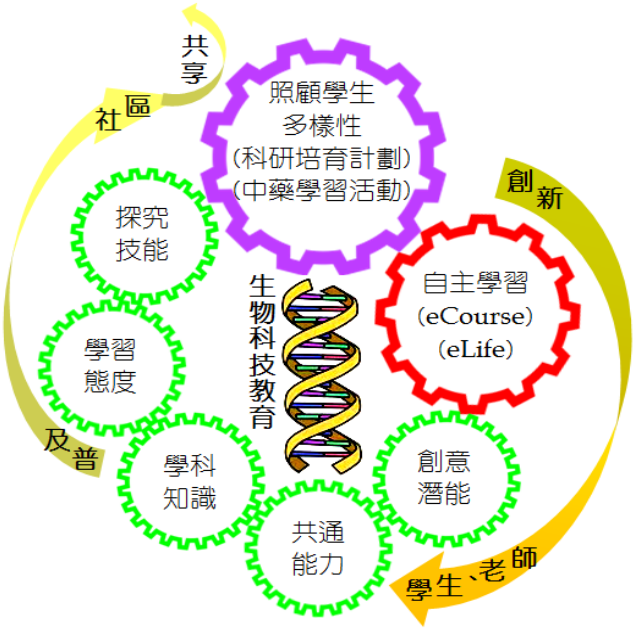
Lok Sin Tong Ku Chiu Man Secondary School

STEM Ed@biology.kcm

(Secondary 1 Integrated Science)



Name : _____ Class : _____(_____)

優質教育基金
Quality Education Fund

生物科技研習室
BIO TECHNOLOGY RESEARCH ROOM

Hello DNA!
What is your full name?

Who discovered you?
DNA is considered the book of life.
How can I know more about you?

My full name is **D**eoxyribo**N**ucleic **A**cid.

Please install the following app

to know more about me!

Android

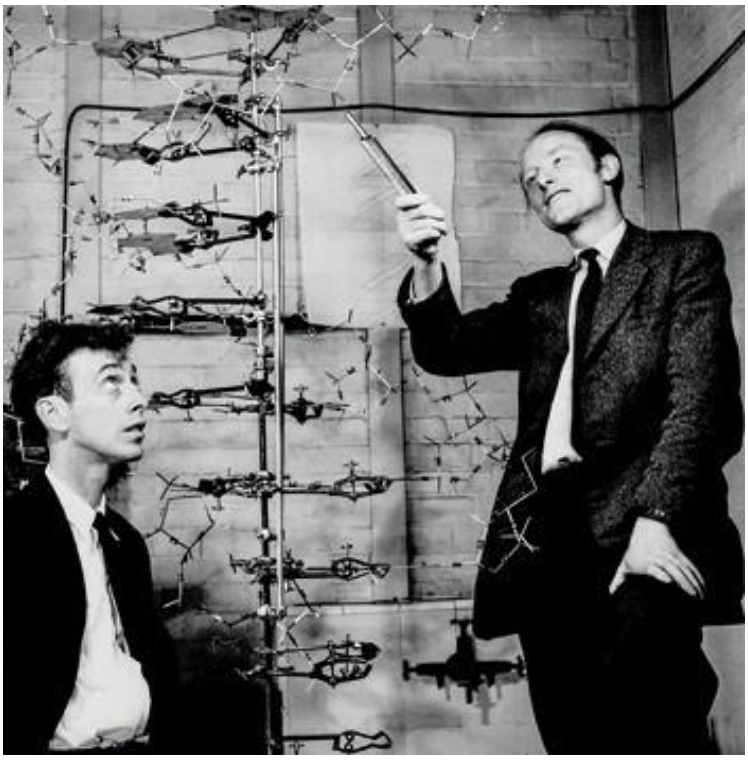
(A) The History of DNA Discovery

James Watson Francis Crick Maurice Wilkins Rosalind Franklin

There were different scientists who showed DNA was the genetic material in their scientific research 150 years ago. However, the structure of DNA remained a mystery. In 1949, there was a scientist called Erwin Chargaff. From his investigations in DNA samples of different organisms, he **discovered the 1:1 ratio between the bases A and T, and the bases C and G**. This was concluded as the Chargaff's rule.

