Teacher Notes

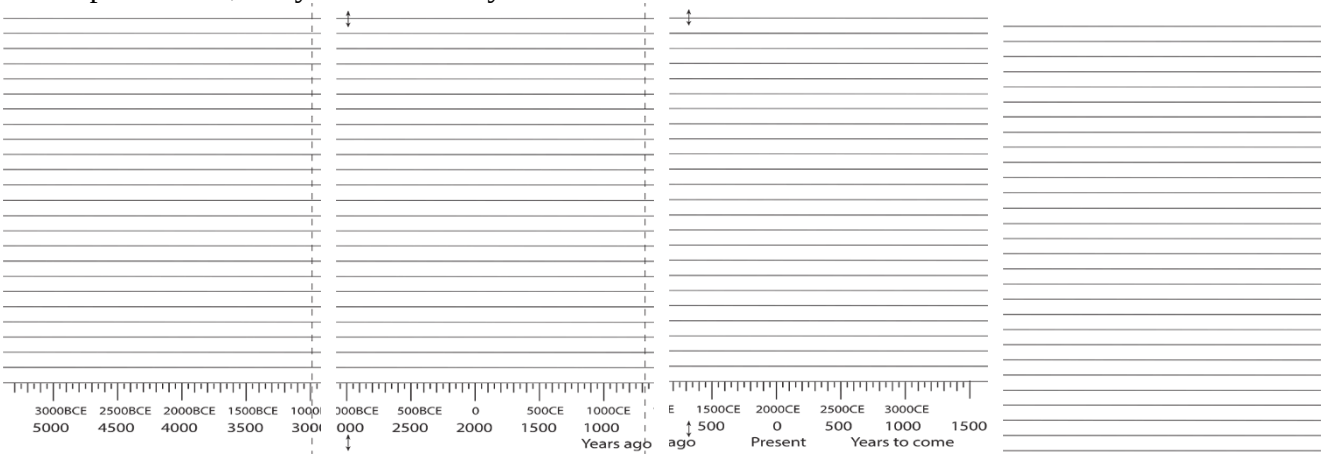
Inside Bubble Earth: Recycling

INTRODUCTION

Glimpses of the Past – Page 5-8

Overpopulation is a main contributor to things going wrong inside Bubble Earth. This exercise will allow students to gain some insight into the changes in world population since the time of Skara Brae 5,000 years ago.

Pages 19-22 of this document have the images needed to form a chart showing the changes of population over a period of 5,000 years. Here they are in a reduced form:



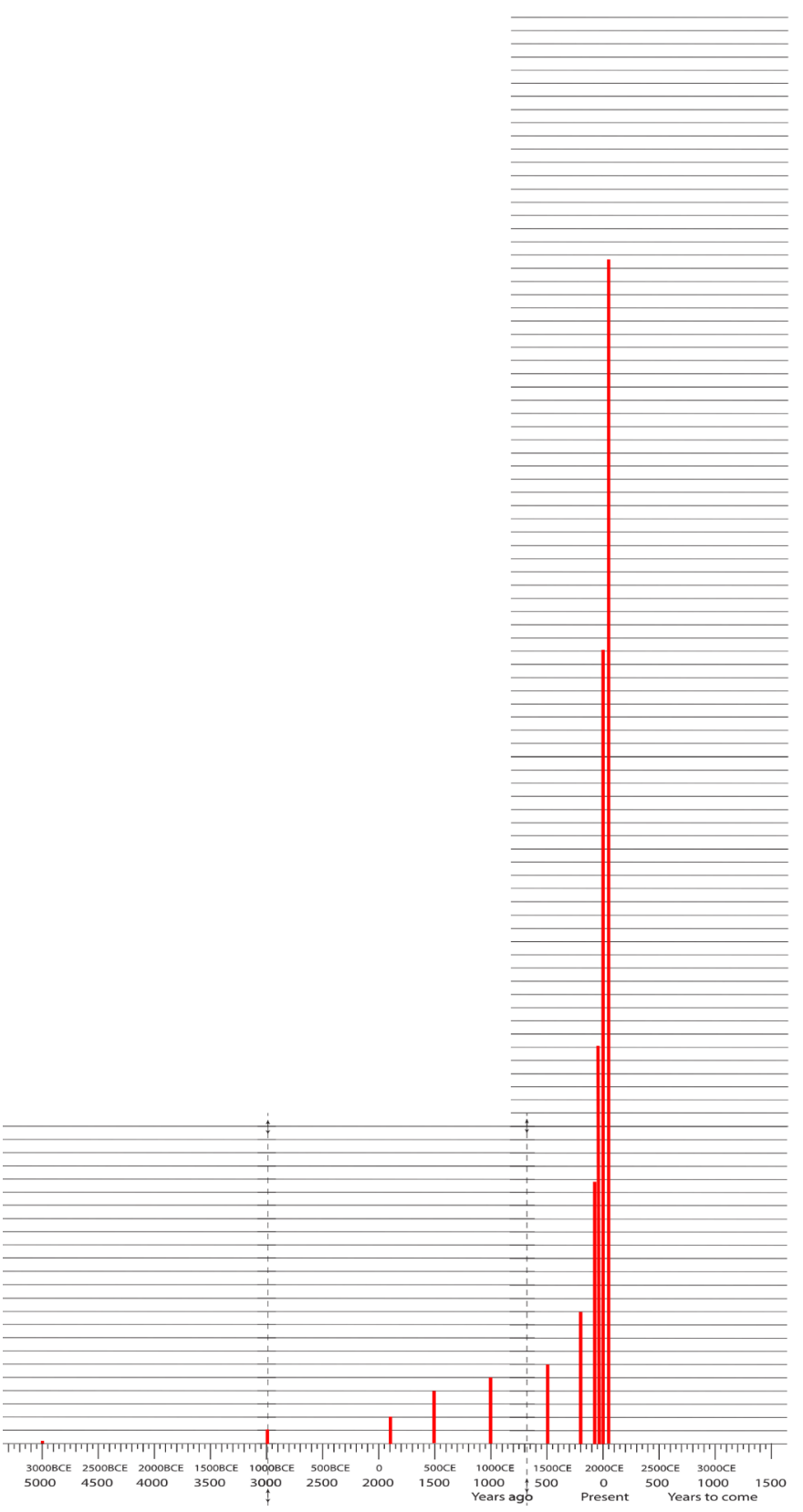
The first two pages need to be cut along the dashed line and then glued to the page alongside using the arrows to get the correct spacing. Four copies of the fourth page are needed to get enough height to represent the population over the last 200 years. Page 2 of this document shows the final chart.

The vertical divisions are 1 cm apart. The scale to use is 1 cm represents 100 million people.
Here is the data to use. Some of these are slightly different to the figures in the book which used upper estimates rather than these midrange estimates.

Year	BCE or CE	Population	Vertical distance on chart
3,000	BCE	10 million	1 mm
1,000	BCE	100 million	10 mm = 1 cm
100	CE	300 million	2 cm
500	CE	400 million	4 cm
1000	CE	500 million	5 cm
1500	CE	600 million	6 cm
1800	CE	1 billion	10 cm
1928	CE	2 billion	20 cm
1960	CE	3 billion	30 cm
2000	CE	6 billion	60 cm
2050	CE	9 billion	90 cm

It should soon become obvious to anyone creating this chart that continued population growth at the current rate is unsustainable. What to do about it, is nowhere near as obvious and could be a starter for discussion. There is space on the horizontal axis to try to predict the population at times in the future although many more copies of the fourth page would need to be printed.

Completed chart will look like this:



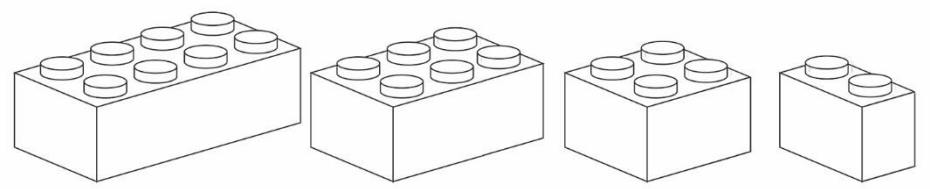
1 HUMAN-MADE

Types of Materials – Pages 9, 10

A simple introduction to materials could identify the materials used to make the furniture in the classroom. Most items will have more than one type of material. The table on Page 10 gives a classification system to use. The activity could be extended to the materials used to construct the classroom and other things around the school such as the play equipment.

