Baby Bonanza TEACHER NOTES

Breed yourselves a bumper-crop of bouncing classroom babies!

- **KS4+ desk activity**
- **Punnet squares & autosomal recessive diseases**

Prior knowledge:

- Cell, cell membrane, chromosomes (two sets), gene
- Babies receive one set of DNA from each parent (activity reinforces this)

Introduces:

- Autosomal recessive diseases / carriers
- Cystic Fibrosis
- Punnet squares

Materials:

- Sperm and eggs, printed out and cut out on red (CF) and green (normal) card. But if this is too much work then you can use any two distinguishable objects (eg red & green counters) and edit the worksheets accordingly. It is not necessary to distinguish sperm from eggs, just the normal gene from the CF gene.
- Student worksheets (A4 copies, shared in pairs). But it's possible to run activity without these.

Introduction:

- Different versions of genes, normal vs faulty genes (mutation)
- CFTR gene (function, pathology, Cystic Fibrosis). Mention that only 1/25 people carry faulty CFTR genes.
- Two copies of each gene; concept of recessive diseases / carriers

Activity:

1. Students are given counters representing normal/faulty CFTR genes (eg green/red counters). Every student gets one of each type (ie everyone is heterozygous).
2. Working in pairs, they each choose a counter without looking and combine these to 'make babies'.
3. Students record the genotypes obtained for each child on their worksheets, working out whether the babies have Cystic Fibrosis or are healthy (carrier/non-carrier).

Plenary:

1. Collate the data from the class. Expected result is approximately ¼ babies to have CF.
2. Why is it ¼? What are the possible outcomes? Introduce punnet square as a way to visualise the possible outcomes. Which are healthy/carrier etc? See why you would expect ¼ CF babies.
3. But what of the individual families; did they show the same split? Would you expect every family of four children to include a CF child? Did any families have none? All?

<u>Ensure students are aware that only 1/25 people in the UK are carriers of faulty CF genes.</u>

Linked topics (not provided):

- Gene testing (family planning), pre-natal testing, ethics of these
- Cell membranes, transport across membranes

Baby Bonanza INFORMATION SHEET

Breed yourselves a bumper-crop of bouncing classroom babies!

What is Cystic Fibrosis?

Cystic Fibrosis (CF) is an **autosomal recessive** genetic disorder most common in Caucasians.

- Genetic disorder = the problem is in your DNA
- Autosomal = the problem is not on the X or Y sex chromosomes, but one of the other 22
- Recessive = so long as you have one good gene then you'll still be healthy

The gene involved is the CFTR gene on chromosome 7, which contains 230,000 base pairs.

The CFTR gene carries the code to make the CFTR protein, which is normally found in epithelial membranes (cells lining internal body parts like the lungs, pancreas and intestine). This protein assembles to form channels in these cell membranes. These channels control the movement of salt (chloride and sodium ions) in and out of cells.

There are over 1,000 different mutations that can cause CF, but the most common is the **ΔF508** mutation, where an entire codon (three DNA base pairs) is deleted from the sequence, deleting one amino acid from the protein sequence.

- Δ = deletion
- F = the amino acid Phenylanine
- 508 = the number of this amino acid in the protein sequence

So long as you have one normal CFTR gene, you can make good channels and you're healthy.

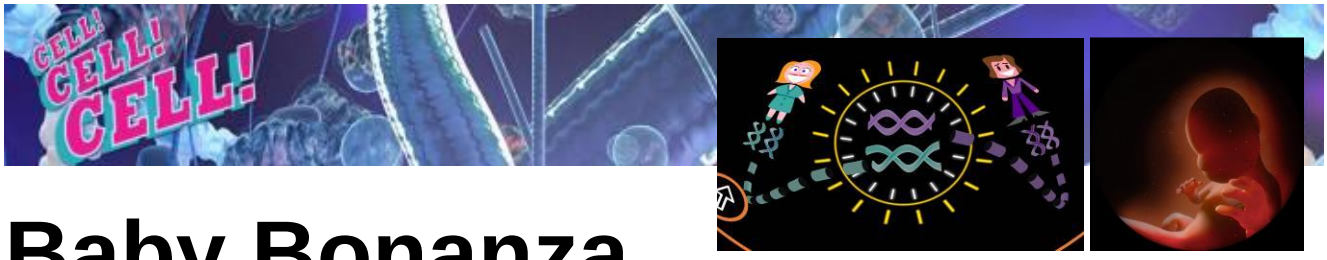
If you have *no* normal CFTR genes, you cannot make the channels properly. You will have many unpleasant symptoms including mucus build-up in your lungs and digestive system. This will make it hard to breathe or to digest foods. You have Cystic Fibrosis.

Improvements in screening and treatments have dramatically improved life expectancy of people with CF over the past fifty years. In 1960, over half of those with CF died before starting school. Today over half those in the UK live to over 41yrs old.

One in every 20-25 people in the UK has a single faulty CFTR. These people are healthy but are known as carriers as they can pass the faulty gene on to their children. If two carriers have a baby, there is a danger that both will pass on their faulty gene and the baby will have no normal genes.

1:2,500 babies born in the UK have Cystic Fibrosis (about 250 per year). Couples who are both carriers have the option of pre-natal screening for CF.

It is a bit of a mystery as to why the ΔF508 mutant gene hasn't been lost through natural selection. Often in such cases there is an advantage to being a carrier. For instance, in Sickle Cell Anaemia (a horrible condition) carriers are partly resistant to Malaria. No advantage has been confirmed for the mutated CF gene, although there are theories that carriers may have partial resistance to typhoid, cholera or tuberculosis.



Baby Bonanza

Breed yourselves a bumper-crop of bouncing classroom babies!

WORKSHEET

Check out your genes:

In this activity, both mother and father will be carriers of the CFTR gene. This means they each have one normal version and one faulty version of the gene.

