Watch your waste!

UNIT 4

This unit takes a holistic look at waste products and the interdependence of the whole natural system, and leads to reflections on the role of humankind on Earth and our mortality.

Using this unit

This unit is differentiated into Foundational and Higher level material because of the different content requirements at GCSE.

Although it is intended largely for individual study or homework, it also provides opportunities for group work and discussion.

Activity 5 is a game and needs to take place in class.

The sections of the unit together make a complete lesson, but individual sections can also be used to supplement other teaching material.

Familiarity with the basic principles of plant nutrition, pollution, and a general knowledge of farming methods are assumed throughout the unit.

Links with GCSE

Sc2 Life processes and living things

- Human impact on the environment: land use, water and land pollution (Foundation); fertilisers, eutrophication, sewage (Higher).
- Nutrient cycles: waste, decay, microbes (Foundation); nitrogen cycle (Higher).

Sc0 Application of science

- Ways in which science is applied and used.
- The benefits and drawbacks of scientific and technological developments for individuals, communities and environments.
- Relating scientific knowledge and understanding to the care of living things and the environment.

Moral and spiritual aims

- To help students to re-appraise the value of 'waste' and the importance of natural cycles of replenishment in a context where modern farming methods are driven by pressures of economics and productivity targets.
- To show humankind as one part of a whole interdependent system, rather than as being entitled to consume everything else.
- To promote reflection on the productivity of death and on personal mortality.

TEACHER'S NOTES

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Notes on the activities (Foundation level)

Activity 1: The nitrogen cycle

This activity is intended to emphasise the interdependence of the parts of the cycle.

The arrows should join the 3 parts going clockwise.

1. (a) Plants get nitrogen from the soil primarily (other sources are not mentioned at this point for Foundation level students).

   (b) Animals get nitrogen primarily from plants.

2. This task reinforces knowledge of the components of the cycle and could be used for revision.

3. This task emphasises dependence of humankind.

Activity 2: Organic farming and gardening

1. This is not intended primarily for mathematical calculation of an answer, but rather to provoke thought.

   It is possible that either Farmer Brown or Farmer White could have more after 5 years. Farmer Brown may have more because the fallow field yielded a better crop as its soil was replenished, and Farmer White could find productivity decreasing as the nutrients in his fields are used up. However, it may take longer than 5 years for Farmer Brown to 'catch up', and Farmer White could replenish the nutrients by using fertilisers!

3. This topic provides an opportunity for investigation work. The students could have samples of organically grown food together with samples produced in the normal way, and they could conduct a survey of opinion on which has the 'better flavour'.

Activity 3: What do we mean by waste?

A possibility is 'biological gift'.

Notes on the activities (Higher level)

Activity 1: The nitrogen cycle

1. Nitrogen is a very important constituent of air with a specific role to play. The molecules of nitrogen are joined by a very strong bond. This bond is one of the strongest known in chemistry. Nitrogen is therefore remarkably stable in its molecular form, and this unreactivity allows it to act as a dilutant for oxygen, making a much more stable situation.
2. The production of fertilisers has brought about the greatest changes in concentration levels of nitrates in the soil. The increase in population and the production and consumption of food has led to changes in the biomass, and therefore the total mass of protein in animals and plants.

Activity 2: Changes in farming methods

1. The food shortage and increase in population in 1950 can be linked to the Second World War.

2. Changes include: clearing of woodland; hedgerows removed to enlarge fields for large machinery; use of chemical fertilisers; use of chemical sprays for weeds, pests and fungi; and drainage of marshland to provide land for crops.

3. A burger only costs 99p to buy, but the environment, animals and people in the developing world pay a high price for its production.

Activity 3: Organic farming and gardening

4. Organic farmers say that bad farming is not taking into account the whole picture. For example, clearing forests may affect global warming and weather systems, endangered species, the lives of tribal peoples etc.

5. **Advantages:** better flavour, more natural, environmentally friendly, not wasteful, more nutritious.

   Disadvantages: expensive to produce, labour intensive, limited yield.

6. It is unlikely to be able to produce enough food to feed everyone cheaply enough.

NITROCYCLE

Activity 5: Nitrocycle

This game aims to draw attention to human intervention in the environment and to emphasise the need to avoid excesses and imbalance of nitrogen between the parts of the cycle.

