about RNA

RNA has a different sugar in its sugar-phosphate backbone; it uses ribose, rather than deoxyribose. RNA also uses a different base from the thymine (T) that DNA uses; the RNA base is called uracil (U). Although they are different bases, RNA’s ‘U’ pairs with ‘A’ just as DNA’s ‘T’ does.





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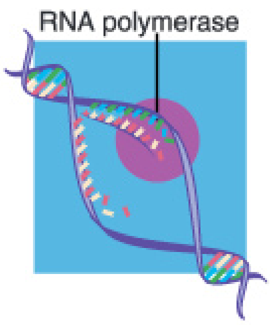
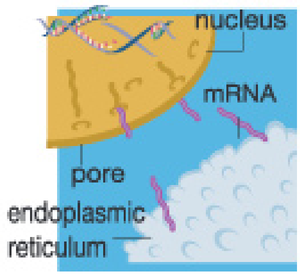
The enzyme RNA polymerase makes the RNA copy, recognizing the 'start here' and 'stop here' signals that appear in the DNA code. It uses available bases, sugars and phosphate molecules from the nucleus to form an RNA molecule that is 'complementary' to the DNA strand. This means that the base A always binds to T (or U in RNA), and C always binds to G. For the codon GTC, the complementary triplet would be CAG.



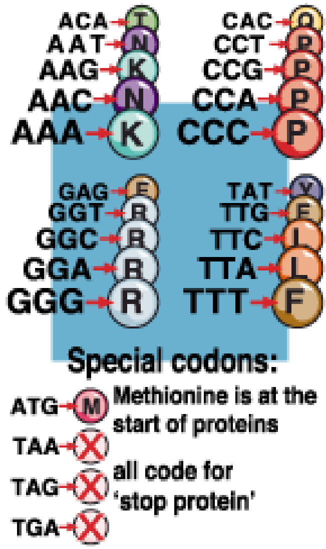
The RNA molecule that is made - called 'messenger RNA' (mRNA) - then carries its 'message' out of the nucleus to the outer part of the cell (the cytoplasm). The mRNA passes through the pores in the nuclear membrane, and makes its way to cellular components called the rough endoplasmic reticulum (ER), where proteins are made. It is called 'rough' ER because, under the microscope, has a bumpy, blobby appearance. The 'blobby' structures are ribosomes: the factories of the cell.



Translation: reading the genetic code

At the ribosomes, the mRNA is used as a template for assembling a protein molecule from its building blocks (amino acids). This process is called translation.

There are 20 different types of amino acids; biologists have given each a code letter. For example, M is methionine, L is leucine, F is phenylalanine (because P is proline). Translation at the ribosomes is very similar to translating from one language to another. In this case, the translation is from the four-letter language of DNA into the 20-letter language of proteins.



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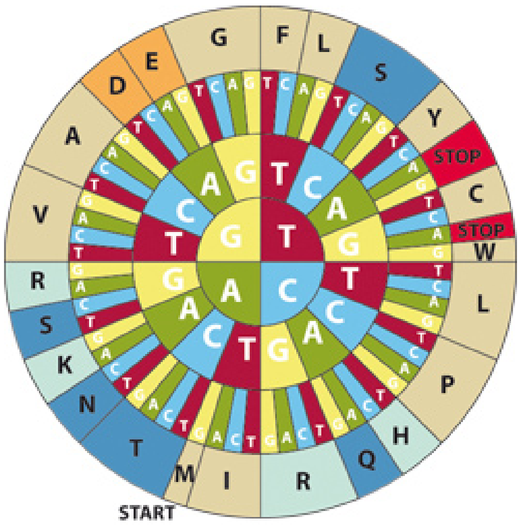
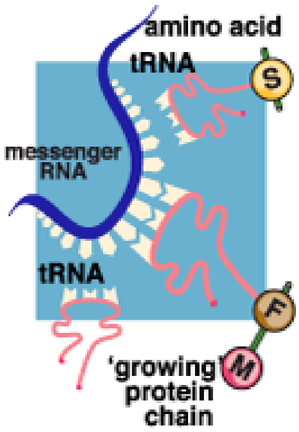
The DNA code is read three letters at a time: these DNA triplets are called codons. Since there are four different RNA letters (A, G, C and U), there are 4 x 4 x 4 = 64 different codon combinations. Most of the codons correspond to a specific amino acid. However, as there are only 20 different types of amino acid, some of the 64 codons code for the same amino acid. Three of the codons are used as 'stop' signals - telling the cell to end the transcript there - and another is the 'start' signal for proteins. (You can get a copy of a codon wheel from our downloads section)



Translation: assembling the protein chain

The genetic code is read by 'adaptor' molecules called transfer RNAs (tRNAs). These deliver amino acids to the ribosomes according to the sequence of the mRNA.



Each tRNA molecule is attached specifically to one of the 20 amino acids and three critical bases recognize the complementary codon in the mRNA. As the tRNAs bind and release, the amino acids on adjacent tRNAs are joined to form a growing amino acid chain.

Each codon on the mRNA molecule is read, one at a time. For each codon, the tRNA molecule with the complementary anticodon temporarily binds to the mRNA. The amino acid that is joined to the end of the tRNA molecule is brought in line with the growing polypeptide chain, and the amino acid links to the end of that chain. Once their amino acid is added, the tRNAs disengage from the mRNA molecule, leaving the next codons on the mRNA molecule to be 'read'.

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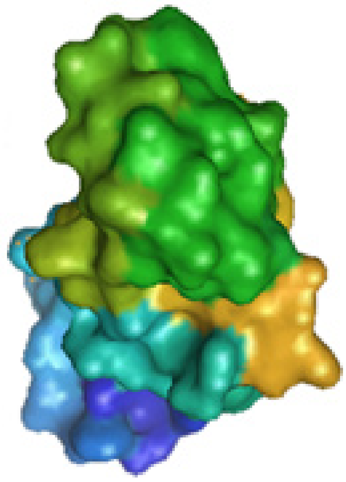
Folding: Putting proteins to work



Proteins carry out most of active functions of a cell. From the DNA, we can recognize and read off the amino acids that make up the proteins in our bodies. However, we still only understand a little about how the chain of amino acids becomes a working protein. Proteins have three dimensional (3D) structures, which are difficult to predict just from the DNA sequence.

Many proteins are enzymes; these biological catalysts enable or speed up chemical reactions in the cell. They can act as enzymes because of their unique and complicated 3D shapes (like the structure of insulin at right). Each enzyme has a region into which two or more chemicals fit snugly. This region is called the 'active site'. While the appropriate substances are attached to the active site, they react with each other. The reaction means that they are no longer fitted to the active site, so they vacate it, leaving the enzyme free to catalyse another reaction.