Chemistry of Materials – Pages 10, 11

This activity uses Lego bricks to understand the structure of molecules. Four different sizes of standard bricks are used:



4x2 3x2 2x2 1x2

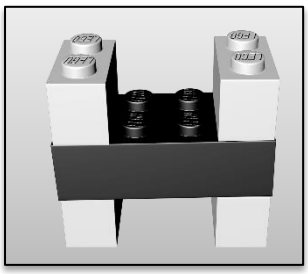
The colours used in the illustrations below are the same as those shown for the atoms in the Periodic Table on page 10. Other colours could be used depending on the bricks available.

Bonds between atoms can either be single, double, or triple. In our model a single bond will be a 1x2 connection; a double is 2x2; and a triple 3x2.

The number of bonds an element can form and brick to use for that element are shown in this table:

Element	Bonds	Brick
Hydrogen	1	1x2
Oxygen	2	2x2
Nitrogen	3	3x2
Carbon	4	4x2
Sulphur	2	2x2

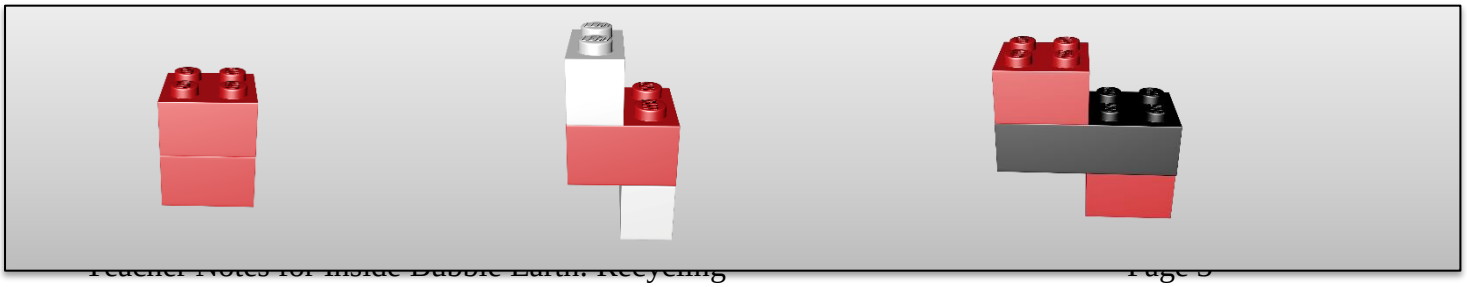
Here is the model for methane CH_4:



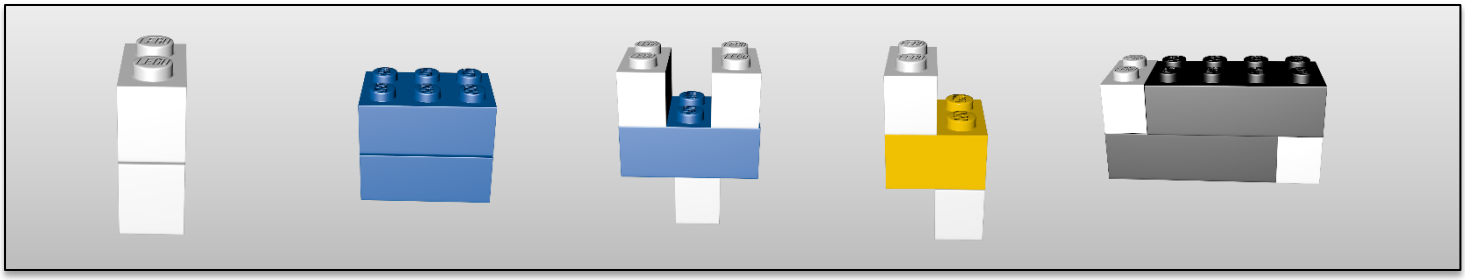
The four hydrogen atoms are spaced evenly distant because they repel each other.

Note that bonding can occur at the top or bottom of the brick but never more than the number of bonds for each atom. In this case the carbon atom (black) forms four bonds and each hydrogen atom (white) forms one bond.

Here are the molecules pictured at the bottom of page 11. Oxygen gas O_2, water H_2O, carbon dioxide CO_2

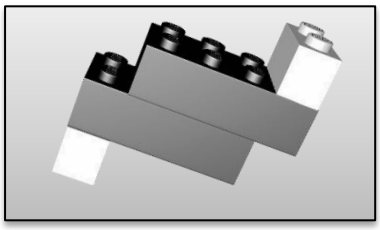


After making these molecules students could be given the formulas of the following and asked to make Lego model of the molecules. (The answers are given below.)
Hydrogen gas H_2, Nitrogen gas N_2, ammonia NH_3, hydrogen sulphide H_2S, acetylene C_2H_2.



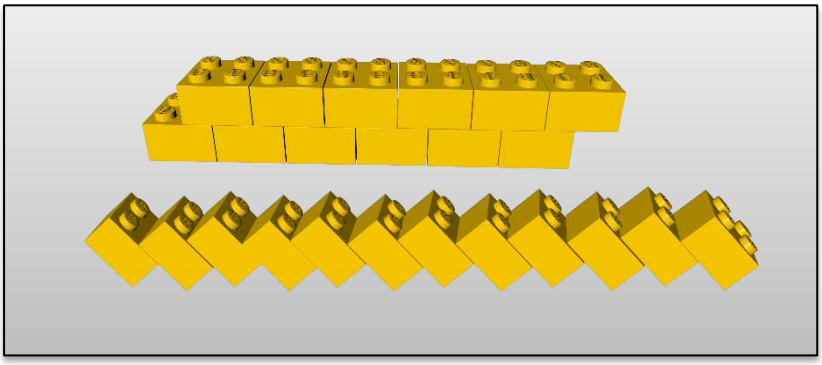
Note that N_2 has a triple bond. This means that it is very hard to pull the atoms apart making it a nonreactive substance. Nitrogen gas is often used to fill food packets like potato crisps to keep them fresh and crunchy for longer than if air was used.

Acetylene (the gas used in welding) also has a triple bond. It could also be modelled as:



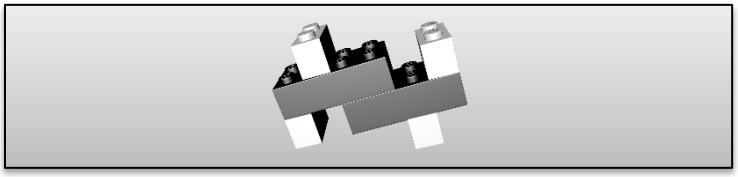
Sulphur is an element that comes in several different forms. The simplest is sulphur gas, S_2, which has the same structure as oxygen gas with a double bond between the atoms. Sulphur solid, S_8, has a ring structure shown below with single bonds joining the atoms together.
Students could be asked to make this molecule. The solution is shown below.

The third form of sulphur is a polymer with hundreds of atoms joined together by single bonds. This information should enable students to make part of the molecule. Two solutions are shown below This form of sulphur is called plastic sulphur.