In the early 1950s, there were 2 separate groups of scientists who attempted to reveal the structure of DNA. The first group was James Watson and Francis Crick. The second group was Maurice Wilkins and Rosalind Franklin. In 1953, Maurice and Rosalind captured the X-ray diffraction Photo 51, which showed the regular distance between DNA bases. Combining the analysis of Photo 51 and the Chargaff's rule, James and Francis figured out **the structure of double helix of DNA** and they made the 3D model of DNA. This explained the research results obtained by different scientists.

In 1962, James Watson, Francis Crick and Maurice Wilkins shared the Nobel Prize in Physiology or Medicine.



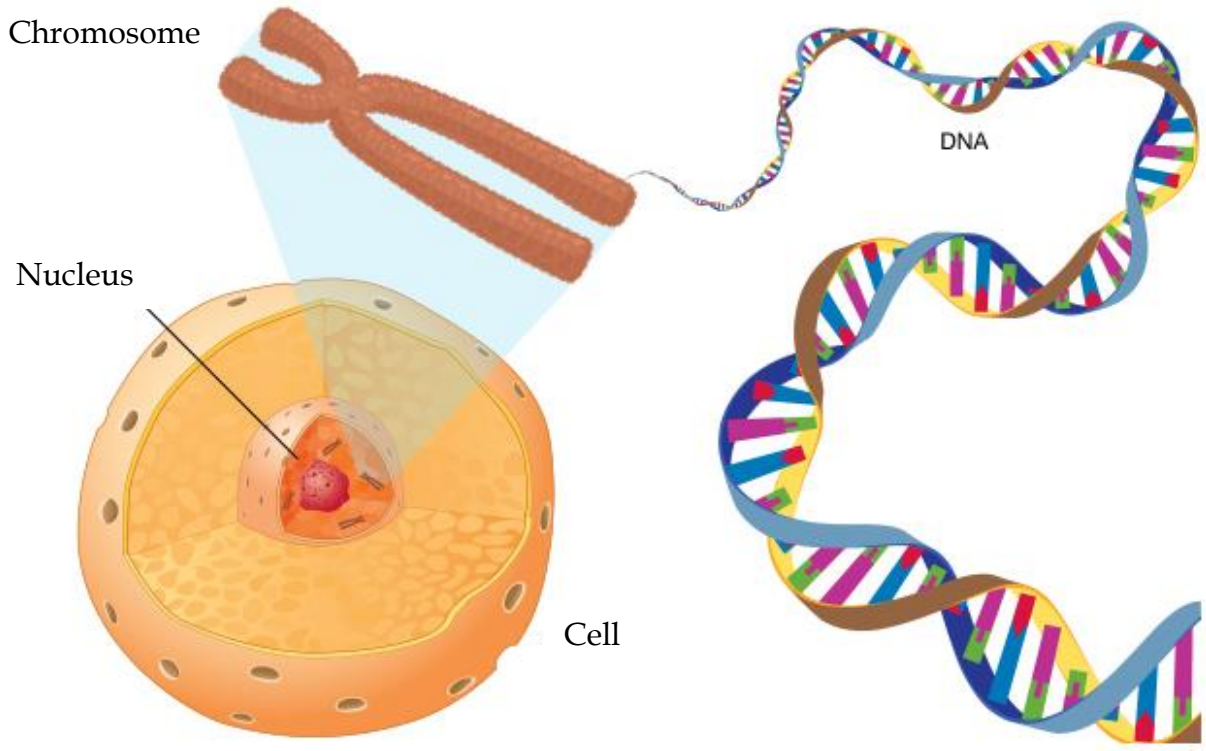
Extended thinking:

1. The above is a DNA 3D model.
   (a) Is it the same for the ratios between the bases A and T, and the bases C and G?
   Yes
   (b) Is the distance between the two long chains of DNA constant?
   Yes
   (c) What structure forms when the two long chains entangle?
   Double helix structure

2. What are the characteristics of the nature of science? Put a ✓ in the ☐ to express your thoughts.
   ☐ Requires creativity and imagination
   ☐ Requires careful observation
   ☐ Requires logical thinking
   ☐ Scientific research requires cooperation with others
   ☐ Scientific knowledge is not constant

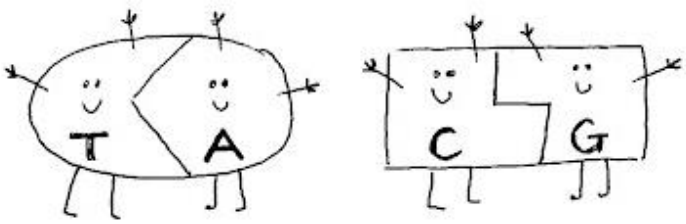
(B) The Structure of DNA

(i) Bases A, T, C and G, and base pairing



Cells are the most basic unit of organisms. Genetic material is stored in the nucleus to control cellular activities and determine body characteristics of organisms. There are chromosomes in the nucleus. A chromosome is formed by a very long DNA.

