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Kit No. 18

Science Debate Kit: Is DNA evidence reliable enough?

99.9%?

"Keep these kits coming please!"

For in-depth resources on this debate go to: forensics_dk.imascientist.org.uk

Debate Kit: Forensic Science
Is DNA evidence reliable enough?

A structured practice debate on a controversial topic. The different 'rounds' of the debate help students think through the issues and reconsider their opinions. The structure also shows them how to build a discussion and back up their opinions with facts.

You can use all eight characters, or fewer, as you wish.

The minimum is the four essential characters **(in bold)**, this gives two for and two against.

Characters Yes	No
• **Erin Nevin - Juror**	• **Daiyu Hai - Barrister**
• **Panaya Ria - Scene of Crime Officer**	• **Graham Ross - Medical Statistician**
• Jake Okiro - 16 year old student	• Saïd Ali - 20 year old identical twin
• Will Tenor - Psychologist	• Eira Hughes - Fingerprint expert

Facilitation tips

- Ensure pupils know there is no right or wrong answer.
- Be observant of ones who want to speak and are not getting a chance.
- Encourage students to give a reason for their opinions.

Designed for KS4 but can be used with ages 11-18.

Learning notes

Learning objectives:

- To develop oracy skills, practise discussing issues and expressing an opinion.
- To explore the applications of science in a real-life context.

Other learning outcomes:

- Consider different points of view and develop the British Values of respect and tolerance.
- Think about different points of view.
- Learn to back up opinions with facts.

Curriculum points covered:

Thinking scientifically

- Evaluating the implications of technological applications of science
- Developing an argument
- Reflecting on modern developments in science

"Particularly like the format plus the accuracy of the scientific information"

99.9%?

Jake Okiro
16 year old

I don't trust the police. People who are ethnically minoritised or from poorer backgrounds get accused and arrested and convicted more than other people. DNA is a great, unbiased tool for showing the truth. The police can't stitch up the genome to make it black, or match whoever they grab for it. It isn't even the same person who interprets the DNA as collects it – not like you see on TV. The person who tests it probably doesn't know if it belongs to a suspect or a victim.

Fact: In the UK in 2020, black people made up 13% of the prison population, but only 3% of the general population.

Issue: DNA can't identify a biological human race – races are social not biological, and usually come from appearance, culture, or family history. We inherit 50% of our DNA from each parent randomly, so you could even have a direct relative but share no DNA.

Question: Are the police responsible for ethnic differences in arrests and convictions, or does this reflect wider societal issues, such as poverty?

Erin Nevin
Juror

I just received a letter asking me to do jury service. It's very annoying to have to take time off work right now, and what could I contribute? DNA evidence is objective and almost foolproof; it should be used to say whether someone is guilty or not; it shouldn't be left to the opinions of jurors! What if my fellow jurors just don't like the accused person, perhaps because of social prejudices or because they don't seem worried enough – they could wrongfully convict or acquit. What if we are emotionally led by clever lawyers? It makes me uneasy.

Fact: Decision-making research shows that we tend to make decisions based on our emotions and then justify them afterwards.

Issue: The impact of emotions depends on who has those emotions: jurors find angry men convincing, and angry women unconvincing!

Question: Should emotion figure in a juror's decision – or is it always wrong?

Daiyu Hu
Defence Lawyer

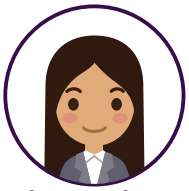
As a defence lawyer, it's my job to remind people to ask questions. If your DNA is found at a scene, how did it get there? Did you put it there, or did somebody else? Scientists have such powerful technologies, they can now analyse trace DNA – tiny fragments passed by touching. But maybe if I shake your hand, then touch a knife, and later someone else uses it, your DNA could be at a crime scene. It's important to remind people of that. Of all the possibilities.

Fact: DNA analysis is now so sensitive that the amount found in 76 cells is enough to make a profile... but too little to detect what biological material it's from, e.g. skin, blood, or semen.