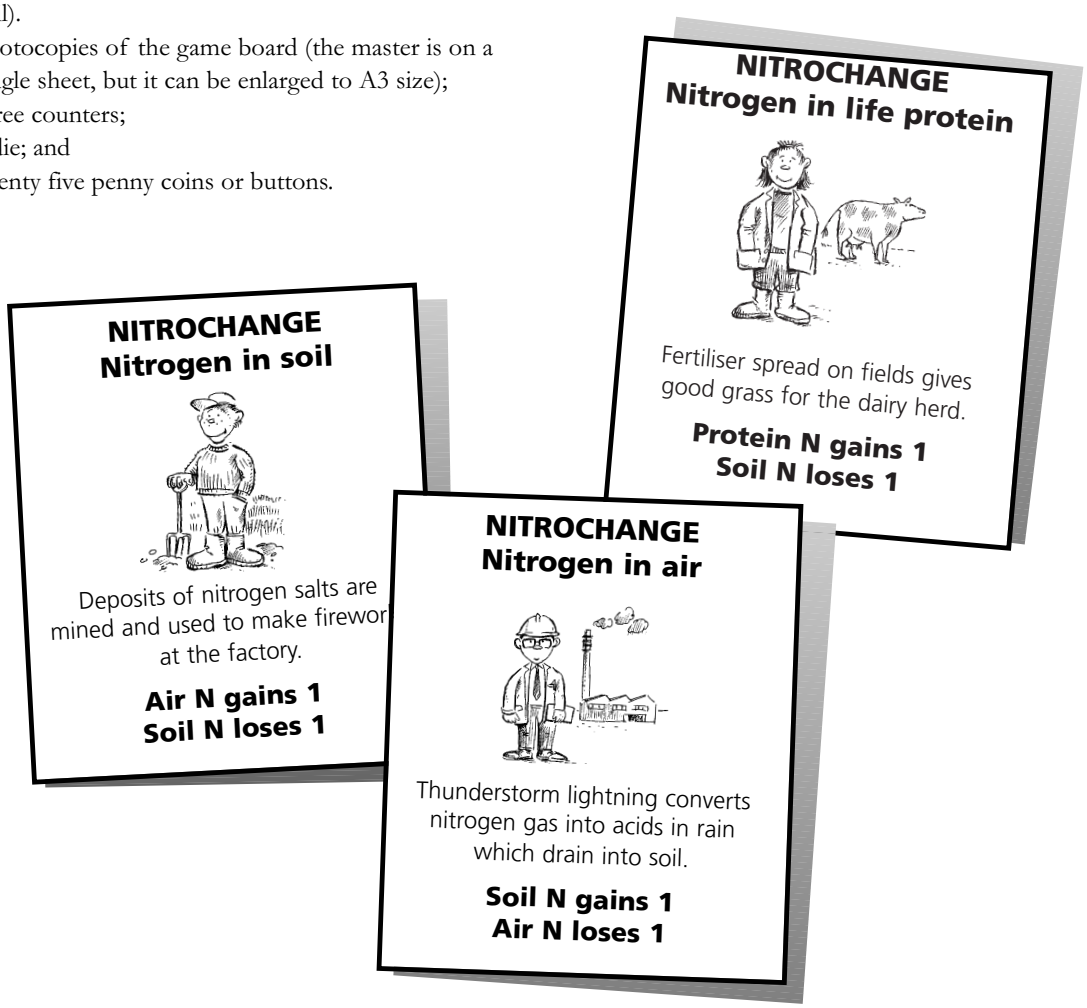
It involves the pupils in working out what is happening to nitrogen in a number of situations, and can be used to reinforce the principles of the nitrogen cycle.

For each group of 3 pupils you will need:

- card of different colours onto which to photocopy the Nitrochange cards (we suggest you use blue for air, green for life protein and buff for soil).
- photocopies of the game board (the master is on a single sheet, but it can be enlarged to A3 size);
- three counters;
- a die; and
- twenty five penny coins or buttons.

Alternatively they can be photocopied on to white card, or paper, and then coloured by pupils, or given a coloured spot for easy identification.

Once photocopied, the sheets of cards should be cut into individual cards.



TEACHER'S NOTES

TEACHER'S NOTES

Watch your waste!

UNIT 4

Foundation level

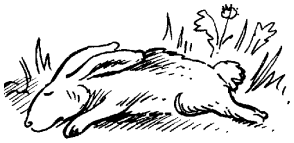
All living things need nitrogen in order to grow because it is an essential part of protein, the material that cells are made from. One of the ways in which animals and plants differ is where they get their nitrogen.