Their gametes (eggs/sperm) get just *one* of the copies of the gene. There is an equal chance that this will be the normal version or the faulty version. You will get 'sperm' and 'eggs' of each type:

GREEN contains the **normal** gene

RED contains the **faulty** gene

The baby gets one CFTR gene from each parent, giving it two copies of the gene. But which gene versions will it inherit?

Making babies:

1. Choose a name for your baby!
2. Make your sperm and egg: jumble up your gametes behind your back, count to three and (without looking) both parents show ONE of their counters. These are the genes that have gone into your sperm/egg, and will be combined to make the baby.
3. Write down which type of gene (good or faulty) the baby inherited from each parent below.
4. Work out whether the baby is unaffected, a carrier or has Cystic Fibrosis.
5. Take back your sperm/egg and make more babies!

Name	Parent 1 gene	Parent 2 gene	Unaffected, Carrier or CF?
Baby 1:			
Baby 2:			
Baby 3:			
Baby 4:			

If your baby has <u>at least one normal gene</u>, they can make the membrane channels and be healthy.

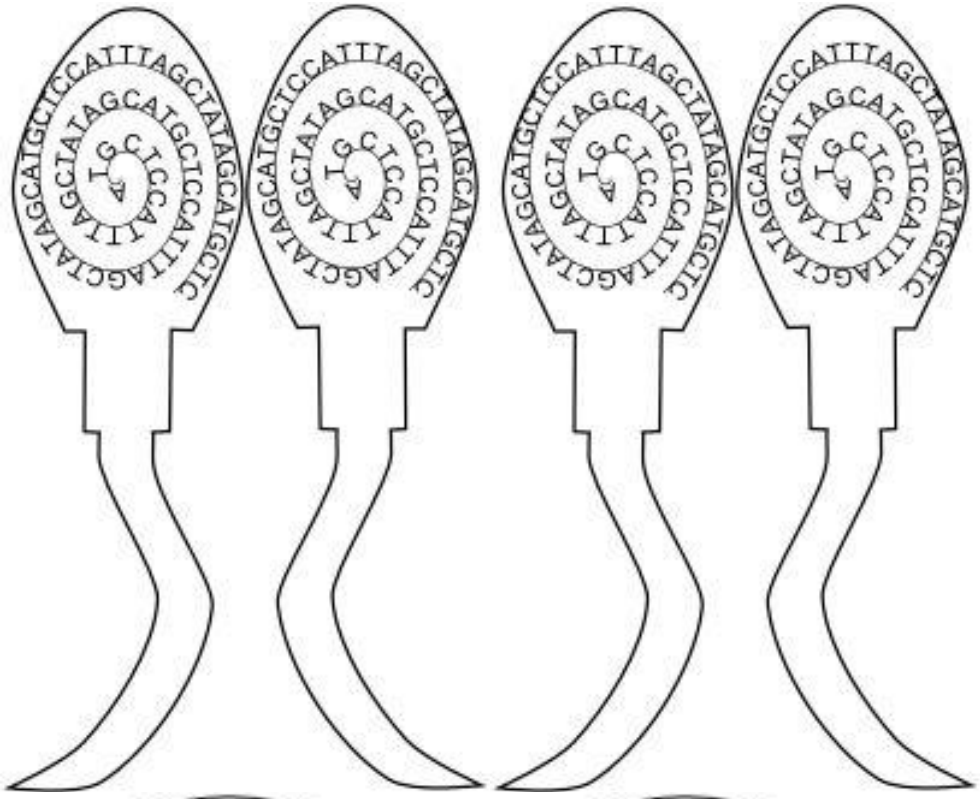
If your baby has <u>only faulty genes</u>, they cannot make the channels. They have Cystic Fibrosis.

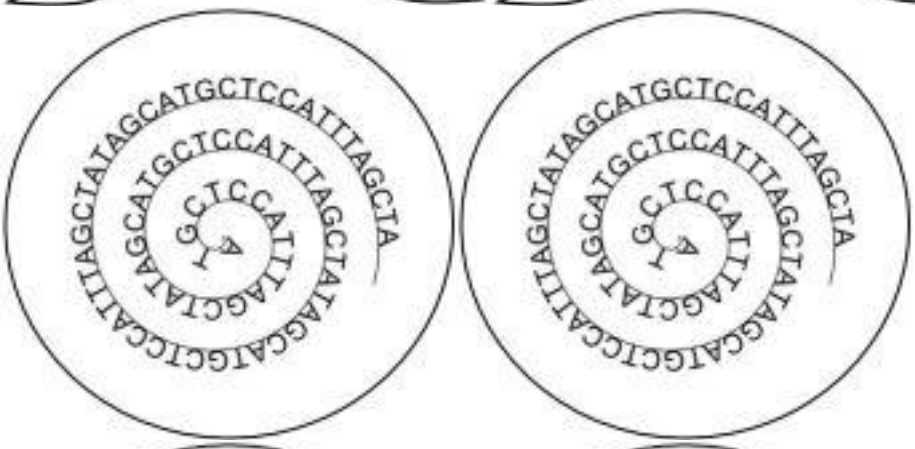
If your baby has <u>one normal and one faulty</u> gene, they'll be healthy but could pass the faulty gene on to their children (just like the parents in this game). People who are healthy but carry a copy of the faulty gene are called 'carriers'.