DNA consists of two long chains. Each chain is lined with four different bases (A, T, C, G).
Base A on one long chain can only be paired with base T on another long chain.
Base C on one long chain can only be paired with base G on another long chain.

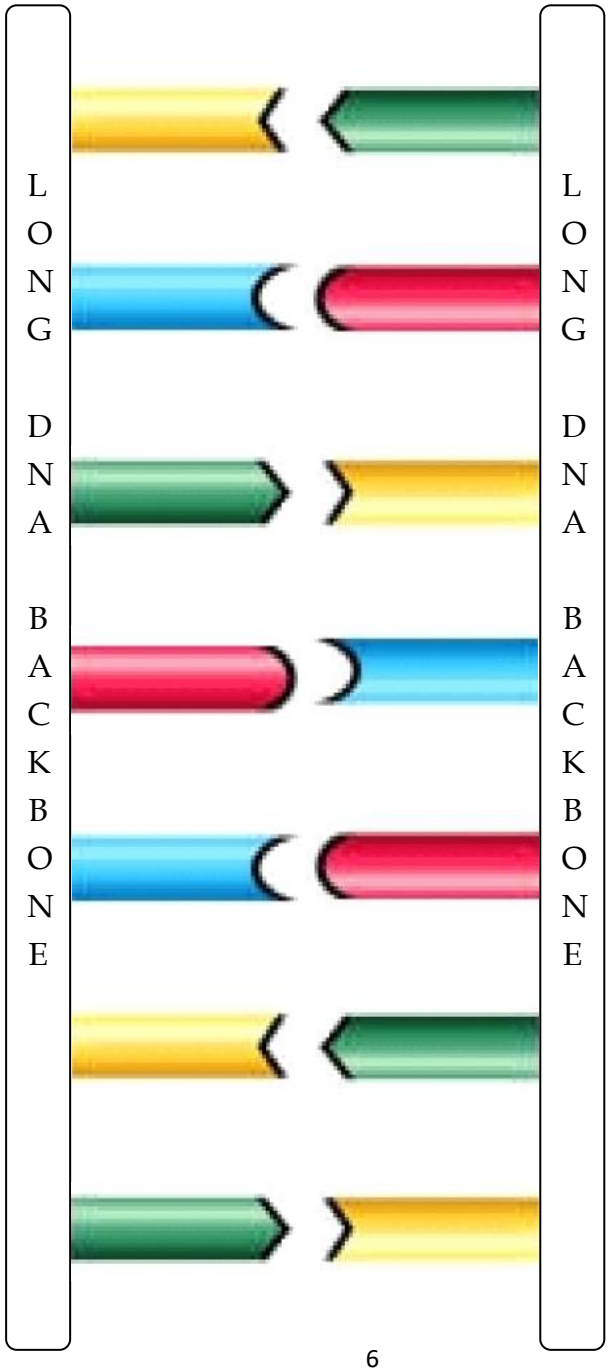


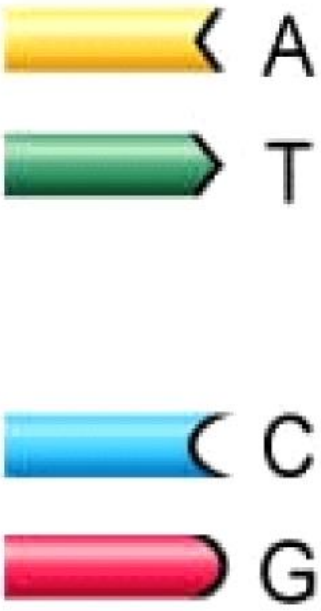
(ii) Double helix structure

DNA consists of two long chains. The two long chains intertwined to form a double helix structure.