Issue: Just because trace DNA is found on an object, doesn't necessarily mean the person it is from ever touched it, but juries tend to assume they did.

Question: Why do forensic scientists care what biological material DNA comes from – would it change the forensic implications?

Panaya Rai
Scene of Crime Officer (SOCO)



We perform checks and take control samples to make sure the DNA we get from crime scenes isn't contaminated. Our own DNA gets taken and excluded from samples. We not only wear the full body suit, we have to take pictures, bag everything, document everything, measure the distances between items. We have precise procedures. This is all to preserve the quality of the evidence. Yeah sure, it's possible to contaminate DNA, but we make sure that doesn't happen at a crime scene.

Fact: SOCOs have been involved in British policework since 1968. They do not investigate crimes or analyse evidence; their job is retrieving high quality evidence from crime scenes.

Issue: DNA is invisible to the human eye. SOCOs use professional judgement and years of experience to identify where DNA samples may be found at a crime scene.

Question: Is it better to take lots of samples which will take time to process, delaying an investigation, or fewer and risk missing something?

Saïd Ali
20 year old identical twin

I'm an identical twin, but we're very different people. It worries me that my twin committed a crime once, and his DNA was taken. Now the police have that information on me, because our DNA is basically the same. They can keep it in the national database forever and I could be falsely accused of a crime. That scares me. I've read that there are other kinds of forensic evidence that could tell us apart, like fingerprints and vein patterns on the back of your hands, but not DNA. It's definitely not a gold standard.

Fact: Fingerprints and vein patterns develop in the womb and are affected by small changes in womb fluid, foetal position and movement, and so are not identical for identical twins.

Issue: When analysts choose a bit of DNA to sequence, it is pot luck whether this contains a mutation that would distinguish between twins.

Question: Is the National DNA Database ethical? Is it okay to store information on it from people who have not committed crimes?

Graham Ross
Medical Statistician

Medical statisticians like me calculate a match probability between a DNA sample and a suspect. We don't say the DNA definitely belongs to them, we give a chance. It has to be only a chance: analysts don't sequence everything. There are millions of base pairs in a DNA sample and it's time consuming to sequence, so we take bits called short tandem repeats (STRs). The more you sequence, the less likely you'll find two matches. We use computer software to make estimates and different software gives different results.

Fact: If the probability that someone other than the suspect is the source of crime scene DNA is less than 1 in 1 billion, we still say 1 in 1 billion so that juries don't have to grapple with absurdly small numbers.

Issue: Analysis of complex DNA cannot be entirely objective: when the match isn't quite right, scientists have to make a decision: is it a poor match or a non-match?

Question: The genome holds lots of information about an individual. Why are some people reassured that scientists sequence only PART of a genome?

Eira Hughes
Fingerprint expert

Fingerprints have falsely convicted people. We used to say if there were twelve points the same, the fingerprints matched. But since the Shirley McKie case, twelve points of difference are used: excluding people. This leaves multiple suspects, but isn't proof of guilt. DNA is no different. One day we'll probably find a better way to interpret it. There is no gold standard: scientific evidence is strongest when there is complementary evidence – several techniques used together and pointing at the same person.

Fact: No two identical fingerprints have ever been found, including on different fingers of the same person.

Issue: Fingerprint evidence has led to false convictions, for example, police officer Shirley McKie, who was accused of lying under oath when her fingerprint was matched (incorrectly) to some found at a crime scene she'd never visited!

Question: Fingerprinting is a different scientific process to DNA analysis – can its history and findings truly reflect the strengths and weaknesses of DNA?

Will Tenor
Psychologist

DNA evidence is reliable, matching a crime scene sample to a suspect correctly almost every time. But people don't want to hear about it if there's a witness or a confession. But these aren't reliable enough: witnesses can make mistakes, have false memories, and vulnerable people get pressured into false confessions. The burden of proof should be really high because it can have huge psychological implications on someone to be wrongfully convicted and prevent them from getting a job, maintaining relationships, or seeing their children grow up.