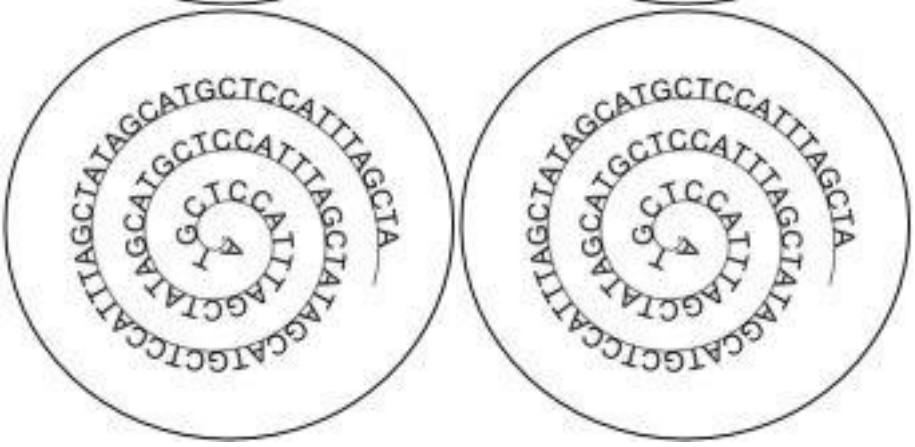
Baby Bonanza

TEMPLATE 1/2

Gametes with normal gene – on GREEN card



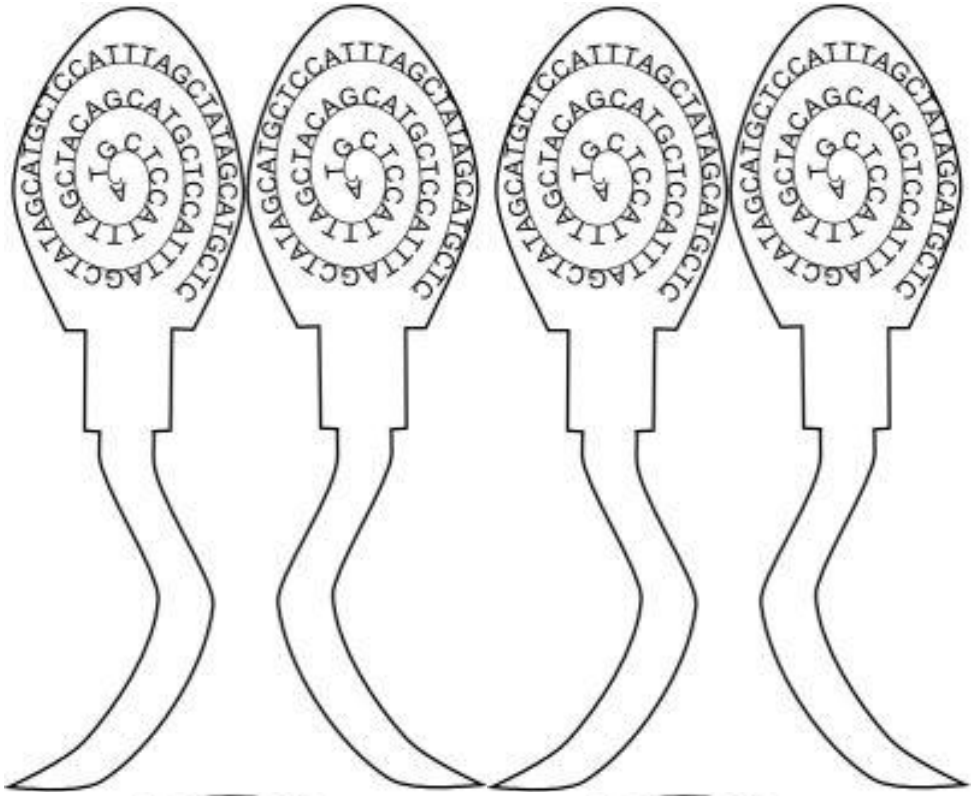


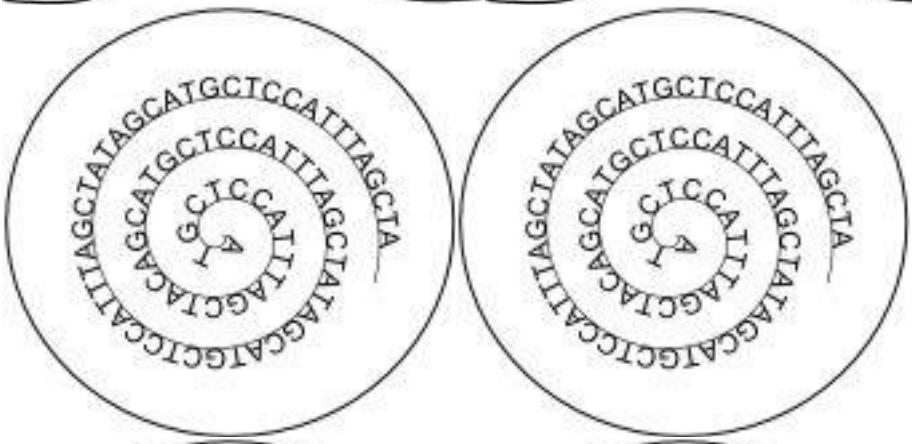


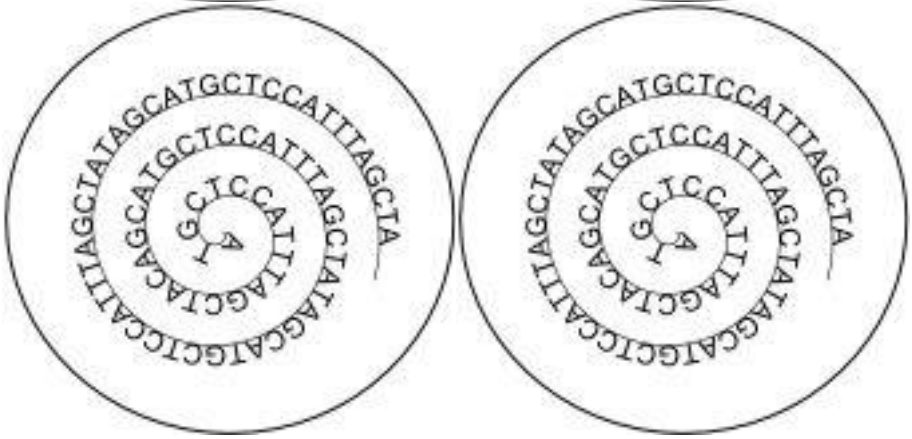
Baby Bonanza

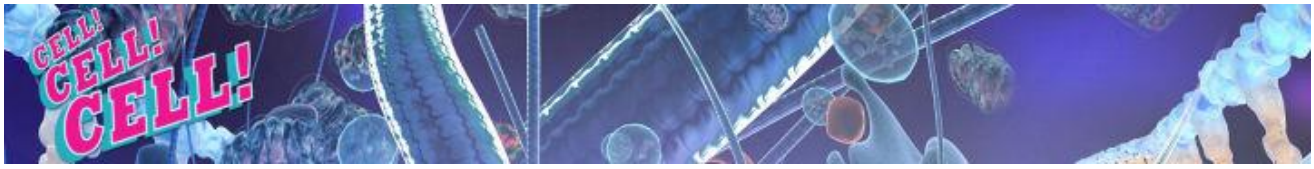
TEMPLATE 2/2

Gametes with CF gene – on RED card









Cheeky cells

TEACHER NOTES

You really are made of cells!

- **KS3+ desk activity**
- **Use microscope to see human skin cells**

Prior knowledge:

- How to use a microscope
- Cell, nucleus, membrane

Introduces:

- You are made from cells
- Identifying basic cell structures

Materials:

- Microscopes, slides & cover slips
- Methylene blue stain (can be bought from aquarium shops)
- Small pipette (for the stain)
- Toothpicks (to collect

Introduction:

- We are made of cells, they are generally too small to see without a microscope.
- Emphasise care required to avoid staining clothes/skin etc
- Emphasise that they only need pick up old naturally-shedding cells, not gouge ones from their flesh!

Activity:

- Practice using microscope to look at familiar objects (finger nail, pencil tip)
- Put drop of Methylene blue onto middle of slide
- Scrape cheek gently with toothpick and touch end of toothpick to dye
- Slowly lower cover-slip on top, leading with one edge to avoid air bubbles
- Observe cells at different magnification levels and draw visible features of cells (membrane, nucleus)

Plenary:

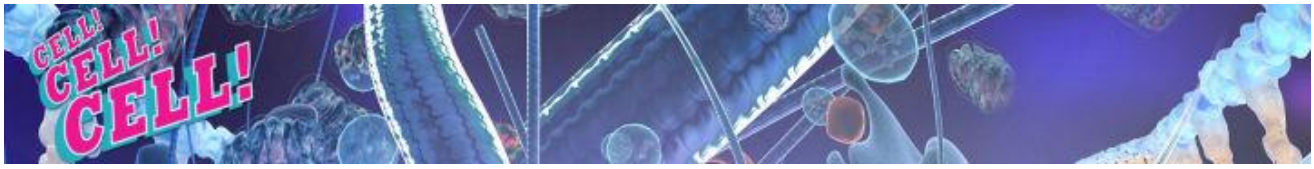
- What parts of the cell did the stain stick to?
- Scale of the cell (human skin cells are about 30 micrometres across)

Linked activity:

- Our “Cut out cells” activity continues exploration of scale (including skin cells)

Extensions (not provided):