1 The nitrogen cycle

Look carefully at this diagram. It needs arrows to complete it. Your task is to copy it and put the arrows in.

The roots of a new plant absorb nitrogen.

Nitrogen is contained in the plant tissues.



The animal dies and decays - nitrogen enters the soil.

An animal eats the plant and the nitrogen forms part of the animal.

1. (a) Where do plants get their nitrogen from?

   (b) Where do animals get their nitrogen from?

   So. . .
   the plants need the animals,
   the animals need the plants,
   the plants need the animals,
   the animals need the plants ...

They depend on each other in a kind of circle.
This circle is called the nitrogen cycle.

2. Imagine you are a nitrogen atom. Write a short story of your journey from the soil, how you are drawn into the roots of ....., eaten by ..... until you have gone right round the cycle, and have come back to the soil again. You could write it in a circle if you like.

3. Make a list of the ways in which plants are important to humans.

2 Organic farming and gardening

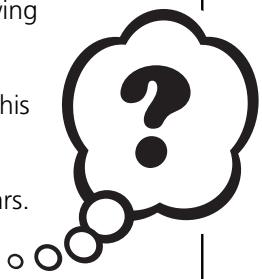
1. There were two farmers and each of them had 4 fields.

   Farmer Brown decided to give one of his fields a rest each year by just growing grass in it. Therefore each year he got crops from 3 fields.

   Farmer White, on the other hand, thought this was a waste. He wanted all his fields to produce crops every year. So he got crops from 4 fields every year.

   After 5 years they counted up how much they had harvested over the 5 years.

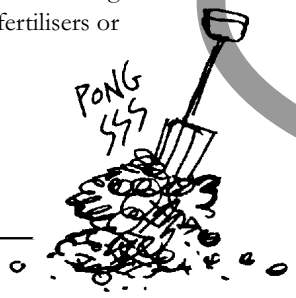
   Which one do you think had the most and why?



Some people like to grow things entirely by 'natural' methods, paying a lot of attention to the nitrogen cycle. They are called 'organic farmers'. They do not use fertilisers or pesticides.

"Farming is an understanding of the garden as a whole - the soil, the weeds, and all the creatures that inhabit it as well as the crops and plants."

(*The Organic Garden* by Sue Strickland, Hamlyn, 1992)



2. Here are 6 statements about organic farming. Some are good points and some are bad points.

   Copy the table below, then put the statements in the table choosing carefully which side of the table to put them.

A Organic farming produces vegetables which some people think have better flavour and more nutrients in them.
B Organic produce is more expensive.
C Organic farming does not waste much.
D Organic farming is natural and takes care of the environment.
E Organic farming does not produce vast quantities.
F Organic farmers have to work very hard - their farms are too small for machinery.

Organic Farming	
Good points	Bad points

3. Perhaps all farming should be organic. What do you think?

   Do you care about the flavour of potatoes?

   Do you care about not spoiling the environment?

   Would you pay more for organically grown food?

   How much would you be prepared to pay for a bag of crisps made from organically grown potatoes?

   Discuss your ideas with your group.

3 What do we mean by 'waste'?

Biologists use the word 'waste' when talking about faeces and dead bodies.

1. Using a dictionary, make a list of 5 meanings of the word 'waste' .

Now look again at the nitrogen cycle diagram. Organic farmers try not to waste anything in their gardens - they even think manure is wonderful stuff! Everything that dies is rotted down on the compost heap to replenish the soil.

2. 'Waste' does not seem a very good word to use? Can you think of a better one?

A Jewish teacher once said:

"All go to the same place; all come from dust, and to dust all return."
(*Ecclesiastes 3 v 20*)

A pile of dust is all that remains of a body when it has been cremated.

Is that all there is left of a person after they have died?

Watch your waste!