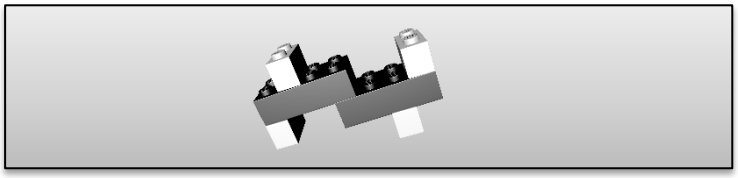


Structure of Plastics – Pages 11,12

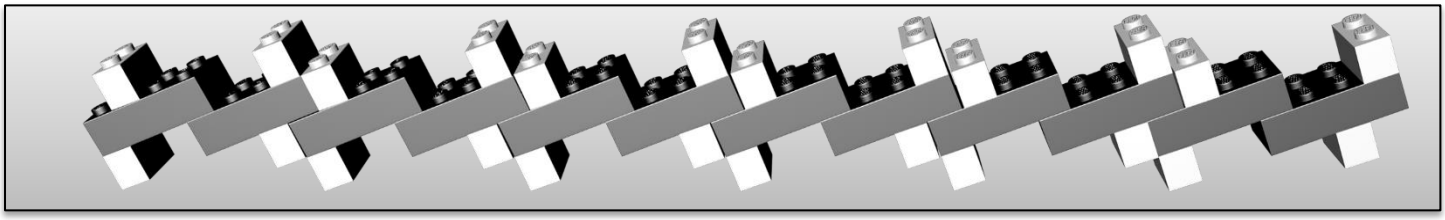
This activity follows on from the above, particularly the plastic sulphur exercise.
Ethene also known as ethylene is the monomer to make the common plastic polyethene or polyethylene, abbreviated PE. The formula is C_2H_4. The atomic model is shown on page 12. Here is the same model made with Lego. The hydrogen atoms could be placed differently but this is best for forming the polymer.



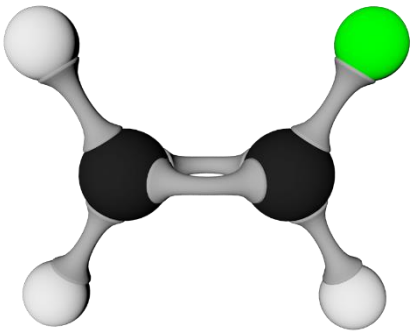
When ethene forms a polymer the double bond between the carbon atoms is changed to a single bond leaving each carbon with an empty bond like this:



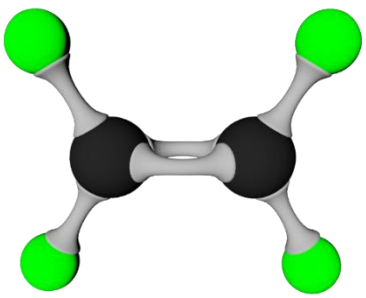
These empty bonds link together to form the polymer:



Students could model PVC polymer commonly called vinyl. Here is the structure of the monomer vinyl chloride. The green atom is chlorine. The molecule has the same structure as ethene except one hydrogen has been replaced by a chlorine atom. The formula is C_2H_3Cl.



Another possibility is Teflon based on the monomer tetrafluoro ethene, C_2F_4, which is ethene with all the hydrogen atoms replaced by fluorine atoms,



Manufacturing – Pages 14-16

This activity investigates the extraction of a useful chemical from one of Bubble Earth's key resources – seawater. The chemical we are after is commonly salt which has the chemical name sodium chloride and the formula NaCl.

Sodium chloride is used in the manufacture of a wide range of chemicals which are needed to make human-made materials and to refine organic materials such as wool and leather. Examples are listed in this table:

Common Name	Chemical Name	Chemical Formula	Everyday Use
baking soda	sodium bicarbonate	$NaHCO_3$	cooking
washing soda	sodium carbonate	Na_2CO_3	washing powder
caustic soda	sodium hydroxide	NaOH	drain unblocker
spirits of salt	hydrochloric acid	HCl	metal soldering
chlorine gas	chlorine	Cl_2	large swimming pools
bleaching liquid	sodium hypochlorite	NaOCl	Janola
bleaching powder	calcium hypochlorite	$Ca(OCl)_2$	home swimming pools

Activity: Extraction of Salt from Seawater

If you haven't got access to sea water just dissolve some salt in water and nobody will know the difference.

We will use solar energy to extract the salt. The best container is a flat baking dish, preferably one coated in black Teflon. The Warehouse has a Living and Co Flat Baking Sheet for $15 (https://www.thewarehouse.co.nz/p/living-co-flat-baking-sheet/R2750872.html?gclsrc=aw.ds&&gclid=Cj0KCQjwsdiTBhD5ARIsAIpW8CLnXblLP8_n_iIEQuRkgnd4ziLrJOIy_KBuDhd459GOVPy8CVdSKyIaAhRFEALw_wcB&gclsrc=aw.ds)
The black surface gives better absorption of the sun's energy and makes it easier to see the salt crystals. Another way is to put black paper into a flat dish.

Cover the bottom of the dish with sea water. Put in a warm sunny place and leave for several days. The white crystals that form will mainly be salt.

The main source of salt in New Zealand comes from Lake Grassmere in Marlborough. The following link will download an information sheet:

https://dominionsalt.co.nz *› uploads › 2017/11*

Activity: Making a Plastic

Manufacturing an oil-based plastic is difficult to do in the classroom or home. However, there are two bioplastics that students could make. The first is outlined here, the other will be covered in biodegradable plastics.

Casein is a protein found in milk which can easily be made into a plastic. New Zealand is the world's largest exporter of casein. The protein is our twelfth largest export earning over half a billion dollars a year.

In the following video Nanogirl shows how to make casein plastic.
https://www.youtube.com/watch?v=QulxqE4XY9M

With a chemical formula of $C_{18}H_{125}N_{22}O_{39}P$ the casein monomer is way too complex to model using Lego.

Casein plastic was used up until around 1980 to make small items such as buttons, beads, buckles, combs, handles, and knitting needles. It has since been replaced by other plastics that are cheaper to manufacture.

Landfill – Pages 16-18

Finding out about landfills, both closed and active, can be difficult because there is no central store of this information. If you're lucky your local district council will have collected some information and made it available on their website. The following site links to all district councils.

https://www.lgnz.co.nz/local-government-in-nz/new-zealands-councils/

The following has limited information about landfills that are in danger of being exposed by sea level changes.

https://www.stuff.co.nz/environment/124123042/more-than-300-old-dumps-at-risk-of-coastal-erosion-and-flooding

2 RECYCLING

Plan A: Self-reuse

There are hundreds of activities online that reuse waste materials in craft activities. A search for *Recycling Ideas for Kids* yielded these results and a whole lot more.

https://cleanriver.com/recycling-projects-kids-schools/
https://www.thesprucecrafts.com/top-trash-to-treasures-crafts-1254258
https://babbledabbledo.com/100-of-the-best-recycled-crafts-for-kids/
https://www.favecrafts.com/Earth-Day-Crafts/16-Recycle-Crafts-for-Kids

Plan B: Reassembly

A PDF file on a New Zealand deposit recycling scheme can be obtained from:

https://environment.govt.nz/publications/container-return-scheme-snapshot-of-the-consultation/

3 PROBLEMS

A New Zealand series of videos called Wasted is available on YouTube. The link to the first of six episodes is:

https://www.youtube.com/watch?v=Bcd7L-U4LQY

A European resource called Plastic Pirates has many activities that would work well in New Zealand. The source page is:

https://www.plastic-pirates.eu/en/material/download

There are four different PDF files. Although developed in Germany the language of these files is English:

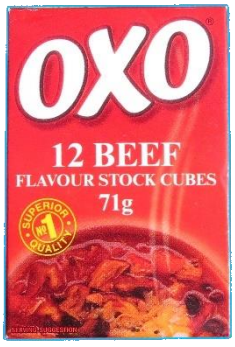
			
Project booklet	Guidelines for teachers and group leaders	Teaching materials	Construction manual sampling sieve
pdf 15.53 MB	pdf 936.42 KB	pdf 15.03 MB	pdf 1.21 MB

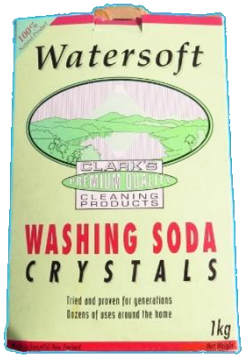
4 ORGANIC

End of Life for Organic Materials – Pages 40-46

This activity safely grows bacteria using common household materials.

