



Gene editing: Bioethics

Step 1: What is gene editing?

Listen to the introduction, **watch** the videos and **answer** the questions.

1. What are the 4 steps needed for gene editing?
2. What is the name of the system for gene editing, which has made it faster, simpler and cheaper?
3. What does CRISPR stand for?
4. What type of enzyme is Cas9?

Step 2: Why is gene editing controversial?

Listen to the interview carried out by the BBC with Professor Doudna (the leader of a group of scientists in the US who developed the CRISPR-Cas9 system for gene editing) and **answer the questions** below.

1. What is Cas9?
2. What can Cas9 be used for?
3. Since Professor Doudna published her work back in 2012, what type of organisms has CRISPR been used in?
4. What could the practical uses of this gene-editing technology be?

5. What great advantage does this 'tool' for genome editing have over previous technologies?
6. What could this gene-editing system do for human health?
7. What are the 'redlines' that Professor Doudna thinks we shouldn't cross using these gene editing technologies?

Step 3: What are the ethical implications of gene editing?

The Nuffield Council of Bioethics, set up to assess the ethical impact of rapidly advancing technologies like gene editing, has suggested that there should be;

- (i) increased public awareness of what is possible, and
- (ii) democratic decision making about what is legally allowed.

They have published a review considering the possible applications and ethical implications (September 2016).

Read the Nuffield Council of Bioethics booklet on 'Genome editing' about the ethical implications of this new technology.

Step 4: What do you think now?

Consider the use of CRISPR-Cas9 technology in 6 scenarios. Use a 'line of agreement' to show your current opinion about each.

Step 5: Making scientific arguments

You should now understand the possibilities created by gene editing technologies, and the improvements in ease, speed and cost offered by the CRISPR-Cas9 system.

Opinions you form may be based on your experience, beliefs, knowledge and emotional response. All of these are valid components of a decision. When expressing a reasoned scientific argument, you need to be able to articulate points for and against the subject, to provide the reason(s) that lead you to this opinion and connect them together.

A scientific argument consists of a **claim** (assertion):

For example, 'Scientists should be allowed to use gene editing to develop new plant strains in agriculture, for example disease-resistant strains of wheat'.

Then **data** (evidence or facts in support of the claim):

For example, 'Humans have been selecting traits in plants that are beneficial to agriculture (and the health of plants) through selective breeding over many generations without causing problems.'

And finally a **warrant** (or summary statement, which connects the data and the claim):

For example, 'So altering wheat to become disease-resistant using gene editing is a positive development as it mimics the process of selective breeding, but also speeds up the process of introducing positive traits into agriculturally important crops.'

Decide which of the scenarios you want to consider. You may wish to consider one in detail, adding a lot of 'data' statements, both for and against the 'claim' on your argument, before summarising with a 'warrant'. Alternatively, you may wish to consider several scenarios relating to a particular topic in less detail, for example 'gene editing in humans', 'gene editing in animals', or 'gene editing and consumer choice'.

Draft scientific arguments, with claims, data and warrants. It is OK to change your mind about issues as you link the data and claims together!

Step 6: Discussing the implications of gene editing

If you have completed the previous exercises you are now among the most informed people about gene editing in the population. The methods behind and the reasons for your decision-making are very important in establishing what is

considered acceptable in terms of gene-editing. Professor Doudna, whose interview you watched with the BBC, is one of a group of scientists who were sufficiently concerned about the 'unknown risks to human health and well-being' from our increased ability to edit genes that, in 2015, they halted their experiments and called a Forum on Bioethics to discuss the applications and implications of gene editing and to call for worldwide guidelines (Baltimore *et al.*, *Science*, 2015).

Before explaining your decisions and reasons, you will have a chance to exchange your arguments with other students, so you can experience their thoughts on gene editing.

Discuss your reasoned opinions with other students.

Step 7: Expressing your opinions on gene editing

Your final task is now to **write a letter** to the Nuffield Council of Bioethics (who you will remember put together the booklet on gene editing, that you have read). Their job is to '*make arrangements for examining and reporting on bioethical questions with a view to promoting public understanding and discussion*'. The opinions and evidence that they gather is used to make recommendations to the Government.

Although students of your generation will be the today will be decision-makers for issues about DNA manipulation of ever-increasing complexity, very few engage with the decision-making process. This is your chance to change that. You are informed about gene editing, and as well-equipped to make these important decisions about what should be acceptable and what should not be acceptable as any other citizen.

Your letters will be sent to the Nuffield Council on Bioethics for consideration. You can also contact them yourselves.

Their website is <http://nuffieldbioethics.org/>.

Their address is: Nuffield Council on Bioethics, 28 Bedford Square, London, WC1B 3JS.

Their email is: bioethics@nuffieldbioethics.org.

Your letters will be assessed using the criteria below:

1. Introduction: Is it clear what question is being addressed?	
2. Body: Is there at least one assertion, supported by evidence and joined into a warrant?	
3. Body: Are references provided to support the data?	
4. Body: Are there warrants for and against the question?	
5. Conclusion: Are there references to the warrants, with the opinion of the writer made clear?	

Write your letter. **Assess** your letter. Make any improvements. **Send** your letter.