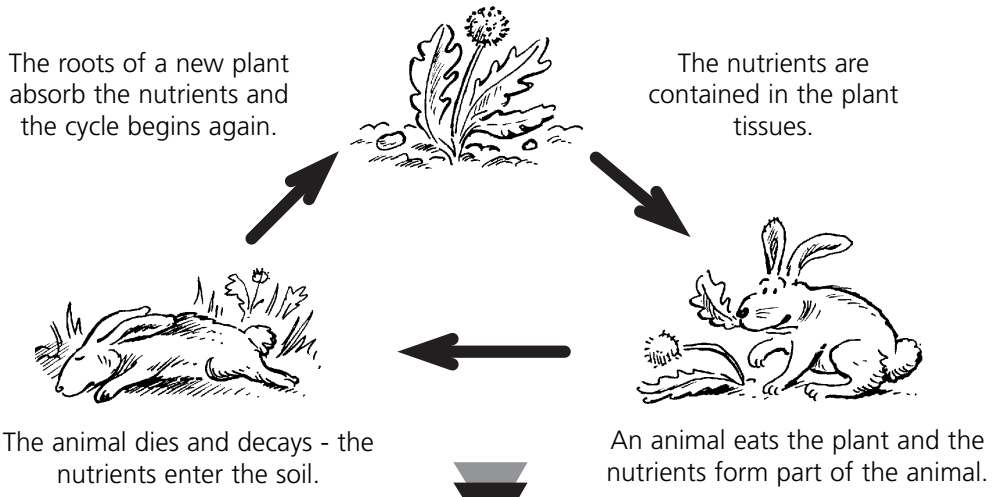
UNIT 4

Higher level

All living things need nitrogen in order to grow because it is an essential part of protein, the material that cells are made from. One of the ways in which animals and plants differ is where they get their nitrogen.

1 The nitrogen cycle

All elements in the tissues of plants and animals are cycled through nature.



Nitrogen is an essential part of protein from which all living things are made. Although nitrogen is plentiful, forming about 78% of the atmosphere, neither plants nor animals can obtain their nitrogen directly from this source.

Plants absorb their nitrogen through their roots as mineral salts in the soil.

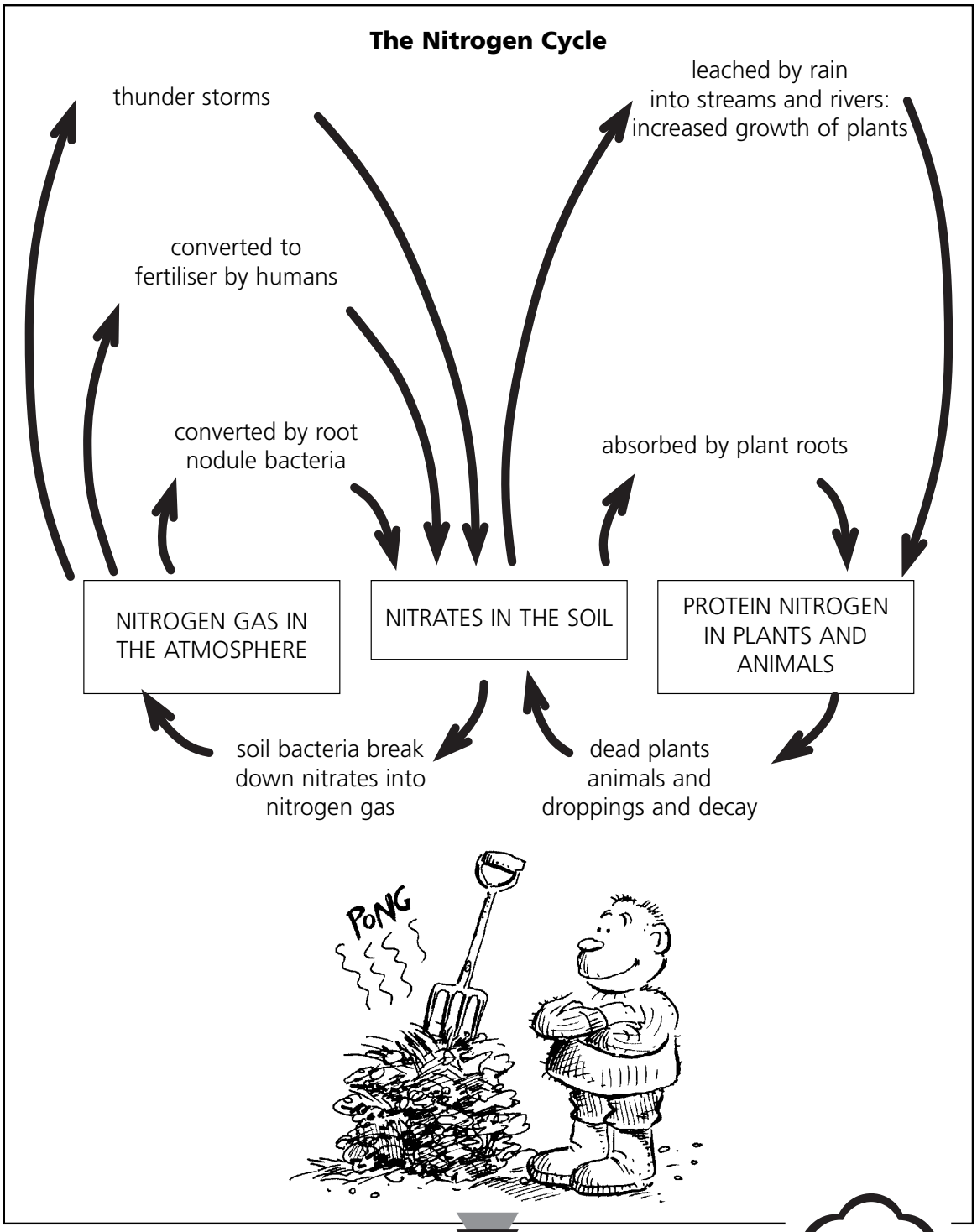
Animals obtain their nitrogen by eating food containing protein.

