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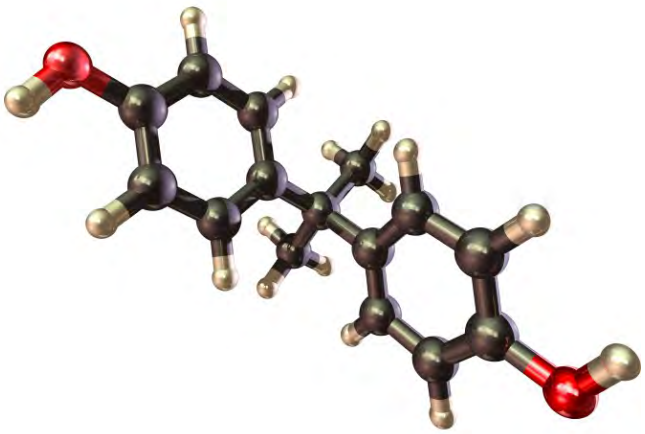
Learning in Context
Environmental Toxins

Chemicals in Our Food

A Resource for New Zealand Schools

Shawn Cooper



Is it safe to eat?

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The "Black Gold" Revolution

The invention of the steam engine sparked a major change in the way we live. It marked the beginning of the industrial revolution.

Fossils fuels such as coal and oil became important energy sources and allowed factories and motor vehicles to speed up the pace of life.

During this time oil become very valuable and "black gold" became a common nickname for it.

Cities were formed and networks of railways and highways were constructed to transport goods in glass and metal containers to and from those cities.

Today, not a day goes by when we don't hear someone talking about the price of petrol!

PROBLEM: Containers made of glass and metal were very rigid and heavy, causing cars, trucks trains, boats to waste a lot of energy and money transporting all these products. Scientists were put to work to invent lighter, more flexible containers to use in transporting products.

Guess what they discovered to make these containers out of... OIL!

SOLUTION: Using a number of chemical reactions, scientists found ways to turn liquid oil into a number of different solid building blocks. Under the right conditions, these building blocks can be joined together to create large molecules called **PLASTICS**.

Task 1
Getting Started

Look up the word "plastic" in the dictionary or on the internet. to find out its different meanings.

Who once said, "Necessity is the mother of all invention"?

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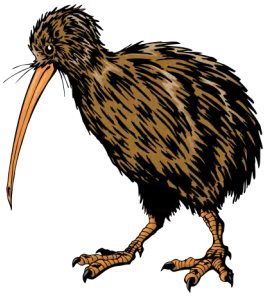
Be A Tidy Kiwi!

Task 2
Getting Sorted?

As a tidy kiwi, you may have noticed the triangle shaped symbols with numbers inside on plastic objects and containers. These numbers indicate the type of building blocks used to make the plastic. See what examples you can find.



Recycling Number (id number)	Name or use of the object/container	Description of the object (e.g. hard/flexible)	Name of the type of plastic (hint: see below)
1 PET			
2 HDPE			
3 PVC			
4 LDPE			
5 PP			
6 PS			
7 PC			

Can you match the correct name with each plastic type above?

Polyvinyl chloride Polycarbonate Polypropylene Polystyrene
Low density polyethylene Polyethylene terephthalate High density polyethylene

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The Plastic Age?

Prehistory is the period of time before humans thought to write down stories of what was happening in their world. In order to learn about how people lived during this time scientists examine fossils and objects left behind by ancient civilisations.

Historians like to divide up time periods in ancient human prehistory according to the type of material used to make tools.

The first man-made tools were made of stone. The period of prehistory when humans used stone tools is called the **STONE AGE**.

Eventually humans learned how to make fire and discovered that metals could be melted out of rock and this metal could be shaped into better tools. Bronze, an **ALLOY** made of copper and tin, was used for sculptures, weapons, armour, containers and jewellery. The **BRONZE AGE** began about 5000 years ago and lasted for approximately 1500 years.

THE **IRON AGE** is most associated with Roman Times. This is when iron (and steel alloys) replaced bronze as a stronger and cheaper alternative.

The invention of written language marks the end of prehistory and the beginning of written history. However, looking back on the material we NOW use to make things, what do you think people in the future will call our age? The **PLASTIC AGE**?

