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A Matter of Taste
Investigating our Genome

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Experiment 1_ Make a Candy DNA Model

Introduction

Ever wondered how DNA, the genetic blueprint of life, can encode and pass on the information on how to grow and maintain that life-form? Just like a cookbook contains a complete recipe for a dish, DNA stores the recipe for the life of an organism. Although each human has a unique DNA sequence, the DNA in all of us is about 99.9% identical! In this activity, you will use pieces of candy to make a model for a short section of DNA—enough to get a sense of what DNA is like and how it encodes life.

Our first experiment is an introduction to the structure of the DNA, visualized in a playful way.

Materials

- ➢ Soft candy that comes in four different colors such as gummy bears, gum drops, or mini marshmallows (10 of each color)
- ➢ Twizzlers (2) (or similar rope-like candy)
- ➢ Toothpicks (5)
- ➢ Paper
- ➢ Pen (or marker)
- ➢ Paper towel

Prep Work

- ➢ Clean the area you will work on, or plan to work with your candies on top of a paper towel.
- ➢ Sort your candies by color. Make sure you have at least 10 pieces of each of the 4 colors you will be using.

Procedure

DNA encodes the genetic blueprint of a life form using four chemicals. It is a long molecule that looks a little like a rope ladder, only about 200,000,000 times smaller! Give the long "ladder" a clockwise twist, and you can see why DNA is also called the **"double helix".**
Following the instructions below, you will make a candy model of a piece of DNA. This will help you see what DNA looks like!

1. DNA uses four chemicals **(adenine, guanine, thymine and cytosine)** to encode the data to maintain and grow an organism. These chemicals are abbreviated by the letters **A, T, C, and G**. We will use different colors of candy to represent each of these chemicals: **yellow (A), red (T), green (G), and orange (G).**

2. These code chemicals are very particular. They always pair up in specific ways: **A pairs with T, and C pairs with G.** In your model, red only combines with yellow, and orange only combines with green. Use toothpicks to make colored pairs from your candies by sticking a candy on each end of the toothpick. Push the candies onto the toothpick so that the candies are pressed together in the middle, and you still have a bit of toothpick sticking out on each side, as shown below. You will create 6 pairs each of yellow-red and green-orange. No other combinations of colors are allowed.

Your DNA has a length of about 3 billion pairs, so your candy DNA will only model a small piece of DNA—not the whole sequence!

3. **DNA looks like a twisted rope ladder.** In your model, you will use Twizzlers for the "backbone" sides of the ladder and then add the candy "pair" rungs. To assemble your DNA model, lay two Twizzlers parallel to one another with about 8 cm of space in between.

4. You will link the pairs of code chemicals to your DNA backbones by attaching each pair to the backbones so that the pair looks like ladder rungs. Lay your pairs between the backbones.

5. Take one toothpick that has a GC or AT pair of candies on it and stick the toothpick into the inside of one piece of the backbone (near the top). Then carefully stick the other end of the toothpick into the other side of the backbone so that your candy pair is connected to both sides.

6. Continue to attach your other candy pairs to the backbones so they make parallel rungs. Leave about one or two centimetre of space between each rung. Do this until your backbones are connected by pairs from one end to the other.

7. Your candy DNA model probably looks something like the one below. Your sequence of pairs might be in a different order than this. That is okay! Lay your model on a piece of paper and use a pen or marker to write the letters next to each piece of candy.

8. Your model is almost finished! One detail is missing: DNA is twisted. Hold one end of your model flat and carefully flip the other end over (180 degrees). This should create a twist!

9. To get an idea of how long human DNA is, count the number of pairs in your DNA section. Human DNA consists of three million pairs. Can you estimate how long your model would be if you modelled all three million pairs?

10. Take your ruler and measure how wide your DNA molecule is when untwisted. A real DNA molecule is about two nanometres or two millionths of a millimetre (2÷1,000,000 mm) wide.