1. Why do you think there is so much nitrogen gas in the atmosphere?

   Is it just an accident with no purpose?

   Would it be more useful if there were more oxygen instead?

In practice the natural cycles are more complicated than the diagram you have just been looking at.



2. Which part of the cycle has changed most in the last 50 years and why?

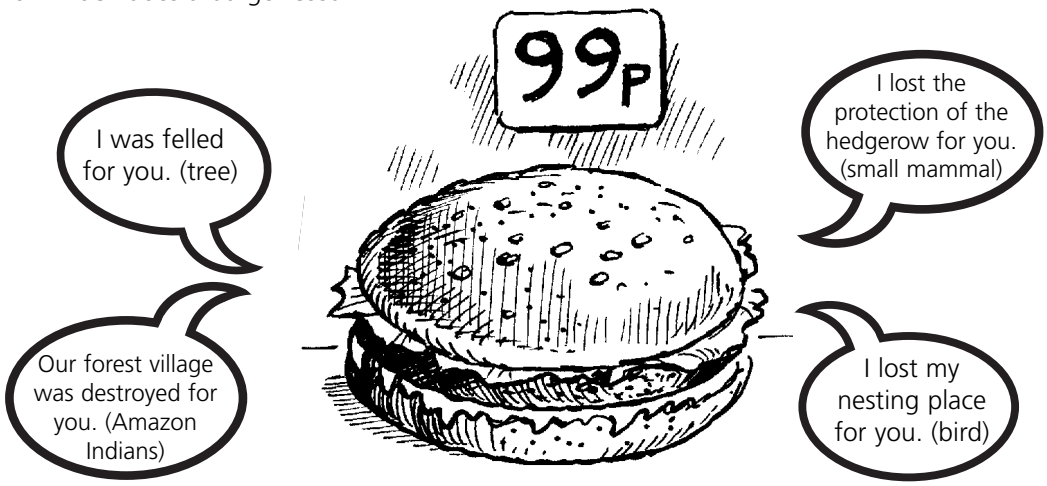
2 Changes in farming methods

Many years ago, farmers, although largely uneducated, understood something of these cycles and worked with them to grow their crops. Their methods were often supportive of wildlife, since they created new habitats such as hedgerows, meadows and farm ponds. After 1950, there was a shortage of food and a growing population, and farmers had to find new ways of producing more food. This led to the changes we have seen in farming since then, including a dependency on the chemical industry and machinery.

1. Why was there a food shortage and population increase in 1950?

2. What are the changes that have occurred on farms? Make a list, writing a sentence for each one. (Think about: field size, fertilisers, pesticides, woodlands, marshlands, machinery, etc.)

How much does a burger cost?



Did You Know?

Today, on average, an area of tropical rainforest the size of more than 10 football pitches is cleared every minute by bulldozing.

One reason for the destruction is to provide land for agriculture, including grazing land for animals. Some of this meat is sold to make millions of burgers every year in Britain and other countries.

3. A burger is both cheap and expensive. Explain this contradiction.

3 Organic Farming and Gardening

More and more people today think the destruction of rainforests is wasteful and unnecessary, and therefore a bad way to use our planet. Some of these people pay a lot of attention to the natural cycles of nutrients, use only natural materials and processes and so reject the use of fertilisers and pesticides when growing things. They are 'organic farmers', and these excerpts are taken from one of their books (*The Organic Garden* by Sue Strickland, Hamlyn, 1992):

"Chemicals are not only undesirable in a garden but completely unnecessary. However gardening without them is not just a case of throwing away the bottles and ordering a load of manure - though this would be a good start!"