Extended thinking:
Are there any example in our daily lives that is related to the double helix structure?

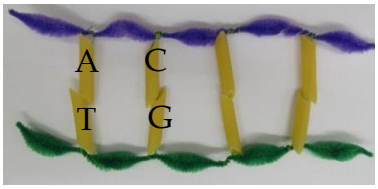
Activity 1: Colour the bases of DNA structure





Activity 2: Make a 3D DNA model using 2 pipe cleaners, 8 penne and 4 iron wires

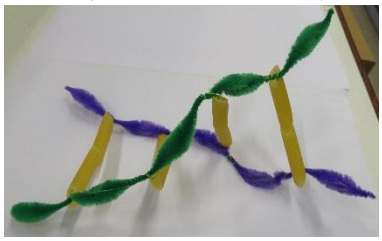
1. Choose 2 pipe cleaners as the backbone of the long chains of DNA.
2. Take 4 penne and use a pen to write down bases A, T, C, G on each of them; repeat this step with another 4 penne.
3. Match the labeled penne correctly; let iron wires go through the pairs.
4. Wrap 2 ends of the iron wires on the 2 pipe cleaners equidistantly to form a double strand of DNA (as shown below).



pipe cleaner

pipe cleaner

5. Twist the ends of the double strand to give the appearance of a double helix of DNA (as shown below).



Value-added corner: If we connect all the DNA in a body cell, we can get a thread of DNA of ~3 meters long. An adult has ~37 trillion cells. If we connect all the DNA extracted from these cells, this thread of DNA can go around the Earth for more than 2 million times!

Activity 3: Making observable DNA

1. Place a bottle of isopropyl alcohol (70 - 95%) into a freezer for later stage of the experiment.
2. Remove the stem and leaves of a fruit (e.g. strawberry). Place it in a mortar and smash it with a pestle; or place it in a zipper bag and smash it with your hands after sealing the bag.
3. Measure 10 ml of water with a measuring cylinder and 1 g of salt with an electronic balance. Pour them into a small beaker with 1 teaspoon of detergent and the juice of the smashed fruit. Mix the ingredients well with a glass rod and wait for 2 minutes.

4. Place a strainer on a big beaker. Pour and filter the liquid mixture prepared in step 3 with the strainer.
5. Press the fruit mash on the strainer with a spoon to further extract juice into the beaker.
6. Measure 20 ml pre-chilled isopropyl alcohol with the measuring cylinder. Slowly add the alcohol into the filtered liquid with a glass rod, so that it forms a transparent layer on the surface of the liquid.
7. Observe the beaker at eye level. You will discover a layer of white substance is forming in the transparent layer. That is DNA.
8. Rotate the glass rod slowly in the transparent layer to allow the DNA to be attached to the glass rod for observation. You can also touch the observable DNA with your hands.

Extended thinking:

1. Which kind of strawberry do you think that can extract the highest amount of DNA?

B

   A. The not fully ripe strawberries
   B. The ripe strawberries
   C. The over-ripe strawberries
   D. There is no difference between the above options

2. Why is it necessary to use salt in the experiment?

A

   A. The salt makes the DNA stick together for easy observation
   B. The salt increases density of the filtered liquid, so that the DNA floats on the liquid surface easily
   C. The strawberry becomes softer after soaking in salt water. This makes it easier to be pressed on the strainer
   D. The salt makes the strawberry become less acidic to reduce damages to the DNA