Task 3
What are alloys?

Alloys are made of one or more metals melted together to form a solid mixture. Investigate different alloys to find what they are made of and their important physical properties.

Alloy	Made of?	Physical Properties?	Uses?
Brass			
Stainless Steel			
White Gold			

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Plastic... Fantastic?

Plastics sure are useful in our everyday lives! We use them all the time, but what do you actually know about them?

Task 4
Fact or Fiction?

Below is a list of commonly shared ideas about plastics. State whether or not you think each one is true or false. Explain your answer.

1. Lids on fizzy drink PET bottles cannot be recycled.
2. Plastic shopping bags cannot be recycled.
3. Reusing plastic drink bottles can cause dangerous chemicals to contaminate the water.
4. The film used for making movies is now made of plastic because the original film would catch fire when the movie was shown in the movie theatre.
5. Takeaway containers can be recycled into comfy clothes such as fleece jumpers.
6. Polystyrene dissolves in fizzy drink to release dihydrogen monoxide, a deadly chemical.
7. Microwaving plastics can release harmful toxins.

ANSWERS:

1. False—Many people think that the lids cannot be recycled, but they are made of the exact same material as the bottle. During recycling, these are melted together and reshaped.
2. False—Shopping bags cannot be placed in wheelie bins because at the recycling plant they get tangled up in the sorting machines and cause them to break down. Some supermarkets have special collection bins for your extra bags.
3. True—But the harmful chemicals do not come from plastics. If you do not properly wash bottles before reusing them, microbes can grow on the inside surface and produce toxins.
4. True—Many theatre fires were caused by film made of cellulose nitrate before stronger plastic films were invented.
5. True—"Polyprop" clothing is made from the same polypropylene building blocks as number 5 takeaway containers.
6. False—Polystyrene is very stable and takes a very long time to break down. Besides, dihydrogen monoxide is chemical name for H_2O... WATER!
7. True—Number 7 plastics that are made of polycarbonate contain a chemical called bisphenol A. This can enter your food when the plastics are heated. Many scientists have shown that this chemical causes unwanted effects in humans.

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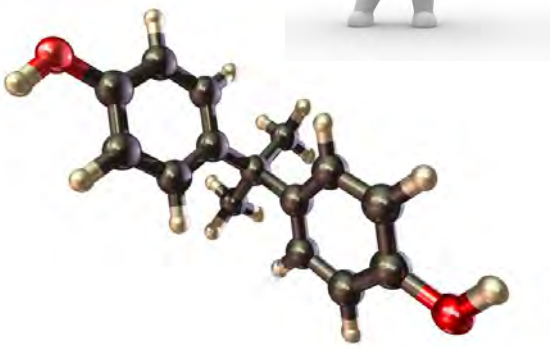
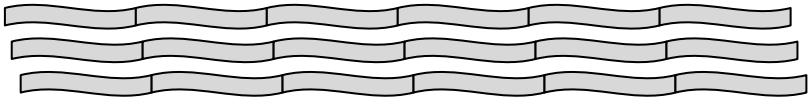
Take a closer look!

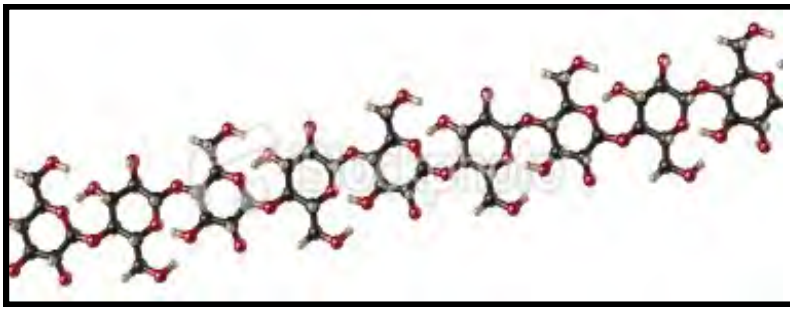
Let's take a closer look at number 7 polycarbonate plastics. These plastics are special because they are made of a chemical building block called bisphenol A, or BPA for short.

BPA is the building block or monomer ("mono" = one, "mer" = unit) used to make long chains or polymers (poly = many) of polycarbonate plastic.