- Compare to unstained cheek cells
- Compare to onion skin cells, tomato skin vs pulp cells, or to prokaryotes (eg from gutter/pond water)



Cheeky cells

INSTRUCTIONS

You really are made of cells!

WARNING!

You'll be using Methylene Blue stain to stain your cells. This chemical also stains hands and clothes so take care with the bottle and anything that has touched the stain.

Before you start:

Check you have a clear area to work in and the following materials:

- Microcscope
- Microscope slide and cover-slip
- Bottle of Methylene blue stain
- Pipette
- Toothpick
- Paper towels

Instructions:

1. Take a microscope slide.

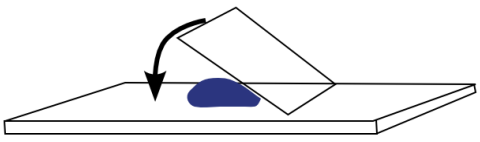
2. Using the pipette, place a small drop of Methylene Blue stain in the centre of the slide. Put the used pipette on a paper towel or straight into the bin.

3. Use a clean toothpick to gently scrape inside your cheek. No need to gouge! Your cheek constantly sheds cells; gentle scraping will pick up these old cells without damaging your skin.

4. Touch the tip of the toothpick to the drop of stain you put on your slide. The cells will float off into the stain. Don't worry if you can't see them; they are very small!

5. Take a coverslip. Stand it on edge to one side of the stain droplet. Now slowly lean it over until it is flat down over the droplet.

   This method should squeeze out any trapped air, avoiding bubbles.



6. If any stain has escaped over the edge of the slide, clean this up immediately with paper towel.

7. Look at your slide under the microscope! Start at low magnification, look for single cells.

Draw what you see, labelling the different parts of the cell that can be seen.

Which parts of your cells has the stain stuck to best?