Image Documentation

Fig.1: Materials

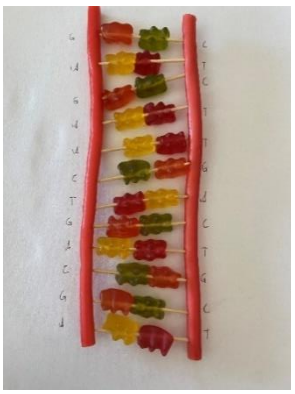


Fig.2: The DNA candy model showing the four nitrogenous bases

Fig.3: The final DNA candy model

EXPERIMENT 2_Extracting DNA from different types of Fruits

This simple experiment will show you how to extract DNA from fruit like kiwi. All you need is some fruit and some things you probably have around the house right now.

Research question

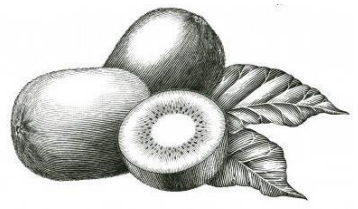
Can DNA be extracted from a kiwi?

Hypothesis

Our prediction is that it will be possible to extract the DNA from the kiwi as well as to see it through a microscope.

Materials

- half of a kiwi
- 4 tsp. 91% isopropyl alcohol – chilled
- ½ tsp. of salt
- 2 tsp. washing-up liquid
- 100 ml water
- teaspoon
- freezer ziplock bag
- 1 plastic cup
- 1 coffee filter
- small glass



Procedure

1. **Peel and chop up a kiwi fruit.** Throw away the skin (most of the cells in the skin are dead and the DNA no longer useful) and put them in a ziplock bag
2. In one plastic cup **mix together washing up liquid, salt and water**. Stir the mixture **slowly** until the salt dissolves (mix it too fast and you'll end up with too many bubbles)
3. Add the solution to **kiwi fruit in a ziplock bag and mush the kiwi thoroughly** but carefully so the bag doesn´t break, for about 3 minutes
4. **Incubate the mixture in a water bath at 60ºC for 5 minutes**. Then mush the kiwi more. Repeat this procedure three times.
5. **Filter the mixture** through the coffee filter and keep the filtrate in the glass
6. **Pour ice cold alcohol slowly and very carefully down the side of the glass**
7. Leave for a minute
8. You should be able to see **DNA appearing between the two liquids**

Observation

While mushing the kiwi, we observed that foam appeared. The color then changed into a lighter green, when putting the kiwi in the hot water.
When pouring the mixture into the beaker, we clearly saw the seeds separating from the liquid.
As the alcohol was added, the DNA separated from the rest of the liquid.
Under the microscope DNA could be seen closer and clearer. It looked like white specks floating in a solution.

Conclusion

The experiment confirms that a kiwi contains DNA, like any other living organism and it can be extracted easily. DNA, though microscopic in a single cell, can be seen when many strands are grouped together. It appears as a white substance.
The experiment demonstrates as well that the membranes protecting the DNA, need to be broken down, in order for it to be extractable.
The alcohol plays a very important role because it makes the DNA visible. The reason for this is that DNA is not soluble in alcohol. Experiments like this help scientists to do research on genetics, traits and heredity to understand these factors better.

Image Documentation

Fig.4: Materials

Fig.5: Kiwi fruit

Fig.6: The mixture set in a water bath

Fig.7: The separated DNA

A Matter of Taste
Investigating our Genome

Introduction

The phrase **"a matter of taste"** refers to something that is subjective and depends on an individual's personal preferences, likes, or dislikes. E.g. a dish like sushi might be a delicacy for one person but unappealing to another. Whether it's "good" or not is a matter of taste.

There's no universal standard; what appeals to one person might not to another. Disagreements about matters of taste don't usually have definitive answers. Or do they?

Let´s have a closer look at our genes.

It is hard to believe that 99% of DNA in humans is exactly the same, and only 1% accounts for all the variability between people – this 1% is what makes each of us unique.