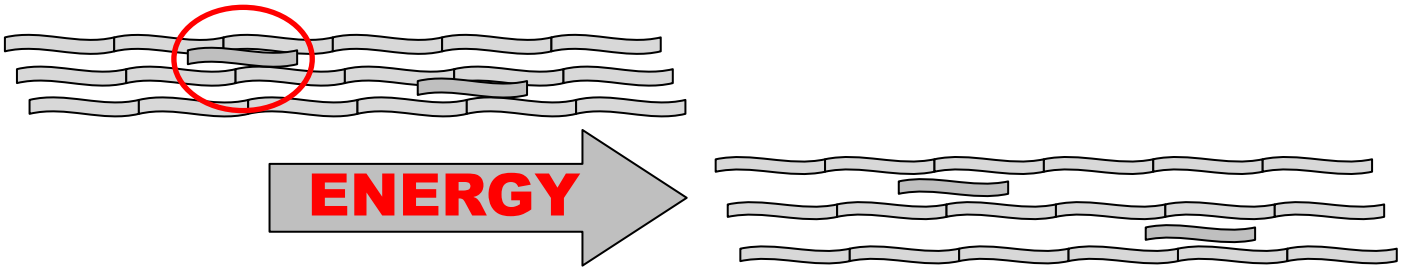
These long chains are joined together by attractive forces to make strong, yet flexible plastics.





Polymers also occur in nature. Here is the polymer **CELLULOSE** found in plant cell walls. It would be "sweet" if you could point out the repeating monomer building block.

When plastics are made, some of the BPA building blocks do not always join up as planned. Instead some BPA monomers get trapped between the polymer layers. Heat energy can be absorbed by plastics made of BPA. This causes the polymer layers to vibrate faster and move ever so slightly apart, allowing the trapped BPA monomers to break free.



Food heated in containers made of BPA plastic can become contaminated with these loose monomers of BPA that escape. Microwaving a number 7 plastic container may mean that BPA becomes an invisible passenger into your body through the food you eat.

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Chemicals in Our Food

Task 5
Chemicals in Food?

What's all the fuss? Does it really matter if a small amount of BPA gets into the food I eat? Isn't food just made of chemicals anyway?

Yes! All of the food we eat is made up of chemicals. Many of which are important for life's processes... The Biochemistry of MRS GREN!

Place these chemicals in the spaces below to learn about the biochemistry of MRS GREN:

sodium chloride, acids, hormones, calcium, toxins, glucose, iron, oxygen, sugars, vitamins

Movement _____ (Ca^{2+} ions) is an important mineral that controls the movement of muscles in our body.

Respiration The nutrient _____ ($C_6H_{12}O_6$) and the element _____(O_2) are both necessary to produce energy in the cell. The protein found in red blood cells contain _____ (Fe^{2+} ions) which are needed to transport oxygen from the air in your lungs to each of your body's cells.

Sensitivity Specialised areas of our tongue can detect chemicals as salty (_____, sweet (_____), sour (_____), or bitter (some toxins are bitter).

Growth Nutrients, vitamins and minerals are used to by the body's cells to grow new cells (mitosis) and repair damaged cells using the building blocks from nutrition.

Reproduction Chemical messengers called _____ control changes during puberty, instruct cells to produce sex cells and they regulate female reproductive cycles and pregnancy.

Excretion Once their job has been done, chemical messengers are broken down into waste products. Drugs, alcohol and _____ are broken down inside the liver and released from the body in a less harmful form.

Nutrition Food we consume is broken down into useful nutrients, _____ and minerals.

Why do you think it is important that humans can taste salty, sour, sweet and bitter? Many eastern cultures identify a 5th taste called "**umami**" – It is believed to open the appetite for protein-rich foods. Research 5 foods thought to produce an umami taste.