"Organic gardening is much more than this. It involves an understanding of the garden as a whole - the soil, the weeds, and all the creatures that inhabit it, as well as the crops and ornamental plants ..."

"Much of the success of organic gardening relies on simple good gardening."

"One place in the garden that is teeming with unseen life is the soil. This is vital to organic gardening where it is the soil which feeds the plants rather than soluble chemicals directed at their roots. Most plant foods in the soil come from the return of waste organic matter, which is gradually being broken down by bacteria and fungi."

Using the paragraphs above:

1. Write out words or phrases that organic farmers would associate with 'bad gardening'.
2. Write out any words or phrases they would associate with 'good gardening'.
3. Write any words or phrases that speak of the 'whole picture' or the interdependence of the components of a garden.

4. Why would organic farmers consider the clearing of the rainforests to be 'bad farming'?
5. Construct a table of advantages and disadvantages of organic farming.
   (Think about costs, flavour, quality, labour, productivity and environment.)

6. Why don't all farmers engage in organic farming?

4 What do we mean by 'waste'?

"Egestion = the getting rid of waste products"

This is a definition found in Biology text books. It is common practice for them to use terms like 'waste products' or 'organic waste' for faeces or dead bodies.

Look up the word 'waste' in your dictionary and copy out 5 definitions.

If we think about what organic farmers say, it seems that 'waste' may not be a very good word to use.

Can you think of a better word?

A Jewish teacher once said:

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(*Ecclesiastes 3 v 20*)

A pile of dust is all that remains of a body when it has been cremated.

Is that all there is left of a person after they have died?

5 Nitrocycle

This is a game for three players.

Nitrocycle is about how humans are part of the nitrogen cycle and often do things which affect the amounts of nitrogen in the air, soil or the protein of living cells. The winner of this game, as in real life, is not the person to finish first, but the one who takes care of every part of the cycle keeping a balance of nitrogen in each part.

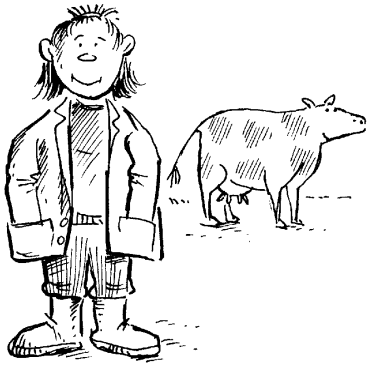
Object of the Game

- You must go right round the cycle once returning to your starting point with just 5 **Nitrotokens**.
- The winner is the person nearest to the finish point with the fewest penalty points, which are given for having too many or too few **Nitrotokens**.

Start of Play

- You need 3 players each with a counter to move round the cycle and each one starts the game cycle at a different place:

Crop Farmer enters at **Nitrogen in the Soil**



Dairy Farmer enters at **Nitrogen in Living Things**

Factory Owner enters at **Nitrogen in the Air**

- Each player has **5 Nitrotokens** (one penny coins) to start with, and the spares are placed in the centre of the board.
- Place 3 sets of **Nitrochange cards** face down on the hexagons outside the cycle.
- A die is tossed to decide who starts.
- You play by throwing the die and moving the right number of hexagons.
- When a player reaches home, the game stops and penalty points are awarded for the number of tokens above or below 5 and also for the number of squares away from home.

Special Hexagons

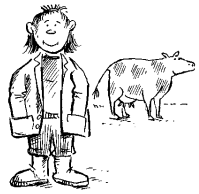
Nitrogen Exchange Hexagons (N)

When a player lands on these hexagons, **Nitrotokens** are exchanged between players according to the details of the **Nitrochange** cards. Another player takes a card, reads it to the first player, who must work out from the details on the card, who gives **Nitrotokens** to whom. If the first player gets it right, he/she can move on. If not, he/she waits for the next round to have another go.

Cooperation Hexagons (C)

These squares give players the opportunity to regain the balance of **5 Nitrotokens** in their hands. They can donate or remove any number of **Nitrotokens** to the centre of the Board.

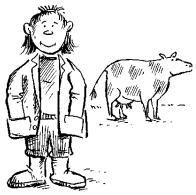
NITROCHANGE
Nitrogen in life protein



Farmer has a bonfire after pruning the trees in the orchard.

Air N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in life protein



Rodents of the forest succumb to virus and die in large numbers.