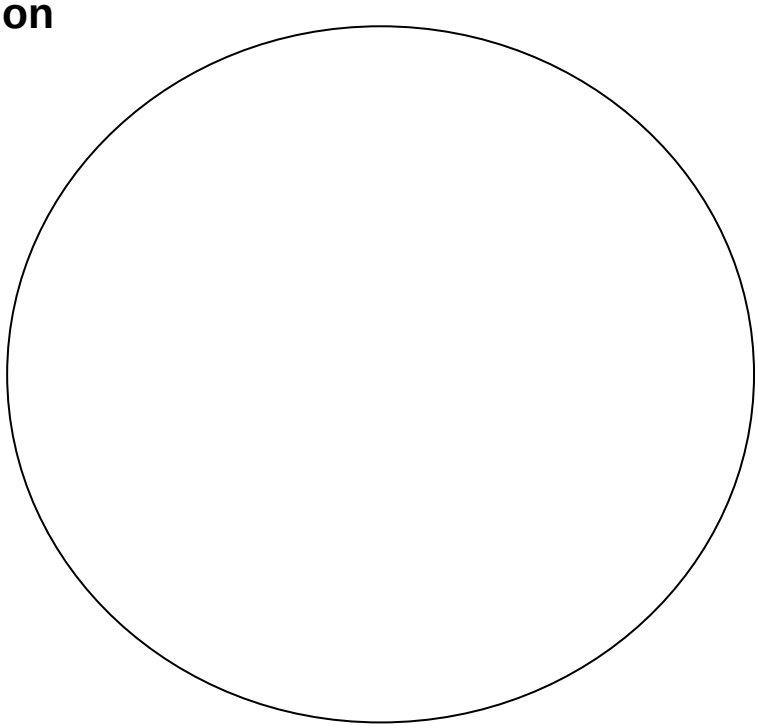
Cheeky cells

WORKSHEET

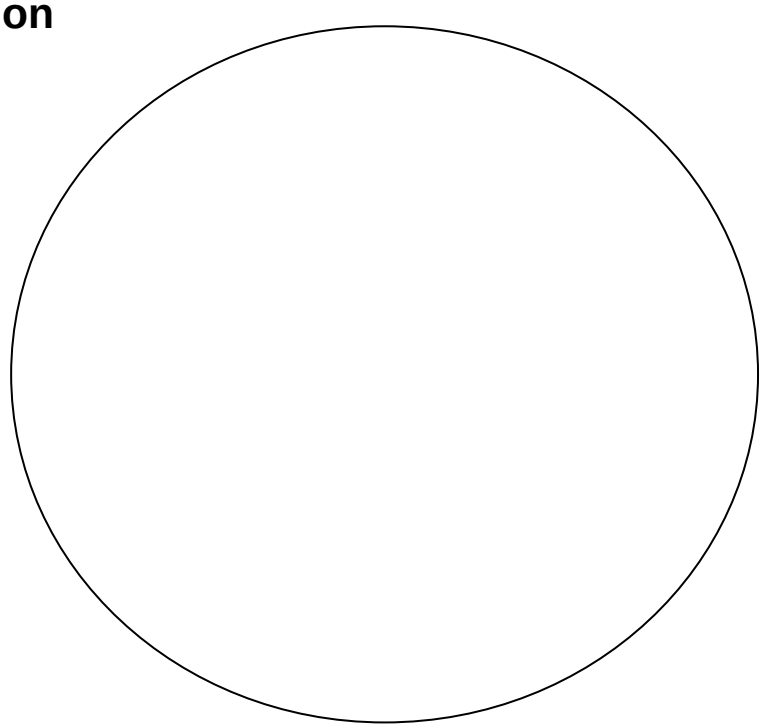
You really are made of cells!

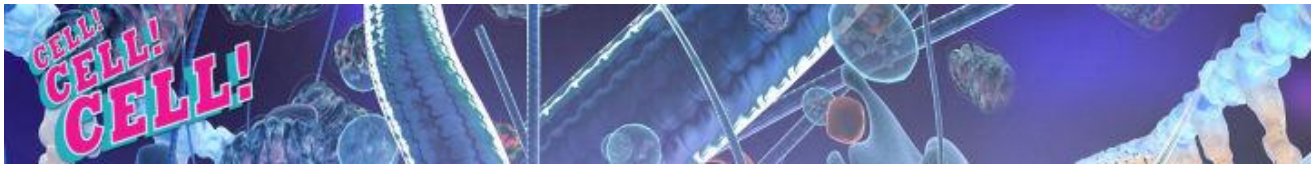
Draw your cells here, including as much detail as possible and labelling the parts of the cell that you can see.