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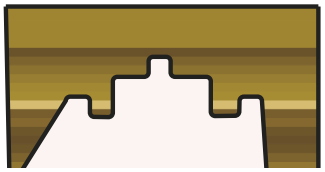
Biochemical Keys

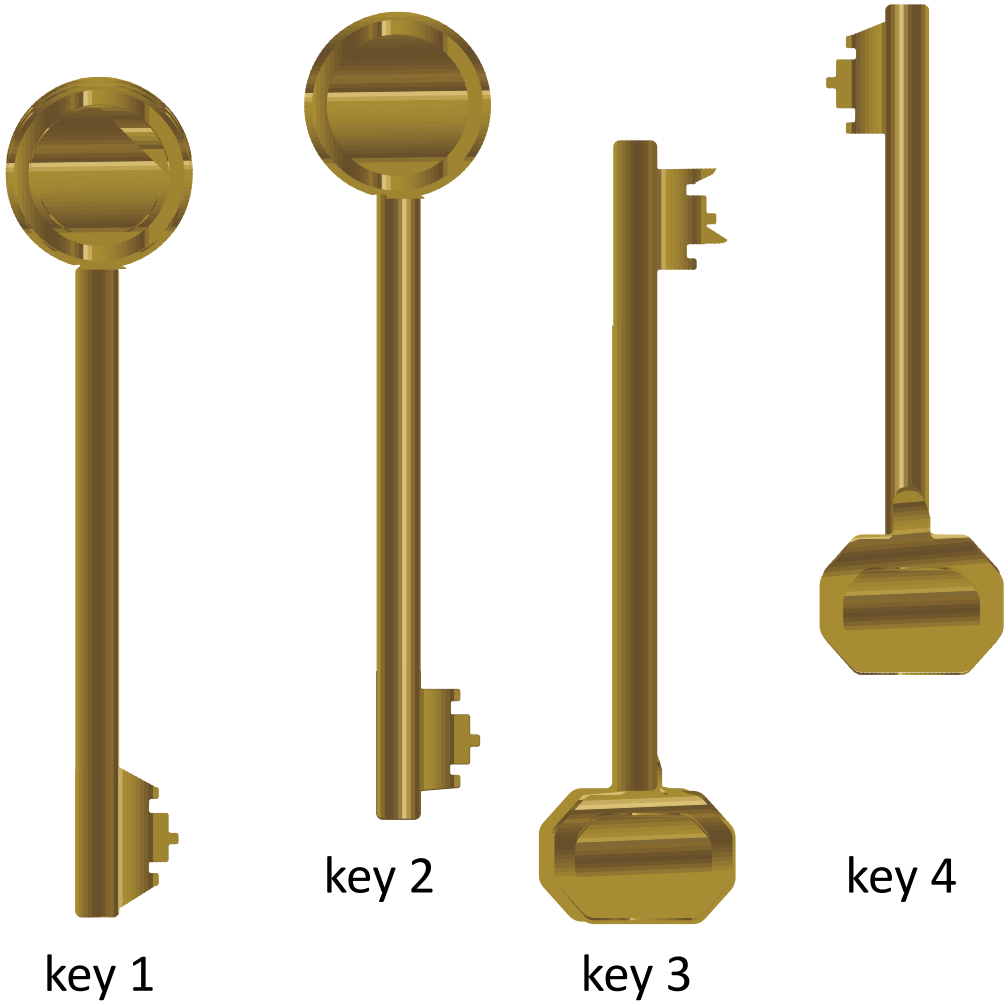
Bisphenol A (BPA) and other chemical passengers we call contaminants, toxins or sometimes poisons can enter our bodies mixed in with all of the other useful chemicals. Often, in small quantities, they go unnoticed at first. However, sometimes they take action by imitating chemicals naturally found in our bodies.

To understand this, consider a key that is required to open a lock.



In order to open its matching lock, one of the keys below must first pass by the plate on the right.

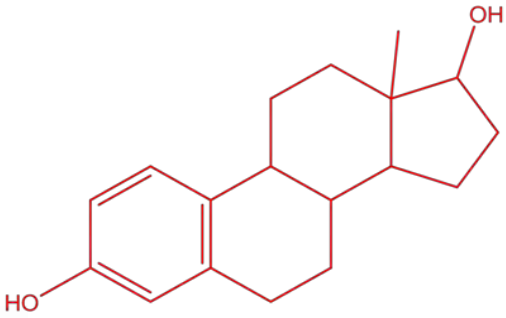
Which of the following key(s) do you think could open the lock?