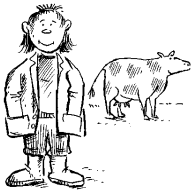
Soil N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in life protein

Compost heap is rotting well and supporting a multiplying population of bacteria and minibeasts.

No exchange

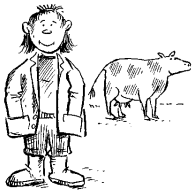
NITROCHANGE
Nitrogen in life protein



A field of clover has root nodules containing bacteria which use nitrogen in the air.

Protein N gains 1
Air N loses 1

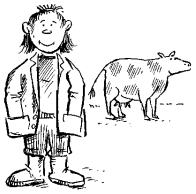
NITROCHANGE
Nitrogen in life protein



Rooks decide to build a rookery in the forest - droppings cover the forest floor.

Soil N gains 1
Protein N loses 1

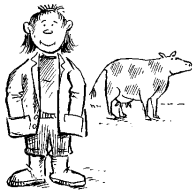
NITROCHANGE
Nitrogen in life protein



Fertiliser spread on fields gives good grass for the dairy herd.

Protein N gains 1
Soil N loses 1

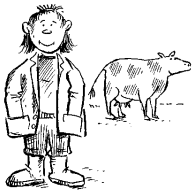
NITROCHANGE
Nitrogen in life protein



Day visitors to pick-your-own farm take home a good crop of strawberries for tea.

No exchange

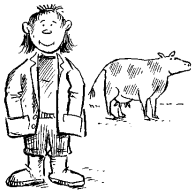
NITROCHANGE
Nitrogen in life protein



Field of pea plants have root nodules which contain bacteria which absorb nitrogen from the air.

Protein N gains 1
Air N loses 1

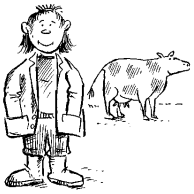
NITROCHANGE
Nitrogen in life protein



Most cars in the neighbourhood do not have catalytic converters.

No exchange

NITROCHANGE
Nitrogen in life protein



Nitrogen salts are leached out from soil, collect in a lake and algae multiply rapidly.

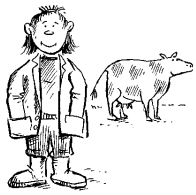
Protein N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in life protein

Wood from forest is used as fuel for pottery kilns.

Air N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in life protein



Deciduous trees drop their leaves which decay, putting nutrients into the soil.

Soil N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in soil

Good crop of wheat grown on the farm this year.

Protein N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in soil

Weather stormy - heavy rainfall and strong winds bring acid rain from industrial areas.

Soil N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in soil

Farm septic tank leaks into soil where bacteria decompose sewerage.

Soil N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in soil

Soil exhausted of nutrients - needs dressing with fertiliser.

Soil N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in soil

Soil bacteria break down nitrates in soil releasing nitrogen gas to the air.

Air N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in soil

Deposits of nitrogen salts are mined and used to make fireworks at the factory.

Air N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in soil

Apple harvest season - all the trees are laden with fruit.

Protein N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in soil

Farmer's family eat blackberry pie made from blackberries grown on the farm.

Protein N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in soil

High temperatures in lightning of thunder-storm cause nitrogen to oxidise. Rain washes nitrogen oxides down to soil.

Soil N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in soil

Blight destroys potato crop. Rotting potatoes decomposed by soil bacteria.

Soil N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in soil

Farmer's wife puts all vegetable peelings on compost heap which she later uses for enriching her garden.

Soil N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in soil

Farmer rotates the crops in his field, including clover in the cycle.

No exchange

NITROCHANGE
Nitrogen in air

A field of beans with root nodules containing bacteria use nitrogen in air.

Protein N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in air

Factory combines nitrogen with hydrogen under pressure to make ammonia for fertiliser.

Soil N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in air

Coal burning power station allows gases to escape from chimneys to the air.

Air N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in air

Acid rain is blown in from across the mountains and rains onto the farm soil.

Soil N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in air

Factory combines nitrogen with hydrogen to make ammonia for medicines.

Protein N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in air

Denitrifying bacteria change nitrates in soil into nitrogen gas which escapes to air.

Air N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in air

Thunderstorm lightning converts nitrogen gas into acids in rain which drain into soil.

Soil N gains 1
Air N loses 1

NITROCHANGE
Nitrogen in air

Much of the wildlife does not survive the severe winter. Bacteria decompose carcasses releasing some nitrogen to air.

Protein N loses 1
Air N gains 1

NITROCHANGE
Nitrogen in air

Explosions in mines release various nitrogen compounds to the air.

