Amazing DNA facts

These facts can form the basis of a quiz (for example, how many base pairs are there in the human genome?). Students should be familiar with most of this material, so the quiz could be run at any point in the day.

Probably best doing this as a quick-fire quiz – maybe put the students into teams and give some kind of reward to the winners (such as loading their gels first).

- DNA is found inside every cell in our body (apart from red blood cells).
- Each cell contains roughly 2 metres of DNA.
- Humans have roughly 100,000,000,000,000 (100 trillion cells).
- If you unravelled all of your DNA from all of your cells and laid out the DNA end to end, the strand would stretch from the Earth to the Sun hundreds of times (the sun is approximately 98 million miles away from Earth).
- You could fit 25,000 strands of DNA side by side in the width of a single adult hair.

- The DNA is tightly coiled up and structured into 46 chromosomes.
- Our chromosomes are arranged in pairs. We inherit one copy of the pair from our Mum and one from our Dad.
- When chromosomes are stained they can be quite easily recognised by their distinctive stripy patterns. This is used to check whether people have the right number of chromosomes and check for any rearrangements.

- There are approximately 3 billion (3,000,000,000) chemical letters (otherwise known as bases) in the DNA code in every cell in your body.
- This is a massive amount of information. It would fill 200 yellow pages in small type font.
- If you tried typing the whole genetic code out (typing at 200 letters per minute) it would take 29 years (without taking any breaks!).

- The DNA is made up of 4 building blocks (an alphabet of 4 letters spelling out the instructions to help us grow, develop and function).
- The four letters in the DNA alphabet - A, C, G and T - are used to carry the instructions for making all organisms. The sequence of these letters holds the code - just like the order of letters that makes words mean something. Each set of three letters corresponds to a single amino acid.

- Sections of DNA that code for proteins are called genes. The complete set of genetic information for an organism is called the genome. The latest estimate is that there are between 20,000 and 25,000 genes in the human genome.
- We share a lot of DNA with other animals, plants and microorganisms. The table below shows some figures on shared sequence between species (please note that these figures are regularly revised, as more DNA sequencing is completed).

Species	**How many genes do we share with them?**
Chimpanzee	98%
Mouse	92%
Zebrafish	76%
Fruit fly	51%
Weed (thale cress)	26%
Bacteria (E coli)	18%

Questions on the practical

These questions can be used to check the students' understanding of the theories behind the practical.

It is best to run this by simply asking them to put their 'hands-up' to answer the quiz.

What does PCR stand for?	Polymerase chain reaction
What does heating up the DNA to 94°C do in PCR?	Breaks the hydrogen bonds between the strands (denatures it)
What happens at 58°C?	Annealing temperature. When the two strands of DNA come back together. The hydrogen bonds form between the bases.
Why do the primers need to be specific sequences?	To ensure that only the target section of DNA is amplified
Where does Taq polymerase come from and what's special about it?	*Thermus aquaticus* bacteria, which live in hot springs. The enzyme does not denature at high temperatures so can withstand the denaturation step.
How many copies of the target sequence are there after 10 cycles? (Assume that you begin with one copy).	1024 (1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024)
What are the main differences between PCR and DNA replication in your cells?	Accept any sensible suggestions (for example, body temperature remains at 37ºC or humans use a different polymerase or we use helicase is used to unzip DNA, as opposed to heat etc).
Why do bacteria need restriction enzymes?	So they can identifying and destroy foreign DNA (for example, DNA from viruses).
Can you explain why restriction enzymes like HaeIII only cut at one specific restriction site?	All enzymes have a specific 3D active site that the substrate must fit into in order for the reaction to be catalysed. Can refer to the lock and key model that is covered in many A-level Biology courses.
Why does the DNA for a non-taster not cut with HaeIII?	A non-taster sequence does not contain the necessary restriction site (sequence reads GGGC instead of GGCC).
If a linear piece of DNA is cut with a restriction enzyme in 3 places, how many bands of DNA would be formed?	4

Questions on evolution

This could just be a stand-alone 5 minute activity, or could be combined with one of the other quizzes. This would fit nicely before the evolutionary story of PTC, but could easily be run earlier on in the day.

Probably best to write some of the statements onto a whiteboard and give the group time to think about the answers. You could go through the answers as a group, or go through them with the students as they are waiting to load their gels.