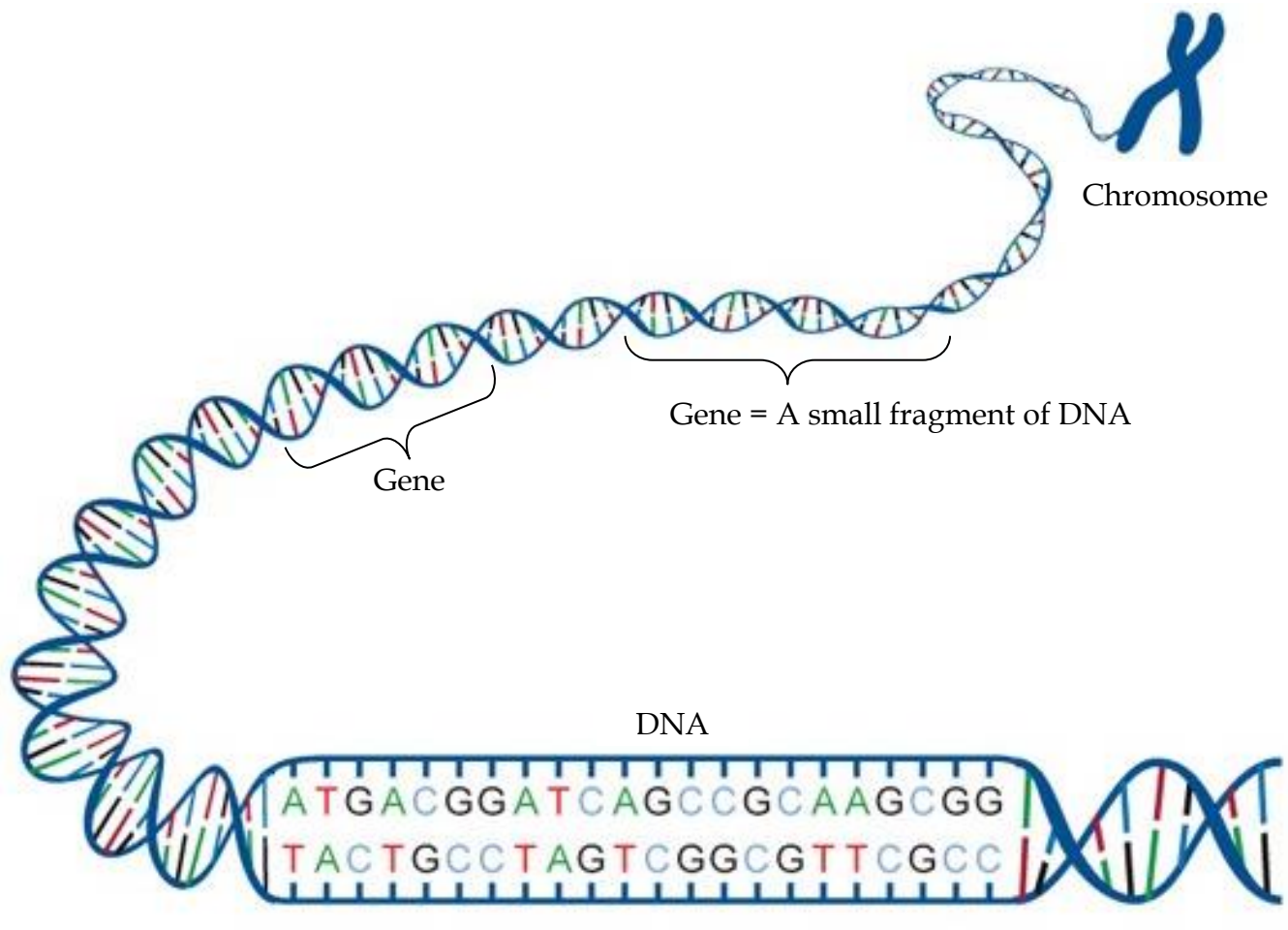
3. Why is it necessary to use detergent in the experiment?

C

   A. The strawberry needs to be cleaned before its DNA can appear
   B. The detergent can make DNA become more stabilized for easier observation
   C. The detergent degenerates cellular structure to allow DNA to leave the cells
   D. The detergent can remove dust in the laboratory apparatus

(C) The Relationship between DNA, Chromosome and Gene

DNA, chromosome and gene are all genetic materials. However, what is the relationship between them?



DNA winds tightly to form a chromosome. A small fragment of DNA is a gene.

In a long DNA, there are many genes with different lengths. Genes carry meaningful genetic information.

Extended thinking: If we make a metaphor for DNA with words, what would a chromosome and a gene be?

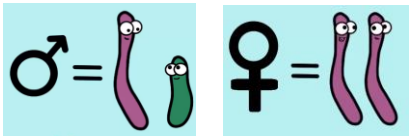
A chromosome is a paragraph. A gene is a meaningful sentence.

(D) The Role of Sex Chromosomes in Determining Gender in Human

(i) The number of chromosomes in human cells

Every cell (except for sperm cells and egg cells) in our body has 46 chromosomes. They can be evenly separated into 2 sets, in which one set is inherited from father while the other one is from mother. Therefore, 23 chromosomes are passed on individually. The chromosomes pair up in the nuclei to form 23 pairs.