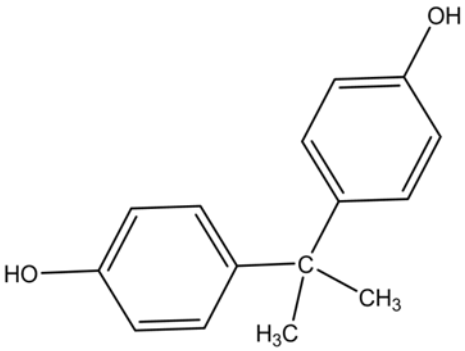


Although they are slightly different, the important parts of key 2 and key 4 (the teeth) are both able to slide past the plate and open the lock.

Unlocking the Secret of BPA

Now look at these two molecules:





Can you spot three similarities between these two chemicals?

Like the locks that keys are designed to open, our bodies are full of receptors (these are our locks) that specific chemicals (the keys) can fit into.

HORMONES are chemicals that act like keys in our bodies.

When a hormone (a key) fits inside its matching receptor (lock) it can turn a reaction on or off.

These reactions affect a person's growth, development, reproduction, mood... virtually any of the processes taking place in our body.

Did you notice the similarities between the two chemicals above?

The molecule on the left is the hormone estrogen. The molecule on the right is bisphenol A (BPA). Because BPA is so similar in shape to estrogen, BPA can fit into the estrogen receptor. Once inside it is able to mimic or imitate estrogen.

BPA can switch on or off reactions normally controlled by estrogen.

Task 6 Hormone Hunt

Oxytocin, estrogen, testosterone, progesterone, and human growth hormone all have different jobs to play in the body. Find out what these hormones do.

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Those Raging Hormones

Estrogen and testosterone are two hormones found in both girls and boys. You may have heard the expression "raging hormones" used as a reason for teenagers' unpredictable behaviour, excitement and attractions.

At puberty, girls start to produce a lot more estrogen because it is needed to switch on the genes that control the development of the female body shape and sex organs.

In a similar way, testosterone is produced in larger amounts in boys during puberty and causes them to mature into men.

Bisphenol A (BPA) belongs to a group of molecules called xenoestrogens. These molecules have a very similar shape to estrogen allowing them to imitate the estrogen that is naturally made by the body. When xenoestrogens get inside the body they trick the body into making unwanted or harmful changes.

Some possible effects of xenoestrogens	
In females: • Early puberty • Difficulty becoming pregnant • Breast Cancer	In males: • Undescended testicles • Lower sperm count • Testicular cancer

BPA is not the only source of hormone imitators!

Hormone imitators get into our food in three main ways

- Some are silently released by plastic food packaging and containers.
- Contaminants in the environment travel up the food chain to our plates.
- Some are found naturally in some foods we eat such as soy beans.

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Solving Mysteries Science

In 1996, a group of scientists studying two lakes in Florida discovered a measureable difference between two populations of alligators in Florida.

This headline appeared in newspapers around the world.

THE DAILY TIMES

Alligator Anatomy Getting Smaller

Research published today suggests that the reproductive organs of male alligators living in Lake Apopka in Florida, USA are getting smaller. Alligators in a neighbouring lake have not experienced the same decrease in size. Scientists are now looking to investigate what might be causing this change in one lake and not the other, and whether or not humans should care.

Two questions emerged:

What could be causing the differences in the two populations?

Does it really matter?

To answer the first question, scientists started hypothesising what was happening differently in Lake Apopka. They asked questions like...

1. Were males with smaller reproductive organs somehow more successful at reproducing, passing on more of these genes?
2. Had there been a change in the alligators' diet causing a change?
3. Was there something different in the water causing this change?

Task 7
Plan a study

As a scientist, how could you design a study to test these hypotheses?

What other questions would you ask?

What would you observe or measure to help make a conclusion?

Would you look only at the alligators and water in Lake Apopka, or would you also make observations from the neighbouring lake?

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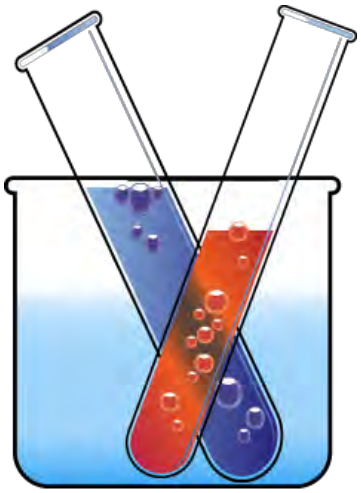
Getting to the Source

Studying the water in each of the lakes, scientists discovered high levels of a specific chemical in one of the lakes which was not found in the other. Lake Apopka contained measureable levels of a chemical called DDT.