You'll need a disposable plastic dish that is wider than it is tall. The cloudy containers used for salads at supermarket deli bars are ideal. You'll also need a measuring cup, teaspoon measures, powdered gelatine, beef stock cubes, washing soda.





Break a beef stock cube into a measuring cup. Add a quarter teaspoon of washing soda. Boil some water and pour 100 mL into the measuring cup. Without the washing soda you'll grow more fungi than bacteria.

Stir while slowly adding 10 g of gelatine — that's one sachet or two teaspoons. Continue stirring until everything dissolves.

Pour into the dish and put in the fridge until it sets to a jelly. This mixture has all the nutrients needed for bacteria to grow.

Adding the bacteria is simple. Find a surface that has not been dusted recently. Drag your finger over the surface and then touch it onto the top of the jelly. Try a few places including the floor.

DO NOT TAKE SAMPLES FROM THE TOILET.
This is a safety measure in case there are disease-causing bacteria around.

Cover the dish with a piece of cardboard and store out of sunlight. Too bright a place and the bacteria will be killed by the light; too warm, and the jelly will melt.

When you check the dish, don't put your face too close to the jelly.

Within a week you should have some bacterial colonies. These are likely to be round, shiny spots. Most will be grey or brown, but with a bit of luck you might get an orange one. Any white fluffy spots are fungi.

After a while you will see pits in the jelly where the bacteria are. This shows that they are digesting the jelly, turning it into a liquid.

To clean up, pour a disinfectant onto the jelly and let it soak for an hour. Then prise out the jelly, wrap in newspaper and put it in the rubbish. Wash the dish before recycling, and then wash your hands.

Here are some images from a completed activity.

5 FUTURE

Biodegradable – Pages 47, 48

A starch-based biodegradable plastic can be made from easy-to-get chemicals. There are many recipes online. These two are a good start:

https://www.wikihow.com/Make-Bioplastic
https://www.instructables.com/DIY-Bio-plastics/

Composting – Pages 49-50

Visible Worm Farm

Worm farms are already popular in many schools. A visible worm farm in the classroom can provide interest for many weeks. Have a look at this video:

https://www.youtube.com/watch?v=McQYDcqc0Nk

Visible composts and worm farms can be set up in any container that has a transparent side. There may even be a plastic aquarium somewhere around the school. If not, a search for *plastic aquarium nz* will give several possibilities less than $20

The key thing for a visible compost is that the light must be blocked from all parts except the top. Worms don't have eyes. but they can sense light and avoid it. Black paper will normally do the job if it's kept tight against the surface. The paper can be removed for short intervals to observe and record what is happening.

6 AT THE END

Ecosystems

Almost every school will have a leaf-litter ecosystem nearby that is worth a visit. The following may be useful:

https://kids.frontiersin.org/articles/10.3389/frym.2021.552700
https://kidsdiscover.com/teacherresources/new-life-old-leaves/
http://static.harpercollins.com/harperimages/ommoverride/teacher_guide_leaf_litter.pdf

Know your bins

Few places in Aotearoa have a full range of recycling bins. Most will have three different containers for waste: a bag or bin for landfill; a bin for plastic(#1, #2 and maybe #5), metals, paper, cardboard; a bin for glass bottles and jars. A transfer station may have additional bins: e-waste (electrical things); batteries; engine oil.

In this activity we'll assume the collections available are:

- **Black** bags for landfill
- **Green** bin for glass
- **Yellow** bin for organic
- **Red** bin for plastic(#1, #2 and maybe #5), metals, paper, cardboard
- **Blue** bin for anything that can't go into any of the other containers.

The activity is a word search through 40 items of rubbish. Each word is circled with the coloured vivid matching the bin that legally can take that item. Highlighter pens could also be used.

If you're unsure about any items visit:

https://www.consumer.org.nz/articles/what-you-can-and-can-t-recycle

There are two levels of difficulty depending on the level of study.

1. Wordfinder from a list.
2. Wordfinder in an up-down/across grid.

The same words are used in both activities.

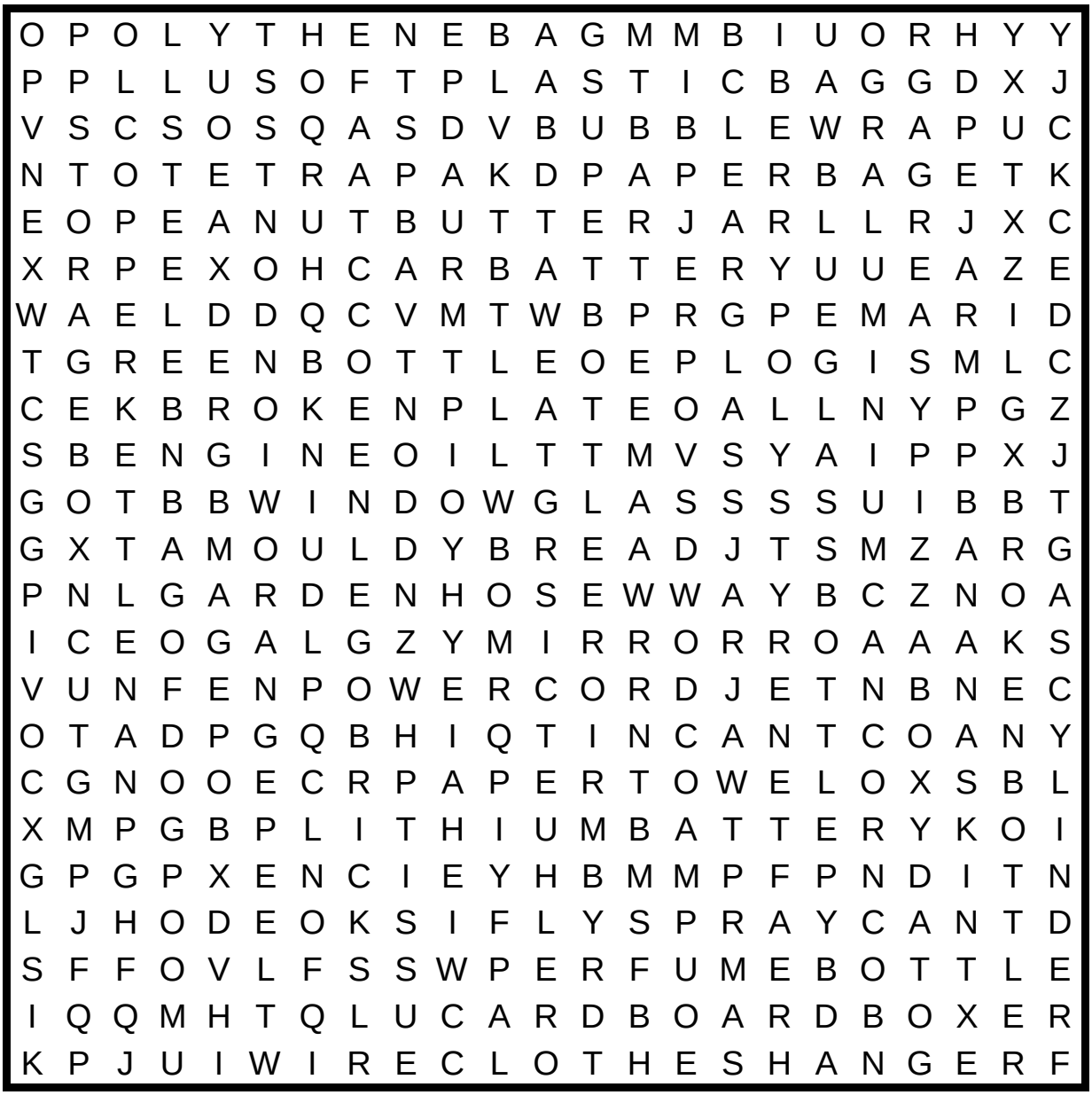
Wordfinder 1

Aluminium can	Garden hose	PET bottle
Bag of dog poo	Gas cylinder	Polystyrene
Banana skin	Greasy pizza box	Polythene bag
Blue glass bottle	Green bottle	Power cord
Broken bottle	HDPE jar	PP storage box
Broken plate	Lego bricks	Soft plastic bag
Bubble wrap	Lithium battery	Steel
Car battery	Mirror	Tetrapak
Cardboard box	Mouldy bread	Tin can
Clear glass jar	Orange peel	Tissue
Copper kettle	Paper bag	Window glass
Corn cob	Paper towel	Wire clothes hanger
Engine oil	Peanut butter jar	
Flyspray can	Perfume bottle	

Suggested answers are given below although some will be different depending on the local council.