Low magnification



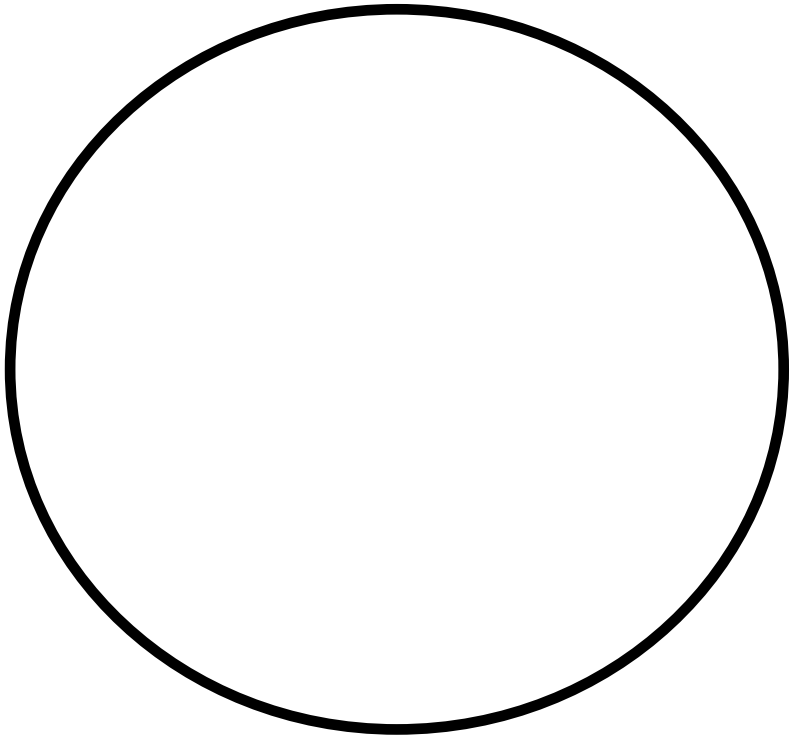
High magnification



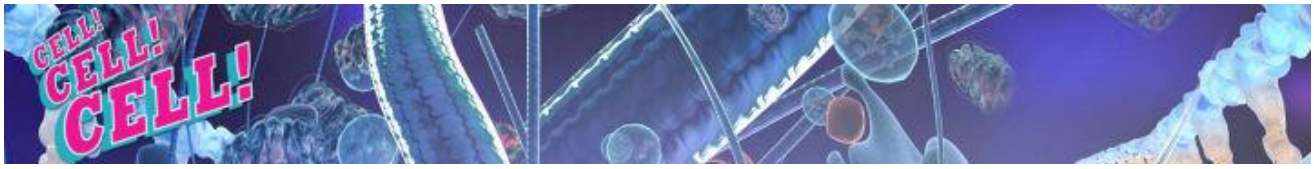


WARNING!

This chemical can stain skin and clothes



Please take care!



Crack the Codon TEACHER NOTES

Decode mutant DNA to discover the effect

- **KS4+ desk activity**
- **DNA triplets coding for protein, including start/stop codons**

Prior knowledge:

- DNA as carrying the code of life
- DNA base-pairings

Introduces:

- Messenger RNA, uracil
- Translation, start and stop codons
- Effects of single-point mutations, and possibly of insertions or deletions

Materials:

- Student instruction sheets, worksheets and code sheets

Activity:

1. Choose A, T, C or G to put into each of the spaces on the DNA sequence
2. Transcribe the DNA into mRNA, remembering to use Uracil instead of Thymine.
3. Find the start codon
4. Decode the codons one by one, writing each amino acid's name directly below each codon
5. Keep going until you reach a stop codon
6. Count how many amino acids are in your protein

Encourage the students to keep everything lined up on the page (using the stripes) as this will make everything much easier when they compare their resultant proteins.

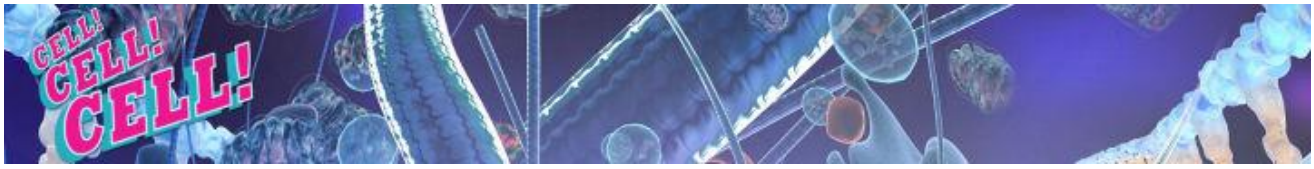
Plenary:

- Remind the students they all started with slightly different sequences
- Get the students to call out what amino acids they have in each position (mostly they will agree) and write these up where everyone can see, showing where people's results differ.
- If people have a different result for an amino acid, ask them what their codon was for that position.
- Relate this back to the three mutations in the DNA.

  Effects of the mutations:

  1. XAT: A gives Leu, T gives Ile, C gives Val, G gives Leu
  2. GGX: Everything gives Proline
  3. ATX: A/G give Tyr, T/C give STOP (shortening the resultant protein)

- What would have happened if there was a deletion or insertion? Discuss the havoc these mutations can wreak compared to single point mutations.
- Why do we have mRNA? Why not use the DNA as a template for translation, simplifying the process?



Crack the Codon

INSTRUCTIONS

Decode mutant DNA to discover the effect

Warning! This will go horribly wrong if you don't do every step in the right order!

1. Transcribe your Messenger RNA sequence

On the worksheet, read along the **template strand** of the DNA to complete the complementary RNA sequence in the box provided. Use the stripes to line up the RNA bases with those in the DNA

RNA is a bit different from DNA:
1. it has ribose instead of deoxyribose sugars in its backbone
2. it has Uracil (U) instead of Thymine (T)

Pairings:	DNA coding strand	Adenine	Thymine	Cytosine	Guanine
		\\	\\	\\\	\\\
	RNA complement	Uracil	Adenine	Guanine	Cytosine

When you see a white square:
This is a wildcard; you can choose this DNA base to be A, T, C or G. In this way, everyone will have slightly different DNA sequences to work with.

2. Find the start of the gene

The ribosome identifies the start of the gene by looking for the **START** sequence **AUG**. Read along your mRNA sequence until you find this triplet of bases, and circle it.

A triplet of bases is called a **codon**.

3. Translate the code into amino acids

Using the Code Sheet, translate the codons one by one. Draw each amino acid within the "protein" strand, lined up underneath their codons.