Air N gains 1
Soil N loses 1

NITROCHANGE
Nitrogen in air

Denitrifying bacteria in sewage works converts some nitrates into nitrogen gas which escapes into the air.

Air N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in air

Turnip crop fails - plants rot in the fields - bacteria decompose them and produce nitrogen into the air.

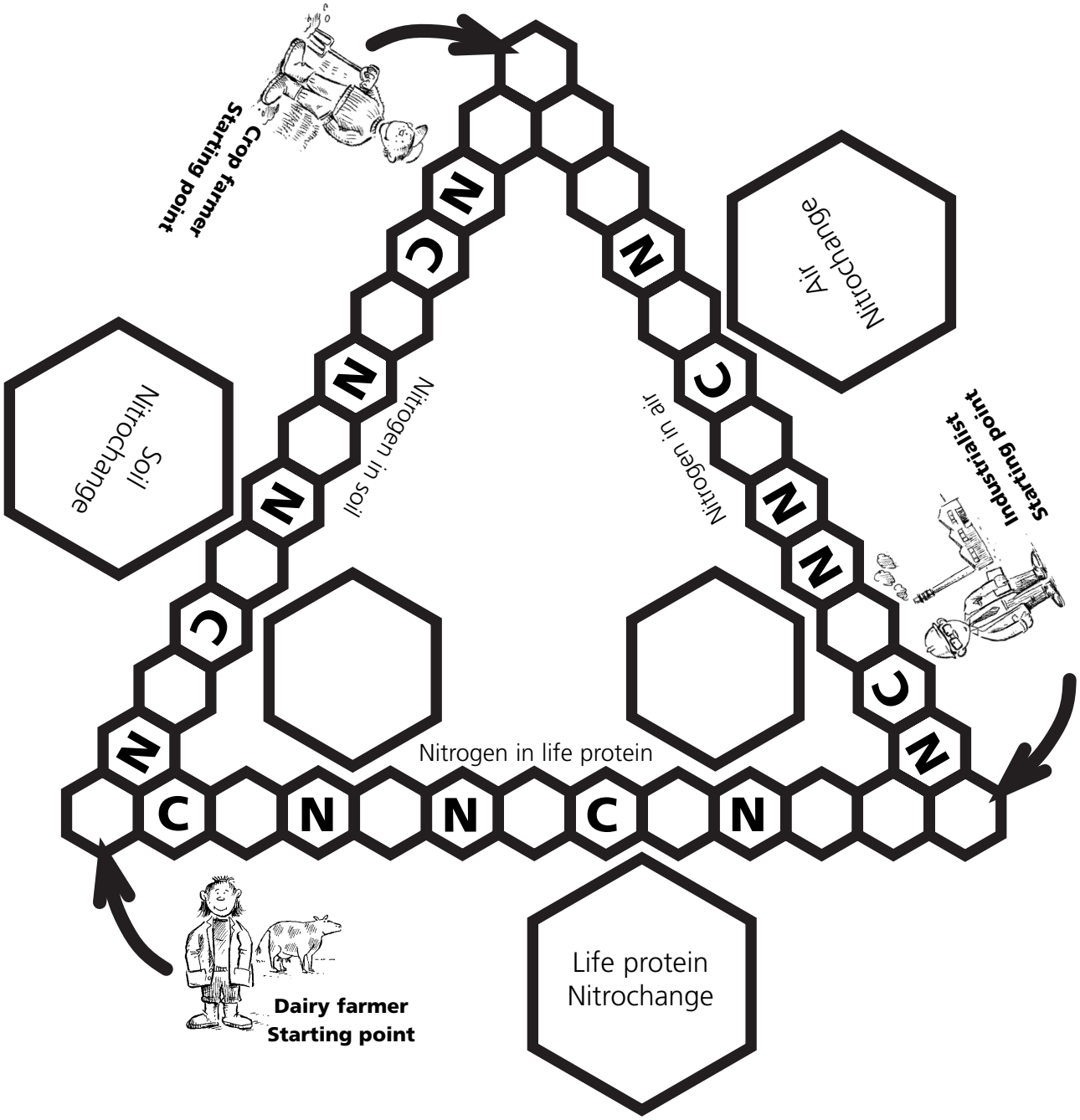
Air N gains 1
Protein N loses 1

NITROCHANGE
Nitrogen in air

Nitrifying bacteria in soil change ammonium compounds into nitrates.

No exchange

NITROCYCLE



NITROCYCLE