Fact: By law, under 18s must have an appropriate adult with them when interrogated by the UK police, as a safeguard against pressures that lead to false confessions.

Issue: DNA evidence has proved that some confessions to crimes are false.

Question: Is the risk of wrongful conviction ever worth taking? How often do you think witnesses and confessions are wrong?

Kit N°18

Teacher Notes

Question:

"Is DNA evidence reliable enough?"

DNA is now readily collected and analysed. Since the case of Colin Pitchfork in 1987, DNA evidence has been used forensically, that is, legally to evidence a crime. In popular contexts, DNA is presented as a "gold standard" of evidence – but is it infallible?

Lesson plan

The different 'rounds' of the debate help students think through the issues and reconsider their opinions. The structure also shows them how to build a discussion and back up their opinions with facts.

Starter: 5 minutes.
What do you already know about forensic science?
Where have you learnt those things? TV Crime shows are very popular and show a fictionalised version of forensic science. DNA evidence is found, analysed and used to catch the criminal over the course of a 50 minute episode.

How realistic do you think this is? Is it a problem if it isn't?
Do you think DNA evidence is reliable?

Designed for KS4. These debate kits have been used with ages 11-18.

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Main Activity: 35 minutes.
1) **Split students** into as many **groups** as characters you want to cover.
2) **Give** them their **character cards** - one per group, and give them a few minutes to read them over.
3) Get one student in each group to **read out** their **first section** to the rest of the class.
   What are the class's initial thoughts? Is there one position they identify with or reject?
4) Take it in turn to **read out** their **fact**. Does it change the way they think?
5) **Read** the **issue**. Any different feelings?
6) Each team **asks** their **question to** the **character of their choice.**

TIP: Visit our resources site, forensic_dk.imascientist.org.uk, to project the character cards on your whiteboard.

Support: To help students you can put the following prompt sentences up on the board:
"I think ..... DNA evidence is reliable enough because....."
"I think ..... DNA evidence is NOT reliable enough because...."
"I think ..... is the most important point to think about."

Plenary: 10 minutes
Vote for which position they agree with most (if there is one). Why? Which arguments were the most persuasive?

Note – Pupils can stay in roles all the way through the debate, or only for the first round if you prefer. If it's all the way through, give them a chance to express their own opinion at the end and in the plenary.

For groups who are not confident at class discussion, it might help to have them start by discussing the question and/or their character's position in pairs, and then compare notes in fours. They've then had chance to rehearse some of what they want to say before having to do it in front of the whole class.

The persistence of DNA depends on the material it has been left on: some materials let it last long, whilst on others, DNA degrades rapidly. The SOCOs will wipe hard surfaces with a sterile-water-moistened swab, cut stains out of soft materials, or wipe with sticky tape to collect surface material. Biological evidence collected at a crime scene must be preserved by drying (large, stained, wet items) or freezing.

DNA analysis has to meet specific quality standards and the people analysing it need to be accredited. In England, private companies do the analysis, but in Scotland, this is handled by the police service. What do you think about this?

Back in the lab
DNA taken from a crime scene has to be processed to make a DNA profile, or 'genetic fingerprint'. First DNA is extracted from cells, then copied using a chemical process known as PCR (polymerase chain reaction). The pieces are then separated by size and detected. The DNA profile will look like a graph with lots of peaks on it, called an electropherogram. The height of the peak relates to how much of that section of DNA is in the sample. Scientists use computer software to try to match a suspect's DNA to a crime scene sample. However, it can sometimes be hard to match these peaks for 3 main reasons:
1. **Degraded DNA:** Old DNA, or DNA that has been in a warm, humid place, can degrade (break down) and some may be missing. This can lead to a profile with missing peaks, peaks that are very low, or disproportionate peak heights.
2. **A mixture of DNA:** This is an issue especially if there is a mixture containing a strong profile (lots of DNA) and a weak one (not much DNA). Separating a small peak in the strong profile from a big peak in the weak profile may be challenging.
3. **Artefacts:** Small peaks on a profile may be "artefacts", or anomalies, that come up during the extraction and copying of inherited from the mother, so all her children have the same mitochondrial DNA.