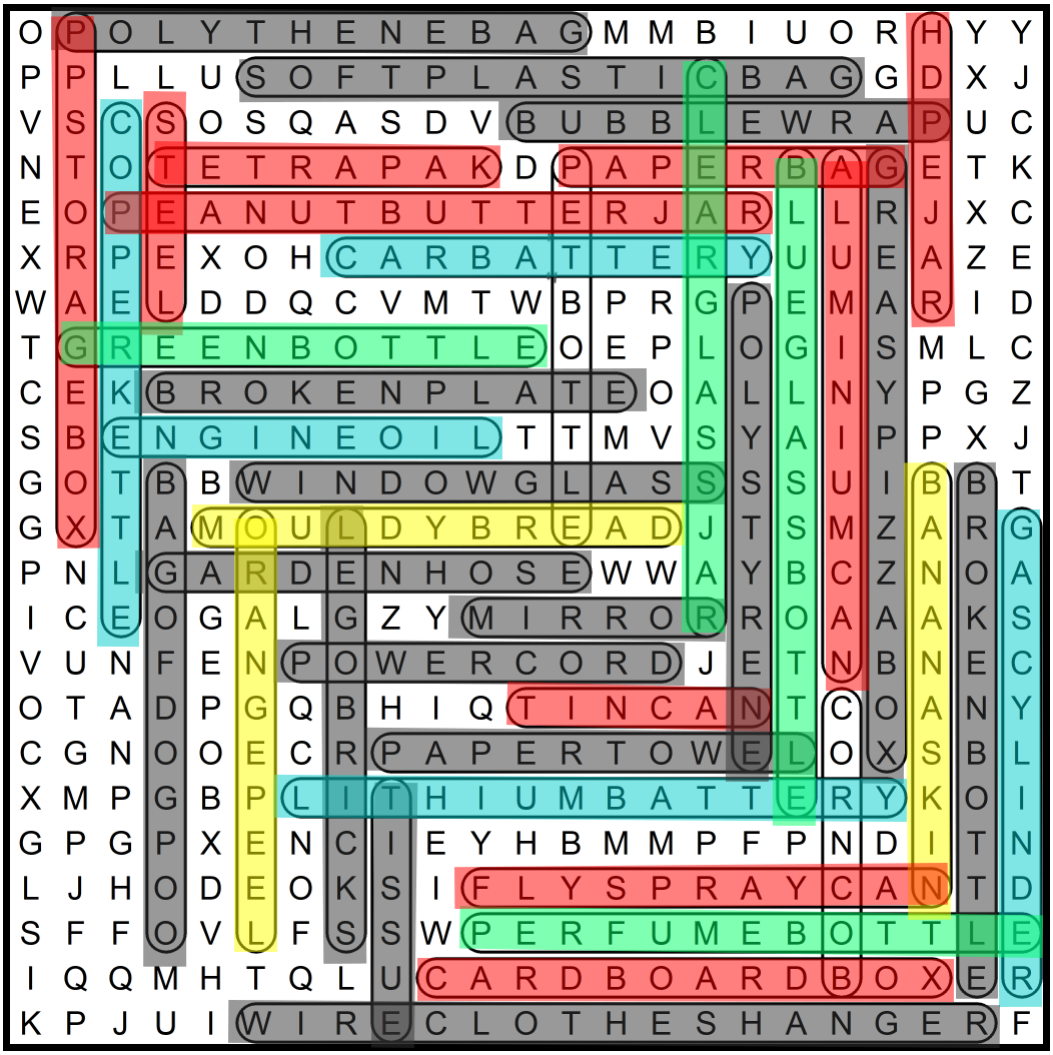
Aluminium can	Garden hose	PET bottle
Bag of dog poo	Gas cylinder	Polystyrene
Banana skin	Greasy pizza box	Polythene bag
Blue glass bottle	Green bottle	Power cord
Broken bottle	HDPE jar	PP storage box
Broken plate	Lego bricks	Soft plastic bag
Bubble wrap	Lithium battery	Steel
Car battery	Mirror	Tetrapak
Cardboard box	Mouldy bread	Tin can
Clear glass jar	Orange peel	Tissue
Copper kettle	Paper bag	Window glass
Corn cob	Paper towel	Wire clothes hanger
Engine oil	Peanut butter jar	
Flyspray can	Perfume bottle	

Wordfinder 2



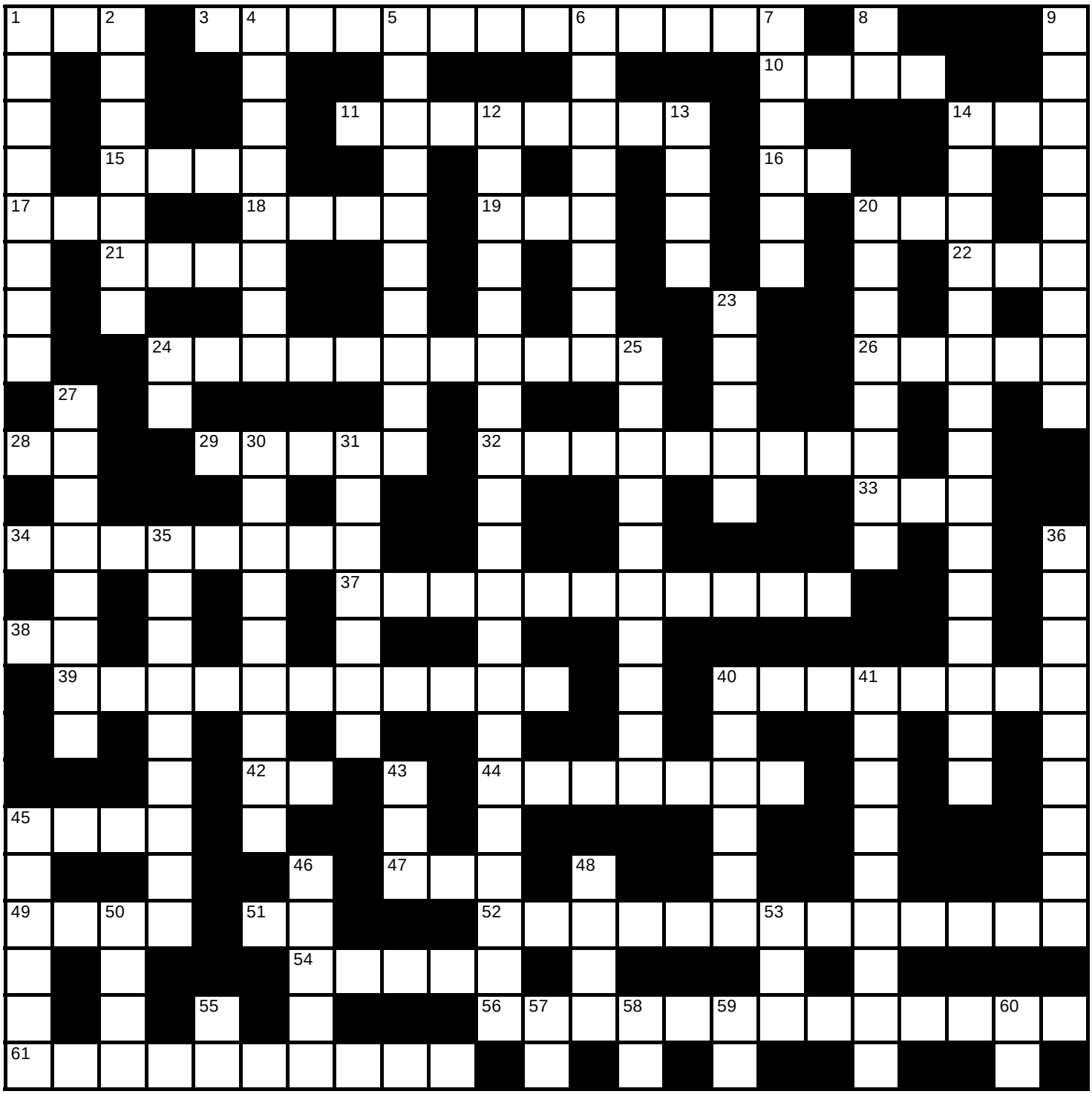
O P O L Y T H E N E B A G M M B I U O R H Y Y
P P L L U S O F T P L A S T I C B A G G D X J
V S C S O S Q A S D V B U B B L E W R A P U C
N T O T E T R A P A K D P A P E R B A G E T K
E O P E A N U T B U T T E R J A R L L R J X C
X R P E X O H C A R B A T T E R Y U U E A Z E
W A E L D D Q C V M T W B P R G P E M A R I D
T G R E E N B O T T L E O E P L O G I S M L C
C E K B R O K E N P L A T E O A L L N Y P G Z
S B E N G I N E O I L T T M V S Y A I P P X J
G O T B B W I N D O W G L A S S S S U I B B T
G X T A M O U L D Y B R E A D J T S M Z A R G
P N L G A R D E N H O S E W W A Y B C Z N O A
I C E O G A L G Z Y M I R R O R R O A A A K S
V U N F E N P O W E R C O R D J E T N B N E C
O T A D P G Q B H I Q T I N C A N T C O A N Y
C G N O O E C R P A P E R T O W E L O X S B L
X M P G B P L I T H I U M B A T T E R Y K O I
G P G P X E N C I E Y H B M M P F P N D I T N
L J H O D E O K S I F L Y S P R A Y C A N T D
S F F O V L F S S W P E R F U M E B O T T L E
I Q Q M H T Q L U C A R D B O A R D B O X E R
K P J U I W I R E C L O T H E S H A N G E R F