(ii) The sex chromosome that determines gender



There is only one pair of sex chromosome that determines gender in chromosomal inheritance.

Every cell (except for sperm cells) in a male body has the 23rd pair of chromosomes with one X chromosome and one Y chromosome; every cell (except for egg cells) in a female body has the 23rd pair of chromosomes with two X chromosomes. Except for the 23rd pair of sex chromosomes, each pair of the 22 pairs of chromosomes shares the same shape and size.

Extended thinking:

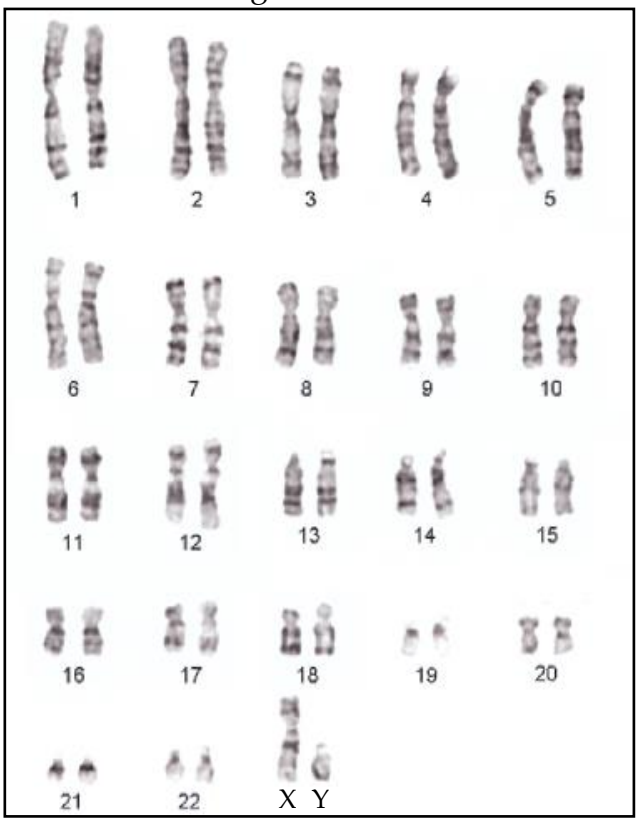


Diagram A

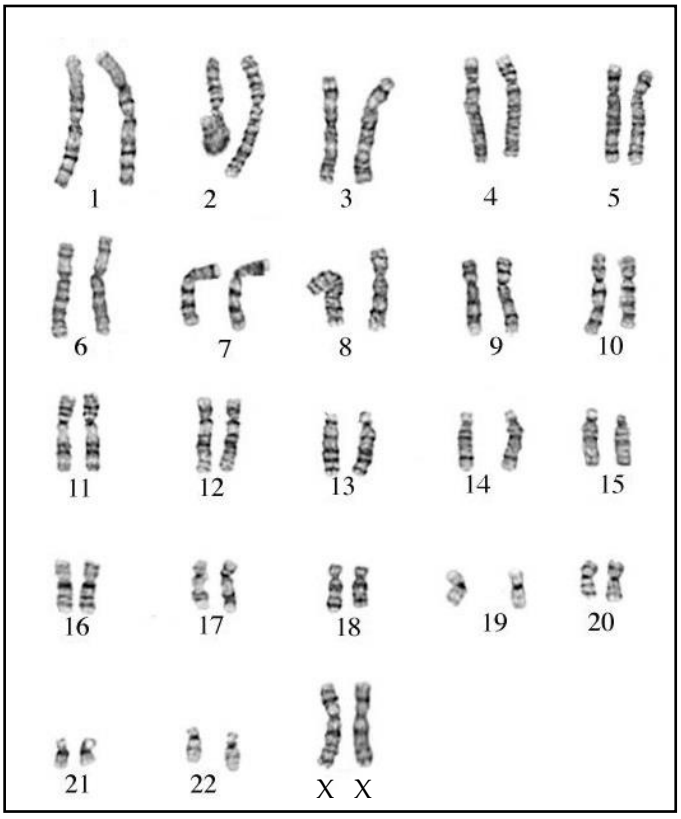
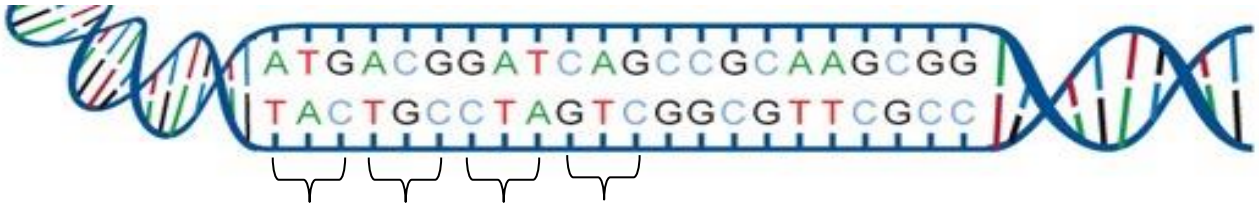