The differences in DNA are spread across the entire genome and can occur in a variety of forms.

The most common differences are manifested as so-called **single nucleotide polymorphisms (SNPs).** A single nucleotide polymorphism (SNP) is the most frequent type of DNA variation, occurring when a single base in a gene's DNA sequence is replaced.
In the sequence shown in the image – an excerpt from the gene – one SNP occurs every 970 base pairs (bp).

***Fig. 1**_ In the sequence shown in the image – an excerpt from the gene – an SNP occurs at 970 base pairs (bp).*

Our experiment examines SNPs, which lead to different versions of a gene, known as alleles. These variations can influence how proteins function.

One notable example is the impact of three SNPs in the TAS2R38 gene on taste perception.

Humans can sense sweet, sour, bitter, salty, and umami tastes. Different types of taste cells, with specific receptors, detect each taste.

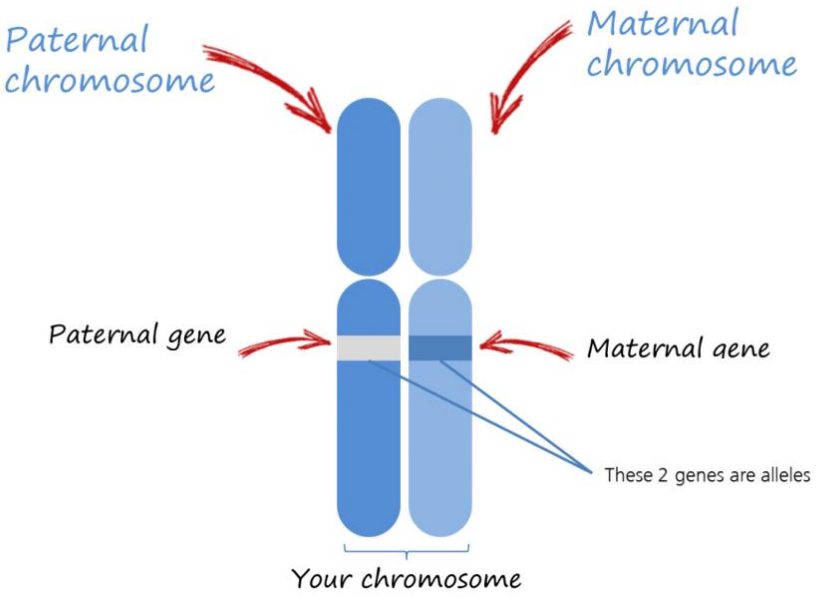
For bitterness, there are 25 known receptors, each reacting to different substances. One of these, the TAS2R38 protein, detects several bitter compounds, including **phenylthiocarbamide** (PTC)

PTC is a bitter compound that can be found in certain foods, particularly in vegetables like *broccoli*, *brussels sprouts*, *kale*, *cabbage* or *cauliflower.*
These vegetables naturally produce PTC, which gives them their bitter taste. However, the ability to taste PTC varies among individuals, as it is influenced by genetic factors.

Some people find these vegetables more bitter due to their sensitivity to PTC, while others may not taste it as strongly or not at all.

In fact, studying a single molecule – phenylthiocarbamide – reveals a direct connection between our genes (genotype) and how we perceive taste (phenotype).

Phenotype	**Genotype**		
Phenylthiocarbamide (PTC)	***TAS2R38 gene** present in following form*		
strong taster	**T/T**	*two dominant traits inherited from parents (maternal allele T and paternal allele T)*	***Homozygote dominant***
mild taster	**T/t**	*Each parent passes a different gene (dominant trait T and recessive trait t) to the offspring*	***Heterozygote***
non-taster	**t/t**	*two recessive traits inherited from parents (maternal and paternal allele t)*	***Homozygote recessive***



So, what are we going to do today?

Nearly every cell in the body contains the entire genome, which makes it possible to isolate and study DNA from almost any type of cell.

Step 1_ DNA Extraction (Cheek Cell Collection)
Cheek cells are ideal for this process because they can be collected easily and non-invasively.