Here is the solution.



Glossary

This crossword mostly uses words in the glossary. Others found in the text are referenced by the page number.



Across

1 Abbreviation for liquified petroleum gas, one of the fossil fuels often used to power barbecues - P61 (3)

3 The full name of the chemical that is the A in ABS plastic - P13 (13)

10 A prefix that means 0.000,000,001 of something - P29 (4)

11 The most common way we get rid of waste material - P17 (8)

14 A liquid fossil fuel that can be turned into petrol and diesel for motor vehicles - P32 (3)

15 A solid fossil fuel - P32 (4)

16 Most of the sustainability R-words begin with this prefix which means again - P58 (2)

17 The formula for water - P11 (3)

18 An organic material that comes from sheep - P39 (4)

19 A material used to reduce friction in engines (3)

20 Abbreviation for compressed natural gas, one of the fossil fuels - P32 (3)

21 A legume that is so rich in protein it is used to make artificial animal materials such as meat - P36 (4)

22 Stone, Bronze and Iron are examples of this term used to divide time - P7 (3)

24 A plastic with the abbreviation PS - P51 (11)

26 Vehicles that sometimes spill plastics into the ocean - P27 (5)

28 Chemical symbol for the element argon found to the right of chlorine in the Periodic Table- P10 (2)

29 The most common liquid inside Bubble Earth - P11 (5)

32 The singular word of bacteria - P41 (9)

33 The city of Pompeii was destroyed in 79 CE. The abbreviation CE stands for Common _ _ _ - P5 (3)

34 The first common plastic invented in 1907 - P62 (8)

37 The first stage of this process is called extraction - P14 (11)

38 The chemical symbol for the element lithium - P10 (2)

39 Something that can happen over and over again without causing problems - P46 (11)

40 Plankton can often be seen doing this in water - P62 (8)

42 Chemical symbol for the element indium which comes just before tin in the Periodic Table - P10 (2)

44 The age that comes after the Bronze Age - P7 (4,3)

45 An important raw material which can be extracted from sea water (4)

47 Abbreviation for the molecules found in the middle of a bacterium cell - P42 (3)

49 An element contains only one type of this - P10 (4)

51 Chemical symbol for the element cobalt which follows iron in the Periodic Table - P10 (2)

52 Increasing carbon dioxide in the atmosphere is causing this - P31 (7,6)

54 A prefix that means 0.001 of something - P29 (5)

56 The main process in the recycling of organic materials - P43 (13)

61 Animals that get their protein from eating plants - P37 (10)

Down

1 The term used for chemicals leaking out of plastics and landfills - P30 (8)

2 The sugar that is the monomer for both starch and cellulose - P34 (7)

4 Outside surface of a plant or bacterial cell - P42 (4,4)

5 Compost pile found on the forest floor - P52 (4-6)

6 Word for 1,000,000,000,000 - P63 (8)

7 Needed to make something move or change. Comes in several different forms - P31 (6)

8 Chemical symbol for the element tin - P10 (2)

9 The simplest form of recycling - P20 (4-5)

12 The full name for DNA - P61 (16,4)