DDT, or dichlorodiphenyltrichloroethane, is a chemical pesticide that is highly effective at killing insects. Paul Hermann Muller was awarded the Nobel Prize in 1948 for his work showing how effective DDT was, particularly at killing mosquitoes, which transmit many deadly diseases like malaria from one person to another.

But there is no malaria in Florida so what was the DDT doing in Lake Apopka and how did it get there?

Well it turns out DDT is also good at killing insect pests that destroy famers' crops.

Scientists showed how chemicals, such as DDT from the pesticides that had been sprayed onto the farmland, were able to move from the crops into streams and rivers which eventually flowed into Lake Apopka.

DDT was not found in the other lake because the farmers who owned the land around the other lake had not used the same chemical pesticides.

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A Case of Mistaken Identity

But alligators are reptiles not insects!

True, however, chemicals do not "know" what they are doing or where they are "supposed" to be. Sometimes chemicals find themselves in new places, or in new organisms and they are mistaken for chemicals that naturally have a job inside that animal.

The scientists looked at the structure of DDT and found that it looked an awful lot like another chemical with a very important job in alligators. It was the chemical that controls how much male hormone gets made.

DDT turns off the reaction that makes male hormones!

The alligator's body knows to start puberty by comparing the amount of male hormone it has to the amount of female hormone it has. When less male hormone is present, the alligator's body believes it has more female hormone than it actually has. As a result, puberty starts later and some juvenile males do not fully develop all the adult features normally found in adult alligators. Most obviously, their reproductive organs grow to be smaller than normal.

Although scientists were concerned with how these changes were affecting the reproductive success of male alligators, what worried the scientists most was whether or not these chemicals could have the same affect on human boys and men.

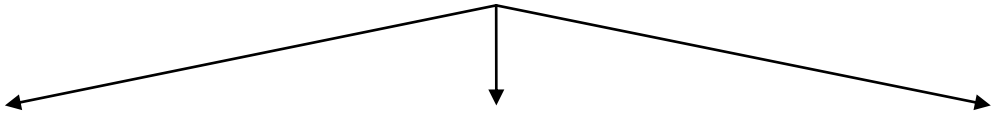
Task 8 Dangers of DDT?

Of course, nobody would want to swim with alligators, but...

1. Can you think of ways that DDT and other chemicals that mimic the effect of hormones might get into the human population?
2. Research other animals that have been negatively impacted by DDT in the environment.

Revision and Research

Hormone imitators get into our food in three main ways



Some are silently released by plastic food packaging and containers.

Contaminants in the environment travel up the food chain to our plates.

Some are found naturally in some foods we eat such as soy beans.

Research:

1. How much bisphenol A (BPA) are you exposed to each day? Each week? Each month?

   i. See if you can find any items made of plastic number 7 that you regularly use. Do you think these items are contaminating your food?
   ii. Draw a food chain showing how food gets to your dinner plate. Label all the sources of toxins that could be getting into the food you eat along the way. (You may wish to consider chemicals used in farming, the nutrients plants and animals need to grow, and how food is processed and packaged before it gets to your plate)
   iii. How many of the everyday food items you eat contain "soy"? Examine the food nutrition labels on the cans, wrappers, boxes and containers of common foods you eat and make a summary to show how many products contain soy.

The Canadian Government has banned baby bottles made of polycarbonate plastics containing BPA. New Zealand still allows BPA plastics to be used in baby bottles and other everyday containers. BPA plastics are also used to line the inside of some metal food cans.

2. Should New Zealand be taking action? Is the Canadian Government overreacting? Do you think New Zealand should be doing more?

   i. Write a letter to a friend telling them about the risks of eating foods contaminated with BPA. Is the risk the same for all people in New Zealand?
   ii. Write a letter to a food company outlining your view on BPA.
   iii. Write a letter to the Government (Prime Minister) with your recommendation.