Matching DNA
The "match probability" is an estimate of the likelihood (or chance) of matching the DNA profile to someone other than the person it's from. Different software is chosen for different DNA samples, for example, depending on whether it is mixed or degraded or not. The data will be analysed again and again before the analyst arrives at a final conclusion on the best match.

DNA is often matched using the National DNA Database, which stores DNA profiles from crime scenes and people arrested and convicted of crimes. If people are not charged or found not guilty, their profiles are removed from the database. DNA profiles "expire" and are removed from the database after 5 years for a minor crime, but may be kept indefinitely for serious crimes. When a new DNA profile is added, the database automatically searches for matches, for example, to unsolved crimes. The database is a valuable tool, but many people are concerned about privacy, especially when innocent people or children's data is held on it.

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A full list of sources and additional reading material is available online at forensics_dk.imascientist.org.uk.

Using the debate kit in a STEM Club setting:
A debate is a great way to support an activity or project you are running or intending to run. It can help students to investigate and relate scientific facts to real world contexts and assist them in making informed decisions. Here are our top tips to make the most of the debate kit in your STEM Club.

1. Introduce the debate kit to your club members a week before you hold the debate.
2. Place the students in debate teams and assign character roles.
3. Challenge the students to research facts and data that support the debate point of their character.
4. Investigate real-world careers and roles that relate to the debate topic.
5. Involve STEM Ambassadors, ask them to attend the debate sessions and provide real world context or experience to the topic.
6. Use the debate to create a related scientific research project.
7. Utilise the debate as a method to improve key employability skills such as speaking and listening.

Background notes for teachers

At a crime scene
When they arrive at a crime scene, scenes of crime officers (SOCOs) use their knowledge to inspect the environment and identify DNA evidence such as body fluids before collecting them. Fluids are identified by testing with chemicals or seeing how they interact with light (a technique known as spectroscopy). Forensic DNA scientists are not just interested in who the DNA belongs to, but also how it got there, and when.

When DNA is transferred from the person of origin onto other people or objects, it is called **trace DNA**. Trace DNA can be analysed in tiny amounts, but scientists cannot determine the biological material of origin (e.g. blood, hair etc).

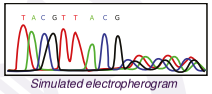
DNA. For complex DNA samples, it may be possible to suggest a match to more than one person.

About DNA
A DNA strand is made of a long sequence of four chemical "bases" (A, T, C, and G) on a sugar-phosphate backbone. Each base bonds exclusively to one other base: A to T, and G to C. Two DNA strands bond via their bases, then twist into a double helix. If the two strands break apart, one strand tells you how to perfectly replicate the other half. In one human cell, there are 6,500 million base pairs.

It is too time consuming to sequence it all, and 99.9% of human DNA is the same for all humans(!), so forensic analysts just sequence a "locus", or section. Loci are usually short tandem repeats (STRs) – sections of DNA that repeat 1000s of times, and so have a high mutation rate and vary a lot between individuals.

The locus could be the same between two or more people just by chance, and so the probability that a match is unique is calculated. The number of loci analysed has increased as technology develops, making it more unlikely that two people could both match a DNA sample. Since 2014, the UK analyses 16 loci, and Scotland analyses up to 23 loci.

Some loci choices:
Y chromosome DNA is chosen to find the DNA of a male in a mixture of male (XY) and female (XX) DNA. This DNA doesn't change much between father and son, and so can also be used to match males between generations.



Simulated electropherogram

Mitochondrial DNA is chosen when there is very little DNA, or a damaged sample. Because multiple mitochondria are in every cell, there are many many copies of this DNA. Mitochondrial DNA is