<u>Draw each amino acid as a circle containing its three-letter name</u>

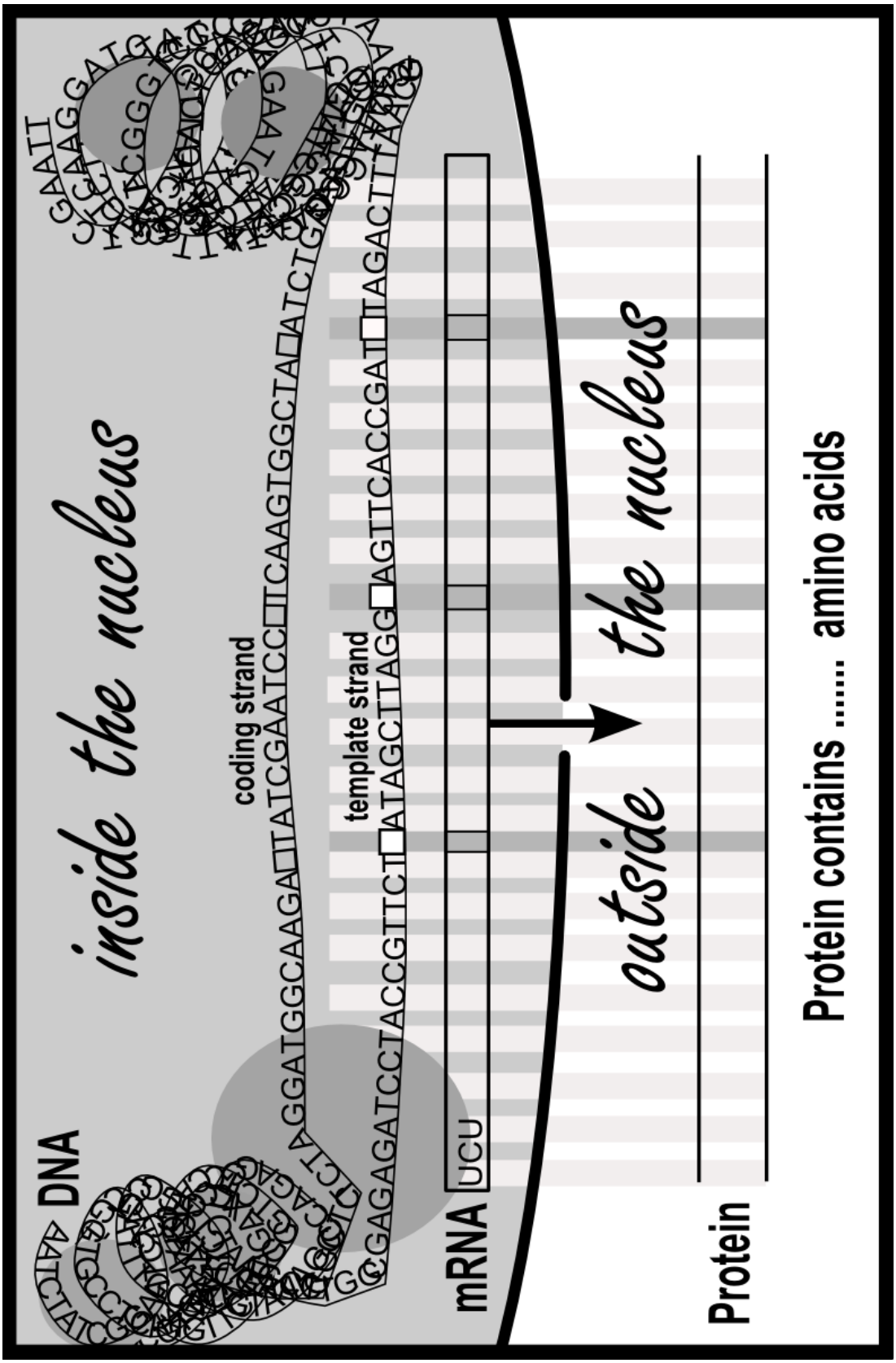
Begin with the **START** codon, which also codes for Met (Methionine). All human proteins are made with Met in the first position for this reason.

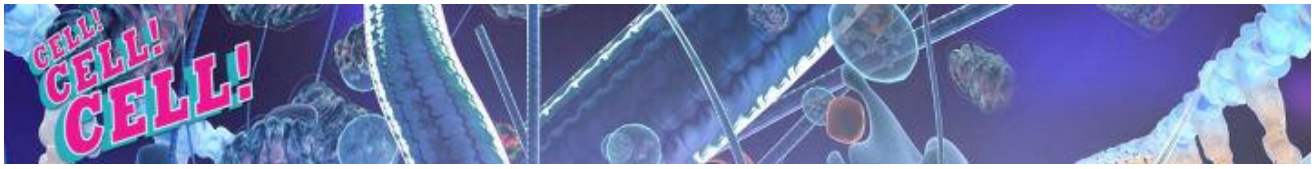
Circle the next three bases after the start codon. Use the code sheet to decode them, writing them in the protein strand. Then the next three. Keep going until you find a **STOP** codon.

Crack the Codon

WORKSHEET

Important: follow the Instruction Sheet step by step!
Where there is a white square, you pick what the base will be.





Crack the Codon

CODE SHEET

Decode mutant DNA to discover the effect

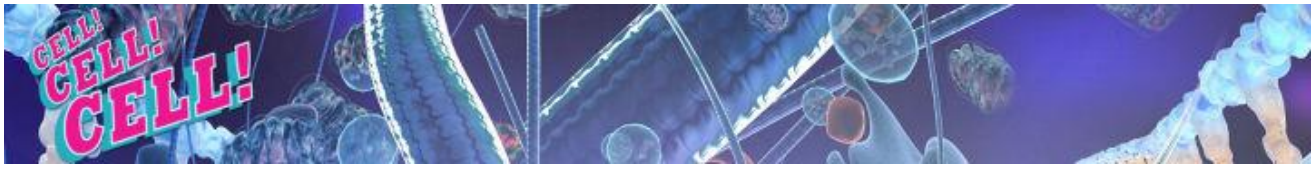
To decode the mRNA, you must take the bases in triplets (**codons**). You will know where to start by finding the **START** codon.

From there, take three bases at a time to decode. Stop when you reach a **STOP** codon.