13 A toy made from ABS plastic - P13 (4)

14 Wood and animals skins are examples of this - P4 (7,8)

20 General name given to somebody who uses a material - P15 (8)

23 A prefix meaning 0.000,001 of something - P61 (5)

24 Abbreviation for number 6 recyclable plastic - P51 (2)

25 The second box in the manufacturing process - P16 (10)

27 Often has the word living in front of it - P8 (8)

30 An organic molecule containing nitrogen atoms - P60 (5,4)

31 The name for a substance that contains only one type of atom - P10 (7)

35 A group of interacting organisms and their physical environment - P52 (9)

36 A plastic that is normally used once before being thrown away - P7 (6-3)

40 Break down food into monomers - P43 (6)

41 Sequence of food moving from one organism to another - P28 (4,5)

43 Three letters that are put below the recycling symbol for polyvinylidene plastics - P50 (3)

45 One of the polymers made from glucose - P34 (6)

46 Two or more things sold as a single pack, such as a compostable set of eating utensils - P55 (5)

48 Element with the symbol Zn - P10 (4)

50 A prefix that often comes before population when talking about Bubble Earth problems - P32 (4)

53 Words beginning with this prefix are almost as common as bio- words - P52 (3)

55 The chemical symbol for the element bismuth that comes after lead in the Periodic Table - P 10 (2)

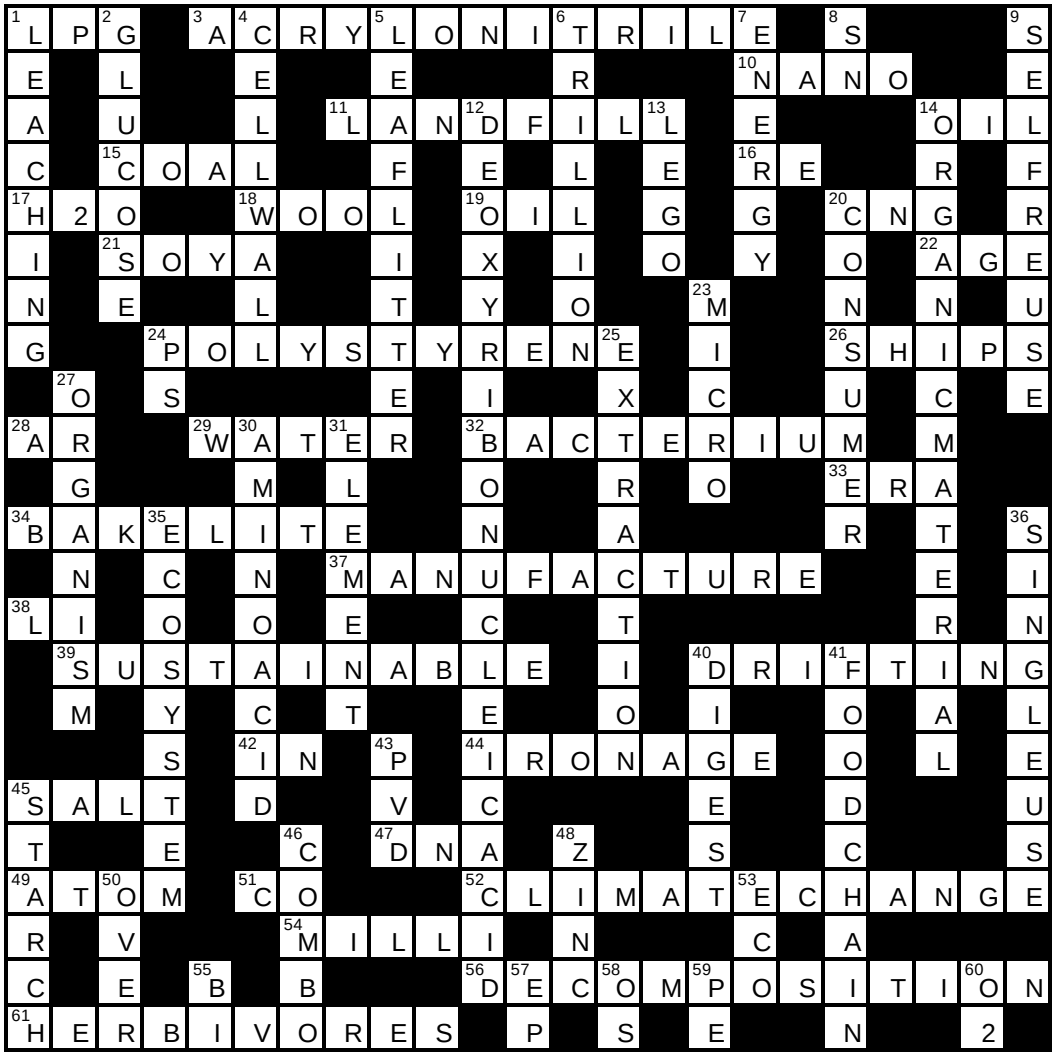
57 Two letters that would come before M in the abbreviation for ethylene-propylene monomer (2)

58 The symbol for the element osmium which is in the same column as iron in the Periodic Table - P10 (2)

59 Abbreviation for polyethene - P12 (2)

60 Formula for oxygen gas - P11 (2)

Solution



Across: 1 LPG, **3** ACRYLONITRILE, **10** NANO, **11** LANDFILL, **14** OIL, **15** COAL, **16** RE, **17** H2O, **18** WOOL, **19** OIL, **20** CNG, **21** SOYA, **22** AGE, **24** POLYSTYRENE, **26** SHIPS, **28** AR, **29** WATER, **32** BACTERIUM, **33** ERA, **34** BAKELITE, **37** MANUFACTURE, **38** LI, **39** SUSTAINABLE, **40** DRIFTING, **42** IN, **44** IRON AGE, **45** SALT, **47** DNA, **49** ATOM, **51** CO, **52** CLIMATE CHANGE, **54** MILLI, **56** DECOMPOSITION, **61** HERBIVORES.

Down: 1 LEACHING, **2** GLUCOSE, **4** CELL WALL, **5** LEAF-LITTER, **6** TRILLION, **7** ENERGY, **8** SN, **9** SELF-REUSE, **12** DEOXYRIBONUCLEIC ACID, **13** LEGO, **14** ORGANIC MATERIAL, **20** CONSUMER, **23** MICRO, **24** PS, **25** EXTRACTION, **27** ORGANISM, **30** AMINO ACID, **31** ELEMENT, **35** ECOSYSTEM, **36** SINGLE-USE, **40** DIGEST, **41** FOOD CHAIN, **43** PVD, **45** STARCH, **46** COMBO, **48** ZINC, **50** OVER, **53** ECO, **55** BI, **57** EP, **58** OS, **59** PE, **60** O2.

Further Reading

The links for further reading are repeated here as clickable links.

A great site for finding out more about materials under the headings glass, paper, plastic, wood: kids.kiddle.co/#Materials

For New Zealand information use: https://www.recycle.co.nz/kids.php

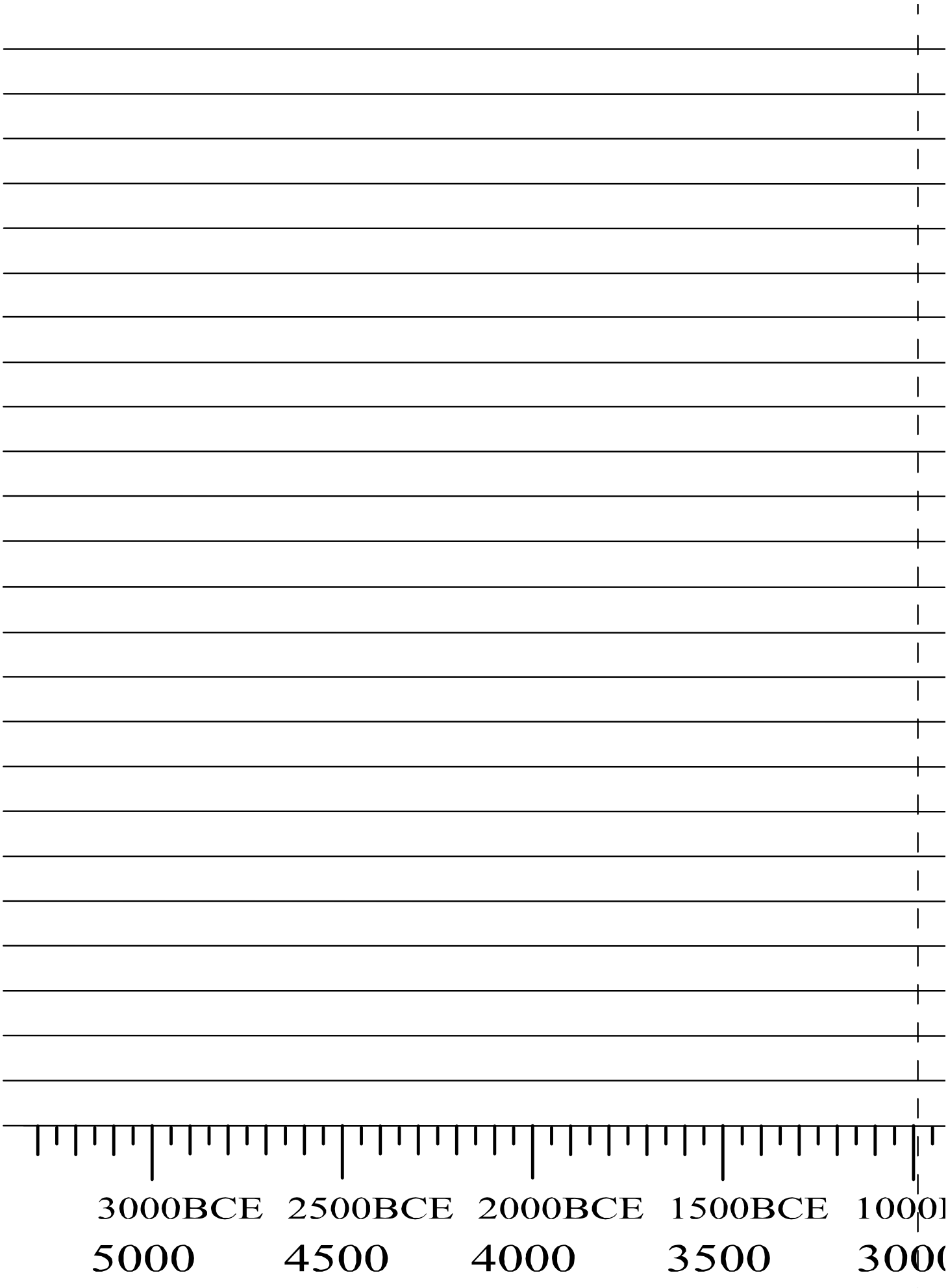
A useful video on how recycling is sorted: thekidshouldseethis.com/post/recycle-video-for-kids