Step 2_ PCR (Amplifying DNA)
Your TAS2R38 genotype will be determined using a method called PCR (Polymerase Chain Reaction). In this process, a specific segment of the TAS2R38 gene is amplified or cloned.

Step 3_ DNA Fragmentation (Cutting DNA)
To differentiate between the two alleles (dominant T and recessive t), a restriction enzyme is used. These enzymes recognize short DNA sequences (4–8 base pairs) and cut the DNA at those specific sites.

Step 4_ Gel Electrophoresis (Separation of DNA Fragments)
The DNA fragments are separated by size using gel electrophoresis, enabling the determination of the genotype.

After completing all four steps, the results can be analysed by observing the separated DNA fragments on the gel plate, as shown below.

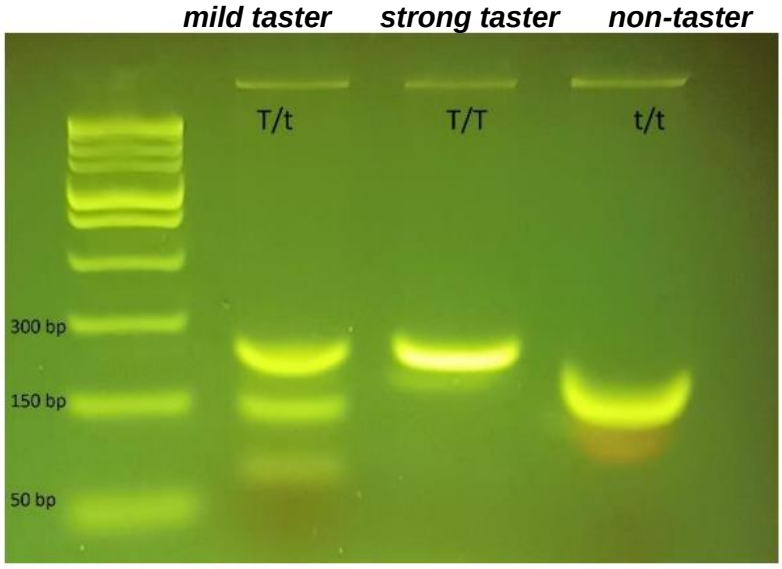


Fig.8: *_ Gel electrophoresis of the genotypes Tt, TT and tt.*

Experiment

Research question

Is personal taste perception linked to the genome?

Hypothesis

According to the test person`s perception of not liking broccoli that much and that it tastes bitter to them, we predict that the test person`s genotype is heterozygote (Tt; mild taster)

Materials

Reagents:	Required amount per person:
• ***Extraction Buffer I:***	*50 µL*
• ***Extraction Buffer II:***	*50 µL*
• ***Hot-Start Mastermix:***	*12.5 µL*
• ***PTC Primer:***	*12.5 µL*
• ***BtsCI Restriction Enzyme:***	*0.5 µL*
• ***CutSmart Buffer:***	*2.5 µL*
• ***Gel-Loading Dye (6X):***	*2 µL*
• ***100 bp DNA Ladder:***	*10 µL per gel*
• ***SYBR Green I (10,000x):***	*2 µL per gel*
• ***Agarose:***	*0.4 g per gel*
• ***TBE Buffer:***	*20 g*

Labor Equipment:	**Consumables:**
• *Thermocycler* • *Gel electrophoresis equipment* • *Transilluminator* • *Microwave* • *Centrifuge*	• *PCR tubes (1 mL and 0.2 mL)* • *Syringes (1 mL)* • *Pipette tips (2-200 µL)* • *Plastic shot glasses (40 cl)* • *Gloves* • *Saline solution* • *Distilled water*
Micropipettes and Pipette Tip Boxes:	**Other:**
• *2-20 µL micropipettes* • *Pipette tip boxes (2-200 µL)* • *20-200 µL micropipettes*	• *Permanent markers* • *Plastic racks* • *Styrofoam box with ice* • *Cups (for disposing of pipette tips)* • *Safety goggles*

