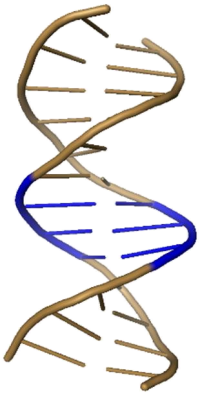
TB8 – CRISPR/Cas9, Gene Editing and Bioethics



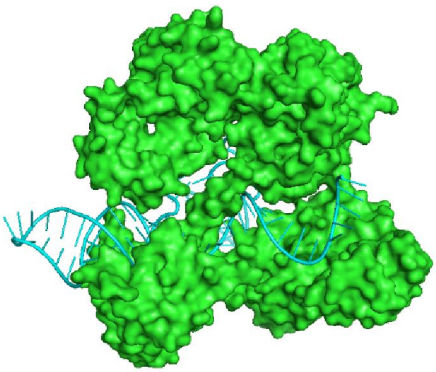
WHAT IS GENE EDITING?

DNA contains a **genetic code**, which determines how organisms develop. **Genes** are short sections in DNA which code for specific **proteins** within the body. If the **genome**, that is the complete set of genes, could be manipulated, and changed, then it should be possible to edit the genetic code. Editing the genetic code would allow particular proteins, and in turn specific parts of an organism, to be changed.

There are currently a small number of experimental techniques which can be used to edit DNA, however this is still a very early technology, and it is a huge area of research. In 2015 it was used successfully to treat two young girls with leukaemia. It can be used purely for research purposes – to find out more about how DNA and organisms function on a molecular level, or has potential to treat some genetic diseases. There is a large concern about the possibility of creating 'designer babies'.

CRISPR/CAS9

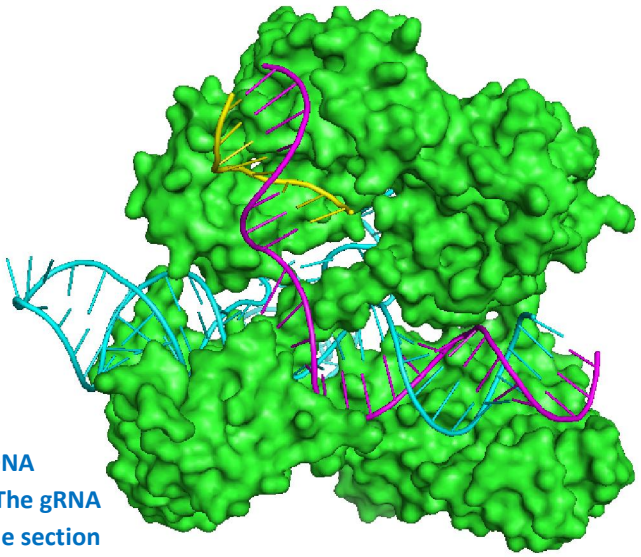
CRISPR are small segments of DNA which are naturally a part of bacterial defence systems. They can be **engineered** alongside an **enzyme** called **Cas9** to edit DNA, and the genetic code. Cas9 is a type of enzyme called an **endonuclease**. This means that it can be used to cut DNA strands, allowing particular sections to be removed and changed. To make sure that Cas9 knows exactly which part of the DNA to cut, it uses **guide RNA** (**gRNA**).



Cas9 protein bound to its guide RNA (gRNA)

WHY USE gRNA?

RNA is a **nucleic acid**, and uniquely it can **base pair** with, and bind to, DNA. We can design short segments of gRNA so that they will bind to the section of DNA that we want to edit. Then the Cas9-gRNA complex will be able to find, and remove a small section of DNA. Once this has been done, the cell will attempt to repair the DNA, as it realises that it is damaged. It is then possible to manipulate the DNA repair process, so that a desired section of DNA is added in place of the old one. In this way the genome can be edited.



Cas9 protein complex showing the target DNA (purple) bound to the gRNA strand (blue). The gRNA has been designed to bind selectively to one section of the DNA, shown in the diagram on the left.

Produced by Adam Stubbs at Newcastle University as part of a summer outreach project.

USES OF GENE EDITING

Techniques such as this have huge potential benefits in medicine, agriculture, and the wider society such as:

- **Removing inherited diseases** which are passed down through DNA
- Treating non-inherited **diseases which are linked to DNA**, such as some cancers
- Reducing the risk of disease by **removing genetic risk factors**
- **Researching how DNA functions** on a molecular level within cells
- To **genetically modify livestock and crops**, to increase yield and reduce food shortages

BIOETHICAL ISSUES

Unsurprisingly, there are still many obstacles to face when trying to edit DNA using this technique. However, as well as the scientific hurdles, there are many **ethical questions** which need to be considered.

One of the biggest questions is about **germline gene therapy**, this is a form of gene editing which is done on **reproductive cells**, allowing changes in DNA to be carried forwards through successive generations. The possibility of eradicating hereditary diseases by eliminating them from the gene pool has the potential to alleviate huge amounts of suffering in the world. Although it may be possible to remove particular inherited diseases from future generations, it isn't known what particular effects will happen long-term. Especially if the technique accidently introduces new **mutations** into the genome, then this could have knock-on effects for each successive generation. There is also a further question to ask – who decides which diseases/conditions should be genetically eliminated?

Another serious concern is that it may be possible to edit and design individual characteristics of a person – so called 'designer babies'. Although it can be used for purely medical purposes, there would be the possibility that it is used to select certain traits to be passed onto an individual, such as their eye colour, skin colour, and height. For example, would it be ethically fair to allow these type of techniques to be done, when they may only be afforded by the rich?

These ethical issues all need to be considered together and weighed up. Even though the scientific techniques are being developed, we cannot forget to consider the bioethics too. In fact bioethics is fast becoming one of the most important areas of the scientific sphere. This intersection between science, policy, and law is a huge area of work.