NASA has some wonderful material planet Earth. Their recycling information starts at: climatekids.nasa.gov/search/recycling/

For more local information try: recyclekiwi.co.nz/

An exploration of New Zealand's future use of materials is covered by this government site: pmcsa.ac.nz/topics/rethinking-plastics/

The following pages have printable grids for the population activity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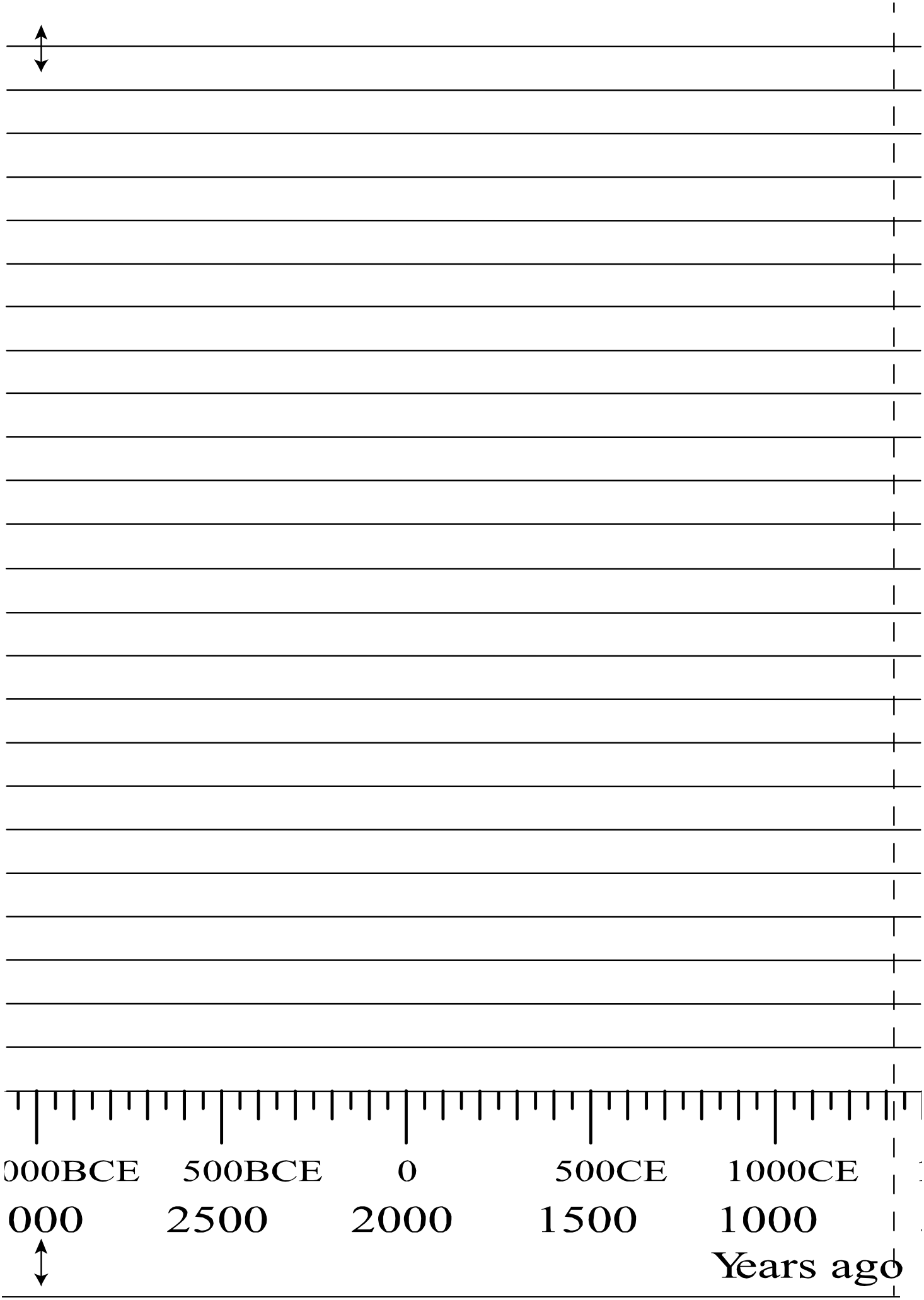
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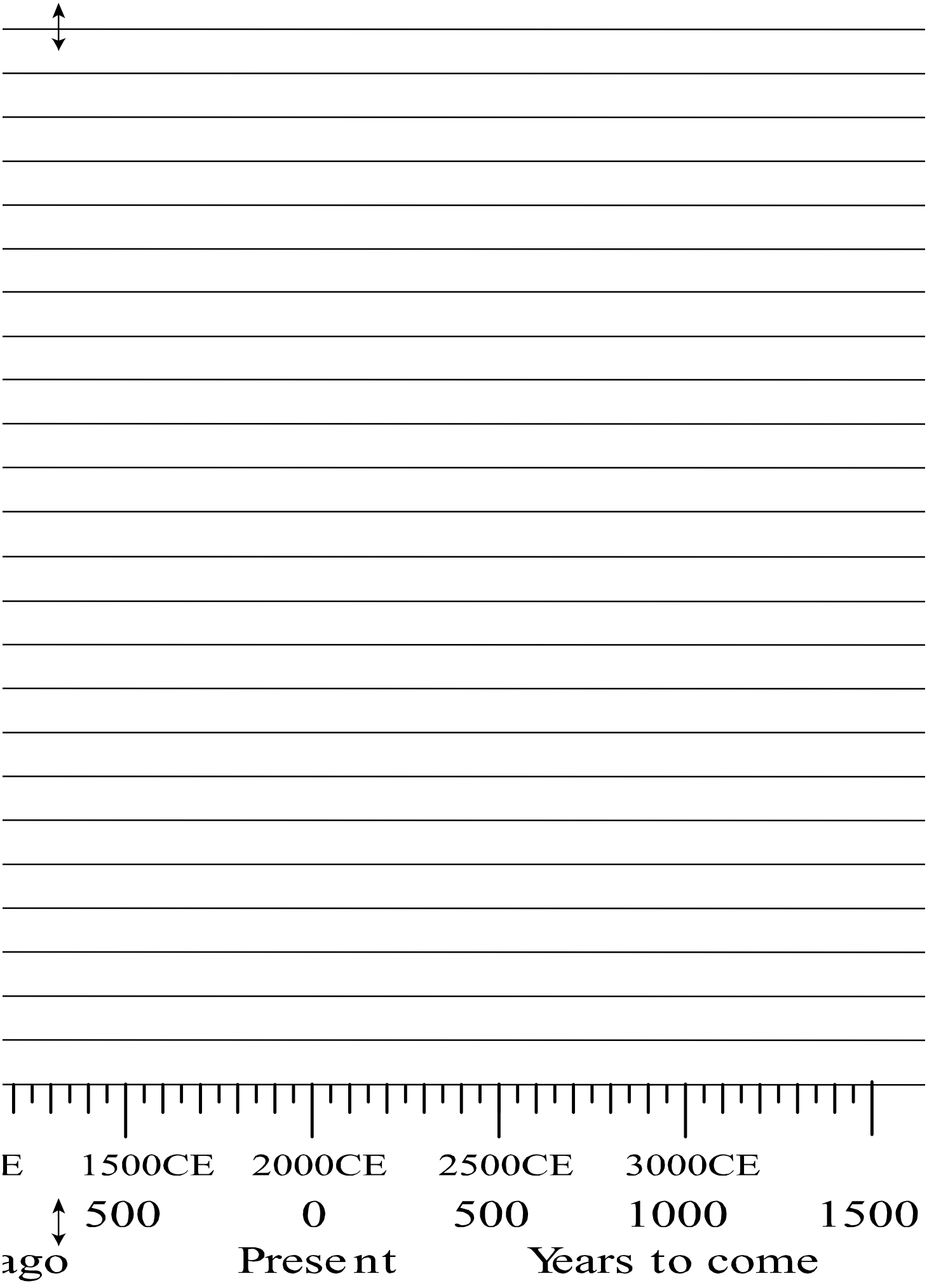
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ago
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