Procedure

Step 1_DNA Extraction (Cheek Cell Collection)

1. *Use a small plastic cup containing 20 mL of salt solution. **Rinse your mouth** with this solution for 30 seconds, focusing on the inside of your cheeks.*

2. *Use a syringe to **transfer 1 mL of the rinsing solution** into two labelled PCR reaction tubes (each 500 µL = 0.5 mL)*

3. ***Centrifuge the filled PCR reaction tubes** at 12,000 RPM for 2 minutes to collect the cells at the bottom of the tube.*

4. *Discard the clear supernatant and **remove any remaining liquid** with a micropipette.*

5. *A visible cell pellet should now be present. If not, transfer another 1 mL of the rinsing solution into the PCR reaction tube and centrifuge again.*

6. ***Add 50 µL of Extraction Buffer I** to the cell pellet and homogenize by shaking.*

7. ***Heat** the cell suspension at 95°C for 10 minutes.*

8. *After cooling, **add 50 µL of Extraction Buffer II** and centrifuge at 12,000 RPM for 2 minutes to separate the remaining cell components from the dissolved DNA.*

9. *The DNA is now isolated and should be used for PCR as soon as possible, preferably within 30 minutes.*

Step 2_ PCR (Polymerase Chain Reaction - Amplifying DNA)

1. *Into a labelled 0.2 mL PCR reaction tube, **pipette the following reagents**:*
   - *12.5 µL 2X Hot-Start Mastermix*
   - *12.5 µL PTC Primer solution*
   - *3 µL of the extracted DNA (use only the clear supernatant!)*

2. ***Mix all reagents** well by shaking, then briefly centrifuge.*

3. ***Place the sample in the thermocycler** and run the PCR with the following parameters:*

   - *Initial denaturation: 94°C, 120 s*
   - *Denaturation: 94°C, 10 s*
   - *Annealing: 58°C, 15 s*
   - *Extension: 72°C, 40 s*
   - *Number of cycles: 30*
   - *Final extension: 72°C, 5 s*

The PCR takes about 70 minutes.

Step 3_ DNA Fragmentation (Cutting DNA)

1. *Pipette 12 µL of the PCR product into a labelled 0.2 mL PCR reaction tube.*

2. *Then, add 3 µL of the mixture of CutSmart buffer and BtsCI.*

3. *Gently mix the contents by pipetting up and down, then heat for 15 minutes at 50°C.*

Step 4_ Gel Electrophoresis (Separation of DNA Fragments)

Gel Preparation

1. *First, prepare 1X TBE.*
2. *Set up a gel chamber with a comb.*
3. *Weigh 0.4 g of agarose (enough for a mini-gel with a size of 9.5 x 6 cm).*
4. *Suspend the agarose in 20 mL of 1X TBE.*
5. *Heat in the microwave for about 60 seconds – the solution should boil, and the agarose must completely dissolve.*
6. *Cool the solution to 50-60°C.*
7. *Add 2 µL of SYBR Green I dye.*
8. *Pour the gel into the gel chamber.*
9. *Wait about 15 minutes until the agarose has solidified, then remove the comb.*

Gel Electrophoresis

1. ***Place the gel with the gel tray into the buffer container*** *and* ***add enough 1X TBE*** *to just cover the gel.*

2. *Fill the far-left well with* ***10 µL of DNA ladder****.*

3. *Then, successively* ***load the wells with the samples*** *(15 µL) and note the order of the samples.*

4. *As a general rule, use a voltage of 5-10 V per cm of running distance – higher voltage will speed up the separation but can reduce resolution.*

5. *The purple dye runs approximately at the same height as a 50 bp DNA fragment. When the dye has travelled about one-third of the total running distance, the electrophoresis can be stopped, and the result can be viewed in the transilluminator.*

Evaluation

1. *After turning off the electrophoresis power supply, remove the lid and allow the gel tray/gel plate to cool down.*

2. *Then, **place the gel tray on the transilluminator**.*

3. *Molecules of the same size form what are known as bands, which appear as fluorescent stripes in the gel. A specific banding pattern is created for each sample.*

Observation

Step 1_DNA Extraction (Cheek Cell Collection)

Saliva can be seen in the solution. After filling this solution into the small pipet, the saliva- salt solution is on the top and the small white part on the bottom are the important cells.
After putting the small solution in the machine for a second time, the white part can be seen more clearly.