1. Try to rate the following in order of how similar you think their genes are to your own:
   - The person sitting next to you
   - A chicken
   - A banana
   - A mouse
   - A chimpanzee
2. Approximately what percentage of each their DNA do you think is the same as your own?
3. Humans have twice as many DNA bases in each cell than a mouse. True or false?
4. Humans are more evolved than chimps. True or false?
5. You have around 10,000 taste buds on your tongue. True or false?
6. How many known different species are there on Earth?
7. What is the estimated number of species we don't yet know about? (could give options)

Answers & notes

1 & 2: Person sitting next to you – 99.9%
Chimpanzee – 98%
Mouse ~ 75%
Chicken ~60%
Banana ~ 50%

Be sure to point out that the differences between these are low in terms of percentage, but that subtle differences in the sequences of each gene can lead to a functional difference in the protein it codes for. It is also important to point out that, because the full genomes of most species have not been fully mapped, these are estimates based on the genes that have been studied to date.

3. False – we have 3.2 billion, mice have 2.6 billion.
4. False – make sure students understand that different species evolve different characteristics over time, as opposed to humans being 'most evolved'.

5. True
6. About 1.8 million species have been given scientific names (over 1 million are insects).
7. Estimates of the total number of living species range from 10 to 100 million. It is likely the actual number is on the order of 13 to 14 million (most being insects & microscopic life forms). However, we may never know because many of them will become extinct before being counted and described.

Practicing with pipettes

Three options to try to get students more skilled…

Closest count

Before the workshop, measure out exactly 1024 µl into 5 tubes (one per bench). Everyone on the bench has to take it in turns to remove some liquid and as a group, they keep a running total of the volume removed from their tube.

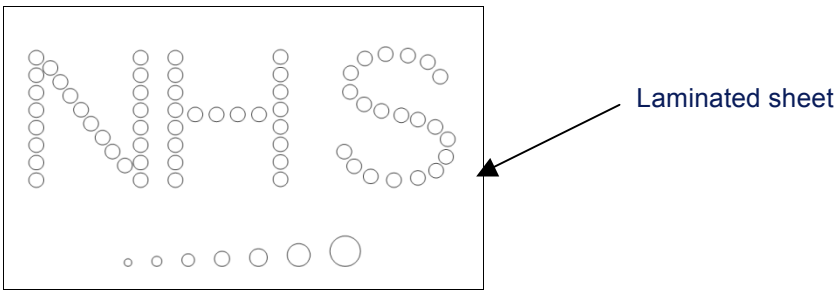
The groups continue to remove liquid from their tubes until the tubes are empty. Ask the benches to make the most accurate estimate of the total content in the tube.

This is quite tough, so if the group get it within the range of 1015 - 1030 µl – it's close enough.

Filling the circles

We have printed and laminated some sheets with printed circles on them (of different sizes). We will give students different colours of food dye to have to go at filling the circles as neatly as they can to fill the dots (and see how many microlitres of liquid it takes to fill the circle).

We're not convinced this will really help them develop their skills greatly, as students might use the pipettes to simply drag liquid about, but it will hopefully keep them practicing for a bit longer.



Weighing game

The students are challenged to measure out exactly 50µl and 150µl of water onto the balance (50µl should weight 50µg). This relies on being able to use accurate scales.

Use a weighing tray and zero the balance and invite individuals up.

With only one balance in the lab - you could organise this one bench at a time. Students will probably need help with the balance.

This is also dependant on the sensitivity of the balance and accuracy of pipettes (depending on whether they have been calibrated recently).

Extra resources

Dialogue activities

At-Bristol created a number of dialogue resources to complement this workshop. These are available to download on the Wellcome Trust's Survival Rivals website (see link below), so some schools might have used them before attending the workshop.

http://survivalrivals.org/a-question-of-taste/resources

Bioinformatics

The DNA Learning Centre (DNALC) in New York has developed a bioinformatics activity to complement this experiment. This is described online on the following link:

http://bioinformatics.dnalc.org/ptc/animation/index.html

The bioinformatics activity is described within the protocol section of the website. It guides you through using an online resource (BLAST) to search for DNA sequences and another programme (BioServers) to align the sequences. This activity uses important research tools and allows you to identify the differences between the taster and non-taster alleles. This website also includes a detailed laboratory protocol - this is because the DNALC developed a kit that uses a similar protocol to the one used in the Question of Taste workshop. The American DNALC kit is supplied through Carolina, so this is one of the ways you can buy the reagents you need.

The National Centre for Biotechnology Education (NCBE) has also developed some resources about bioinformatics and taste receptors. These resources have been designed to use in schools and are available to download on the link below, so schools might have used these before attending the workshop.

http://www.dnadarwin.org/casestudies/11/