Diagram B

In the above two karyograms, which gender does it represent in diagrams A and B?
Diagram A represents a male and diagram B represents a female.

(E) The Heredity of Human Traits

DNA carries genetic codes. A genetic code is formed by 3 bases. It contains the instruction for making specific proteins in a cell and determining different traits (genetic characteristics) in the body. The instruction is determined by the arrangement of bases on DNA.



3 bases 3 bases 3 bases 3 bases .....

(3 bases = 1 genetic code)

Activity 4: Solving the codes of a treasure map

Your teacher has prepared a precious certificate for you. It was placed in one of the laboratories at school. Please complete the following tasks:

1. By following the example in the diagram, fill in the genetic codes in the combination of 3 bases in every ☐ to create a treasure map
2. In the treasure map, circle the following DNA genetic codes:
   AAT ATT ATC ACC ACG TCA TTA TTT TTC TCC TGC
3. By following the route of the circled DNA genetic codes in the treasure map, find out the location of the precious certificate

First base	Second base				Third base
	A	T	C	G	
A	AAA	ATA	ACA	AGA	A
	AAT	ATT	ACT	AGT	T
	AAC	ATC	ACC	AGC	C
			ACG		G
T		TTA	TCA		A
		TTT			T
		TTC	TCC	TGC	C
					G
C					A
					T
					C
					G
G					A
					T
					C
					G

⇨ Science Laboratory

⇨ Biology Laboratory

⇨ Chemistry Laboratory

⇨ Physics Laboratory

The precious certificate is placed in the biology laboratory.

Activity 5: The mix-and-match with traits

Since DNA in the cells are inherited by the parents, children's DNA contains the genetic codes of their parents. These genetic codes lead to the development of some parental traits (genetic characteristics) in the children. This makes the children share similar traits (e.g. appearance) with the parents.

Value-added corner: The gene that dominantly affects the development of traits is called a dominant gene; the gene that its expression is masked is called a recessive gene.

(Mission 1) By following the example below, match the genetic codes with different traits according to the list below and write down the specific combination of genetic codes for each character.

Trait (Genetic Characteristic)	Genetic Code	Trait (Genetic Characteristic)	Genetic Code
Thick eyebrow	AAT	Thin eyebrow	AAG
Double eyelid	TTC	Single eyelid	TGC
Freckles	CGT	No freckles	CTT
Dimple	GAT	No dimple	GAG

AAT TGC CTT GAT

AAT TTC CTT GAG

AAG TGC CTT GAG

AAT TGC CTT GAT

AAT TGC CTT GAT

AAT TGC CGT GAG

AAG TGC CGT GAG

AAT TGC CTT GAG

AAT TTC CTT GAG

(Mission 2) The previous nine characters come from three separate families. By following the example below, find out the parents of the three children. Write down the suitable number in the empty box next to the father and the mother.

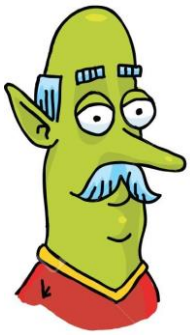
Children:

1. 

2. 

3. 

Father:



1	2	3

Mother:

2	3	1

Extended thinking: After finishing Mission 2, take a look at the traits (genetic characteristics) listed on the previous page again. Which are the dominant traits? Which are the recessive traits?

Thick eyebrow, double eyelid, freckles and dimples are dominant traits，
Thin eyebrow, single eyelid, no freckles and no dimples are recessive traits.