Section 14.1 – Structure of ribonucleic acid

The genetic code

Sections of DNA are transcribed onto a single stranded molecule called RNA
There are two types of RNA
One type copies the genetic code and transfers it to the cytoplasm from the nucleus where it acts has a messenger. Hence it is called **messenger RNA** or mRNA
mRNA is small enough to exit through the nuclear pores
The genetic code is the sequence of bases on the mRNA

The main features of the genetic code are:

- Each amino acid is coded for by a sequence of 3 bases on the mRNA strand
- A few amino acids have only one codon
- The code is degenerate and therefore some amino acids can be coded for by different codons
- There are three codons called "**stop codons**" that do not code for an amino acid.
- Stop codons mark the end of the polypeptide chain
- There is no overlapping
- It is a **universal** code that works for all organisms

Ribonucleic acid structure

Ribonucleic acid is a single strand in which each nucleotide is made up of:
The pentose sugar called ribose (pentose = 5 carbon)
An organic base - adenine, guanine, cytosine, and uracil (instead of thymine)
A phosphate group

Messenger RNA (mRNA)

mRNA is a long strand that is arranged into a single helix
Is a mirror image of the copied DNA strand
mRNA leaves the nucleus through the nuclear pores and associates with the ribosomes
Acts as a template onto which proteins are built
Can be easily broken down

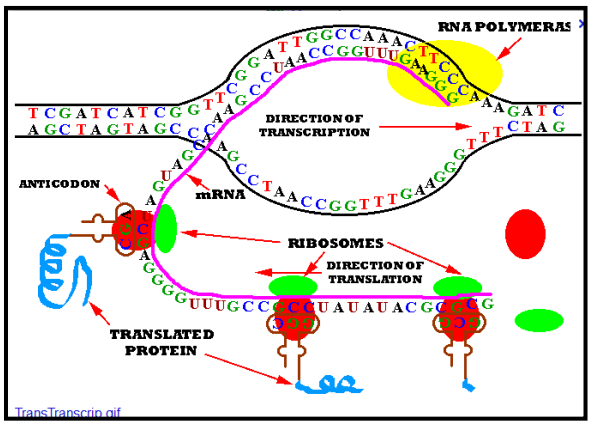
Transfer RNA (tRNA)

Single stranded chain folded into a clover shape
There is a part of the molecule that extends out and allows for amino acids to attach
At the opposite end of the molecule is an "anticodon"
The anticodon will pair with the 3 bases on the mRNA molecule
There are different types of tRNA each with a different "anticodon"

Section 14.2 – Polypeptide synthesis – transcription and splicing

The basic process for polypeptide synthesis is as follows:

1. DNA provides the blueprint in the form of a sequence of nucleotides
2. A complementary section of DNA is made from pre – mRNA (transcription)
3. Pre – mRNA is "**spliced**" to form mRNA
4. The mRNA is used a template for the attachment of complementary tRNA molecules carrying amino acids which are then linked together – a process called **translation**



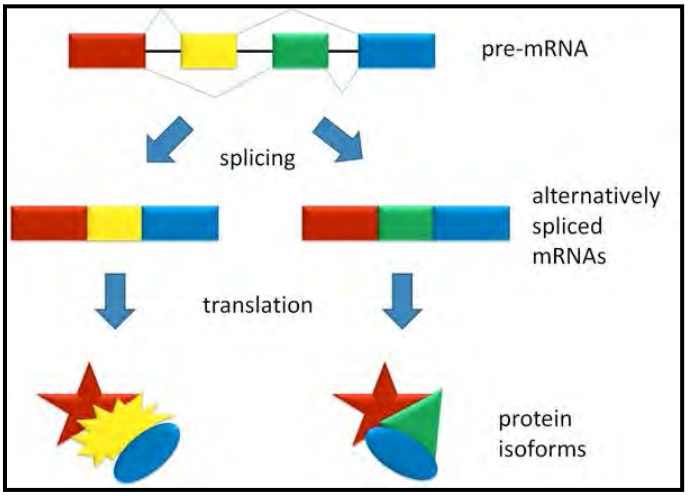
Transcription

The process of making pre – mRNA from DNA as a template
The process is as follows:

1. DNA helicase breaks the hydrogen bond in a specific region of the DNA molecule thus exposing the unpaired bases
2. The enzyme RNA polymerase moves along a template DNA strand and causes nucleotides in the DNA strand to bond with pre-existing free nucleotides in the nucleus
3. As RNA polymerase moves along the molecule causing complementary bases to join up with one another, the DNA molecule recombines behind it
4. Eventually DNA polymerase reaches a stop codon on the DNA molecule and detaches and completes the production of pre – mRNA