➔ Transparent chemicals

Step 2_ PCR (Polymerase Chain Reaction - Amplifying DNA)

The raw materials: Components; DNA sample; 4 types of Nucleotides

➔ DNA primase enzyme is needed for the chain reaction

Strand separation: Denaturation (94- 98 degrees Celsius); two DNA strands separate
Primer Blinding: temperature changes to 50- 68 degrees Celsius; ideal temperature for binding; binds again to the original DNA
Strand Synthesis: Elongation: 72 degrees Celsius: nucleotides are added

➔ This process is repeated 30 times and this lasts 70 minutes

Step 3_ DNA Fragmentation (Cutting DNA)

New measurements (2x6 micrometres) of the solution are filled into the beaker and a different structural pattern can be observed.
This process is used to cut longer strands of DNA into smaller sequences of the same size.
Except from the different pattern, there are no visible changes in the solution.

Step 4_ Gel Electrophoresis (Separation of DNA Fragments)

The gel is placed in the electrophoresis chamber filled with buffer.
The electrophoresis lasts for 25 minutes with a tension of 100 volt. After this process a darker shade of blue can be observed, and the gel is visualized under UV or blue light to observe the DNA bands.
DNA fragments appear as distinct bands on the gel. The different patterns of samples can now be compared in order to get the right results.

Results of the Experiment and Analysis

The hypothesis turned out to be true and the test person is a heterozygote or mild taster. This result shows us that, with the help of DNA extraction, PCR (Polymerase Chain Reaction), DNA fragmentation and Gel Electrophoresis, we can scientifically prove thar different people have different tastes depending on their genotype and the genetic material they inherited from their parents.

Image Documentation

Fig.9: Materials

Fig.10: Saltwater

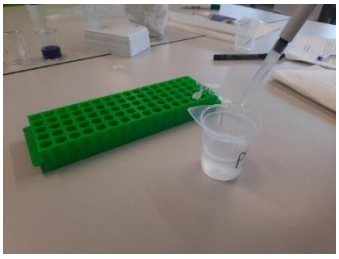


Fig.11: Saltwater with cheek cells

Fig.12: Centrifuge

Fig.13: Thermocycler

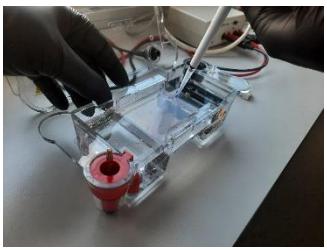


Fig.14: Gel Electrophoresis

A MATTER OF TASTE_APPLICATIONS

The research on SNPs in the TAS2R38 gene and taste perception has several real-world applications:

1. **Personalized Nutrition & Diet Planning**
   Genetic taste predisposition affects diet choices. Strong tasters may avoid better bitter vegetables, missing key nutrients. Nutritionists can suggest alternative preparations to improve palatability.

2. **Food Industry & Product Development**
   Companies can tailor food products to genetic taste preferences, such as creating milder versions of bitter plant-based foods or adjusting processed food formulations.

3. **Health & Preventive Medicine**
   People who avoid bitter foods may be at higher risk of nutrient deficiencies. Genetic screening could help promote balanced diets by identifying alternative nutrient sources.

4. **Pharmacogenetics & Drug Development**
   The TAS2R38 receptor also affects drug taste perception, influencing medication adherence. Pharmaceutical companies could develop taste masked formulations for better patient compliance.