1st base:	2nd base: U		2nd base: C		2nd base: A		2nd base: G	
U	UUU	**Phe**	UCU	**Ser**	UAU	**Tyr**	UGU	**Cys**
	UUC		UCC		UAC		UGC	
	UUA	**Leu**	UCA		UAA	**STOP**	UGA	**STOP**
	UUG		UCG		UAG		UGG	**Trp**
C	CUU	**Leu**	CCU	**Pro**	CAU	**His**	CGU	**Arg**
	CUC		CCC		CAC		CGC	
	CUA		CCA		CAA	**Gln**	CGA	
	CUG		CCG		CAG		CGG	
A	AUU	**Ile**	CAU	**Thr**	AAU	**Asn**	AGU	**Ser**
	AUC		CAC		AAC		AGC	
	AUA		CAA		AAA	**Lys**	AGA	**Arg**
	AUG	**START & Met**	CAG		AAG		AGG	
G	GUU	**Val**	GCU	**Ala**	GAU	**Asp**	GGU	**Gly**
	GUC		GCC		GAC		GGC	
	GUA		GCA		GAA	**Glu**	GGA	
	GUG		GCG		GAG		GGG	

Amino acid names:

Ala = Alanine
Arg = Arginine
Asn = Asparagine
Asp = Aspartate
Cys = Cysteine
Gln = Glutamine
Gly = Glycine
His = Histidine
Ile = Isoleucine
Leu = Leucine
Lys = Lysine
Met = Methionine
Phe = Phenylalanine
Pro = Proline
Ser = Serine
Thr = Theonine
Trp = Tryptophan
Tyr = Tyrosine
Val = Valine



Cut-out Cells

TEACHER NOTES

Cells of all shapes and sizes

- **KS3+ desk activity**
- **Construct scale models of different cell types**

Prior knowledge:

- What is a cell, egg and sperm cells
- Measuring in millimetres

Introduces:

- Different cell types/shapes
- Scale of cells
- Micrometres

Materials:

- Grains of salt
- 30cm rulers (showing millimetres)
- Copies of worksheets for students
- Plain A3 paper (for cell models)
- Scissors
- Calculators if required (at the suggested scale they need only divide by two)

Activity:

1. Measure salt crystals to find one that is 0.5mm (500 micrometres). This concentration on the size of the salt crystal will be important in understanding the scale used for this activity.
2. Explain how the scaling will work and how they can calculate the sizes of the model cells (ref worksheet), showing how to calculate the size of the salt crystal. At the scale given, approx the size of a box of 5 reams of paper. You can use different scales, in which case edit the text on the student worksheets.
3. Complete worksheet to calculate how large each cell type will be.
4. Cut out a square representing the salt crystal at this scale (requires A3 paper), to allow direct comparison.
5. Copy pictures of the cell types at the appropriate scale. At the scale given, the measurements range from 1.3mm (rod cell width) to 60mm (egg cell diameter). Note ‘width’ is ‘widest point’.
6. Cut out cells. Some are fiddly shapes so they may wish to cut around their picture. Also, at the suggested scale some are very small/narrow! But this will help reinforce the sense of how small real cells are.

Plenary:

- Discuss ideas of why the cells might be these relative sizes and shapes. Eg blood cells need to pass through small spaces, nerves need to span distances, skin cells need to pack together.
- Discuss the length of the nerve cell, and how this varies.
  - Brain neurons span shorter distances. A piece of brain the size of a grain of sand contains about 100,000 neurons and over 100,000,000 connections (synapses).
  - The longest is from toe to spine, about 1m. Calculate how long this cell would be at the scale used (500m). The same nerve in a giraffe would be approx 3m. The longest cell in the world is suggested to be a nerve cell from a Colossal Squid, expected to span 12m if to scale with smaller squid!

Cut-out Cells

WORKSHEET

Cells of all shapes and sizes

Introduction:

Cells come in different shapes and sizes. In this activity, you will draw and cut out scaled pictures of different cell types, comparing these to the size of a salt crystal.

Cells are measured in micrometres. There are 1000 micrometres (µm) in 1 millimetre (mm)

Instructions:

1. Find a crystal of salt that is as close as possible to a 0.5mm (500µm) cube. Keep it safe!

2. In your model, one micrometre (1µm) will be represented by 0.5mm. Fill in the table below to calculate how large your model cells will be at this scale:

   Model length (mm) = Real length (µm) x 0.5

	Real length (micrometres)	Length of model (millimetres)	Real width (micrometres)	Width of model (millimetres)
Salt Crystal	500 µm		500 µm	
Egg cell	120 µm		120 µm	
Sperm cell	60 µm		5 µm	
Nerve cell	lengths vary, but for your model use 60 µm		10 µm	
Skin cell	30 µm		30 µm	
Rod cell (eye)	100 µm		2.6 µm	
Red blood cell	8 µm		8 µm	

3. Cut out a square to represent the size of the salt crystal at this scale

4. See sheet with cell pictures. Re-draw each cell type at the correct size for the model and cut out.

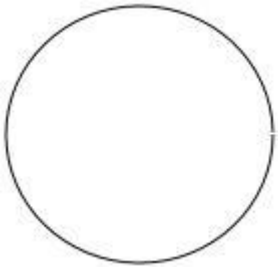
Cut-out Cells

CELL TYPES

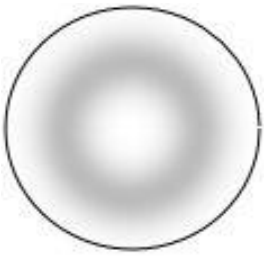
All shapes and sizes

Sperm cell

Egg cell

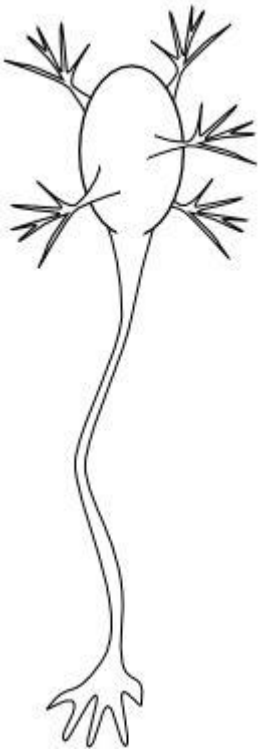


Red blood cell



Skin cell

Nerve cell



Rod cell
(from the eye)

Cells not shown to scale!

See worksheet for sizes and to calculate how large your model cells should be.