Splicing of pre – mRNA

Exons code for proteins, introns do not
Introns would interfere with DNA synthesis and so are removed from pre – mRNA forming mRNA
Splicing – removal of interfering introns and combining of exons
Exon sections that have introns removed from them can be recombined in a number of different ways
This means that one section of DNA (a gene) can code for a variety of different proteins
Mutations can affect the splicing of pre – mRNA



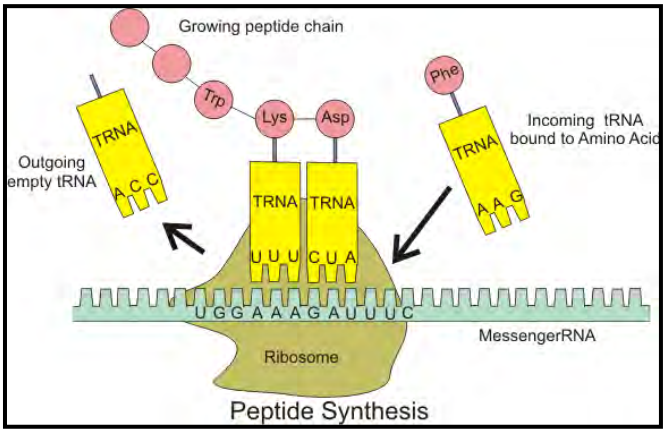
Section 14.3 – Polypeptide synthesis – translation

Each amino acid has a corresponding tRNA molecule with its own anticodon bases

Synthesising the polypeptide

The process of polypeptide formation is as follows:

1. A ribosome becomes attached to the starting codon at one end of the mRNA molecule
2. The tRNA molecule with the complementary anticodon sequence binds with the mRNA with the correct code whilst having an amino acid attached to it
3. Another tRNA molecule with its anticodon binds on to the next codon on the mRNA stand whilst carrying another amino acid
4. The ribosome moves along the mRNA, bringing together two tRNA molecules at any one time
5. Enzymes along with ATP join together the amino acids on adjacent tRNA molecules
6. The ribosome moves along to the third codon and links the amino acids on the second and third tRNA together
7. As this happens the first tRNA is released from the amino acid and is now free to collect a new amino acid
8. The process continues as the polypeptide chain is built up
9. The synthesis continues until a ribosome reaches a stop codon. At this point the ribosome, mRNA and the tRNA all separate leaving behind the polypeptide



Assembling a protein

A protein may consist of one or many different polypeptide chains
What happens to the polypeptide next depends upon the protein being made, but usually involves the following:
The polypeptide is coiled of folded, producing a secondary structure
The secondary structure may be further folded producing a tertiary structure
Different polypeptide chains, along with any non-protein groups and linked to form a quaternary structure

Section 14.4 – Gene mutation

Mutations that occur in gametes can be inherited

Substitution of bases

When one nucleotide is replaced by another it is called a substitution mutation
A change to a single base could result in the following:

A nonsense mutation – Occurs when the base substitution results in a stop codon being transcribed on to mRNA
When this occurs when the polypeptide chain is stopped prematurely and will often not function

A mis-sense mutation – Occurs when the base substitution results in a different amino acid being coded for
Since there is a different amino acid in the polypeptide, it may not function correctly as the intermolecular bonds that give the unique shape of the tertiary structure may be changed and hence the whole shape of the protein will be different

A Silent mutation – Occurs when the substitution does not result in a different amino acid being coded for
The polypeptide will therefore contain the same sequence of amino acids and so will still function correctly

Deletion of bases

Occurs when a nucleotide is lost
The polypeptide chain is often completely different due to the fact that there is a frame shift
The reason there is a frame shift is because the nucleotides are read in threes and so when a base is removed, the bases are read in different units of three
A deletion base at the end of a polypeptide is more likely to have less effect than if it was at the start

Causes of mutation

Can arise spontaneously in DNA replication
The rate of gene mutation can be influenced by mutagenic agents
High energy radiation can disrupt the DNA molecule
Chemicals can interfere with transcription or the DNA structure

Mutation can increase species diversity

Genetic control of cell division

The rate of cell division is controlled by two genes

Proto-oncogenes

Stimulate cell division
Growth factors attach to a protein on the cell surface membrane
Relay proteins in the cytoplasm then "switch on" the genes necessary for DNA replication
Mutations can turn proto-oncogenes into oncogens.
Oncogenes:
Can cause the receptor protein in the cell surface membrane to permanently activated and cell division occurs without growth factors
The oncogene may code for excessive amount of growth factor

Tumor suppressor genes

Inhibit cell division
Mutations can make tumour suppressor genes inactivated so cell division is not inhibited
The mutated cells are normally structurally different from normal cells.
The cells that do not die can clone themselves and form a tumour