

## What am I made of?

### A comparison between the chemistry of the human body and the rest of the Earth

Introduce the names and main features of the Earth's four interacting spheres (diagram opposite):

- lithosphere\* (solid rock of the Earth's outer layers),
- atmosphere (the air),
- hydrosphere (oceans, seas, lakes, rivers),
- biosphere (all living organisms)

**Discuss** the following with the pupils:

(1) These spheres are all made of naturally occurring chemical elements in differing combinations and proportions, but

(2) the essential differences between each of these are due to their different chemical structures:

- lithosphere: ionic lattices,
- atmosphere: small molecules (low intermolecular forces),
- hydrosphere: small molecules with dissolved ions (relatively high intermolecular forces),
- biosphere: largely long-chain polymers.

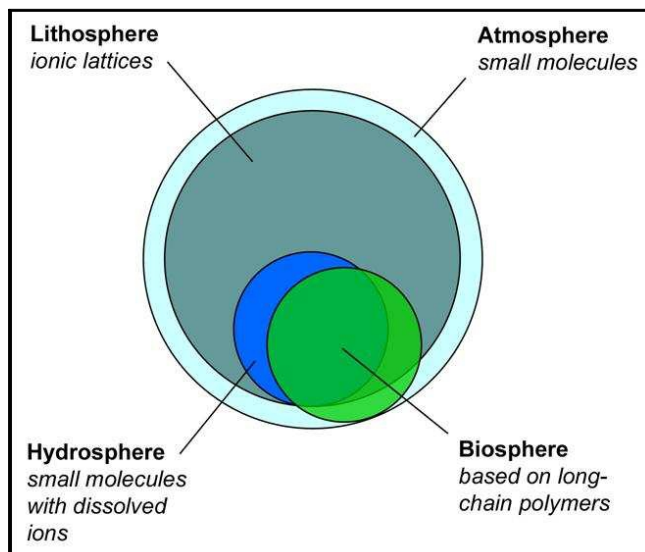
Interesting events take place at the interfaces between these spheres. They involve changes in chemical structure, usually because of chemical reactions, which move the chemical elements between the spheres. There is a continual cycling of elements through each sphere, a cycling which is essential to the existence of each sphere, especially the atmosphere, hydrosphere and, above all, the biosphere.

(3) The elements mostly occur as compounds combined with other elements, and not as separate elements (as shown in the puzzle and in the Tables).

**Organise the pupils** into small groups and supply each group with Table 1 (page 3), the jigsaw puzzle pieces (page 4). Table 2 (page 5) can be used as a follow-up activity, if appropriate.

**Ask the pupils to:**

- assemble the jigsaw puzzle. *Tell them before they start that there are four 'extra elements' which do not occur in the chemistry of a human being.*
- compare the list of chemical elements that make up a human being with those that make up the lithosphere as shown in Table 1. Using information written on the pieces of jigsaw puzzle, fill in the column 'Percentage in the human body'.
- complete the final column of the table by writing 'more' if the human body has a greater percentage of the element than the lithosphere, 'less' if it is lower or 'same' if it is about the same.
- discuss how similar is the composition of the human body to that of the Earth's lithosphere.



The four spheres Photo: Paul Grant

- Look at Table 2 (optional extension) and
  - decide, using Table 2, what are the differences and similarities between the chemical composition of the human body and its surroundings.
  - decide which the human body is most like; the lithosphere, atmosphere or hydrosphere.
- suggest how the compositions of the spheres are maintained.

*\*Note: The plate tectonic definition of lithosphere (the material that forms the rigid plates) includes the crust (5km to 80 km in thickness) and the upper part of the mantle. The lithosphere may be up to 300km in thickness but averages 100km thick. However, in this activity, the term 'lithosphere' is used in a general way to mean Earth's rocky sphere, comparing well with the terms atmosphere, hydrosphere and biosphere. Figures used in the lithosphere column in the Tables are for the composition of the crust alone. Figures for the composition of the lithosphere are not used because they are more uncertain and less familiar than those for the crust.*

## The back up

**Title:** What am I made of?

**Subtitle:** A comparison between the chemistry of the human body and the rest of the Earth

**Topic:** The chemical elements that make up a human body compared with those that make up the Earth.

**Age range of pupils:** 14 - 18 years

**Time needed to complete activity:** 20 minutes - maybe longer if Table 2 is used.

**Pupil learning outcomes:** Pupils can:

- realise that the four spheres on our planet are all made of the same chemical elements combined and mixed in different ways and with different chemical structures;
- realise that there is a continual cycling of elements through each sphere, a cycling which is essential to the existence of each sphere;
- understand that chemical reactions move chemical elements between the spheres;
- realise that matter is not lost or made but conserved;
- know the main elements making a human being;
- realise that these chemical elements combine together to form different types of compound which form bone, blood, tissue etc.
- understand that the human body is made of the same elements that make up the Earth, but in different proportions.

**Context:** Notes and possible answers to some of the questions asked of the pupils are as follows:-

- assemble the jigsaw puzzle, as shown on page 4. (*Note that Si, Al, Ti and Mn are 'extra' elements. These elements are present in the lithosphere, but not in the body.*)
- discuss how similar is the composition of the human body to that of the Earth's lithosphere. *The completed table (page 3) shows that, while some of the important elements in the human body and the Earth's lithosphere are the same, the human body contains some important elements that are rare in the Earth's lithosphere and vice versa.*
- decide, using Table 2, what are the differences and similarities between the chemical composition of the human body and its surroundings. *The results can be seen on the completed Table 1. Note that the human body contains much more carbon than the lithosphere.*
- decide which the human body is most like; the lithosphere, atmosphere or hydrosphere.

*None of these - it is a combination of all three.*

- suggest how the compositions of the spheres are maintained. *There has to be a continuous flow of each element into and out of the body. Therefore there has to be a cycling of each element from one or more of the other spheres, either directly or through food. It is useful to mention conservation of matter at some point, e.g. constant recycling of elements means that a carbon atom on the end of your nose could well have been in a dinosaur's big toe.*  
It is often poorly appreciated that the human body is made of the same 'stuff' (elements and their compounds) as the rest of the physical and biological world. Some pupils may not even appreciate that they are made of elements, and see themselves as being made of different materials from anything else in the world.

**Following up the activity:** Table 2 could be used as a follow-up activity.

**Underlying principles:**

- Earth's four spheres, lithosphere, atmosphere, hydrosphere and biosphere contain many of the same chemical elements but these elements are combined and mixed in different ways; the essential differences are because of their differing chemical structure.
- Changes in chemical structure, usually because of chemical reactions, move the chemical elements between spheres.
- Elements are continually cycling through and between the spheres.
- This cycling of elements is essential to the existence of each sphere, especially to the biosphere but also to the atmosphere and hydrosphere.
- The human body (part of the biosphere) is made of the same chemical elements as the other three spheres, although the elements are in different proportions.
- The properties of compounds are different from the properties of the elements they contain, e.g. the element sodium is highly reactive but this does not mean that its compounds will also be highly reactive.
- Matter is always conserved - never lost or made.

**Thinking skill development:**

By assembling the jigsaw puzzle and comparing the elements with those of the lithosphere, the pupils are establishing a pattern. Discussion leads to metacognition, whilst realisation that people are made of the same chemical elements as the rest of Earth can cause cognitive conflict.

**Resource list:**

- diagram showing the Earth's four spheres (lithosphere, atmosphere, hydrosphere, biosphere)
- jig-saw puzzle of the elemental composition of the human body copied on to card and cut into pieces
- copy of Table 1
- copy of Table 2 (optional).

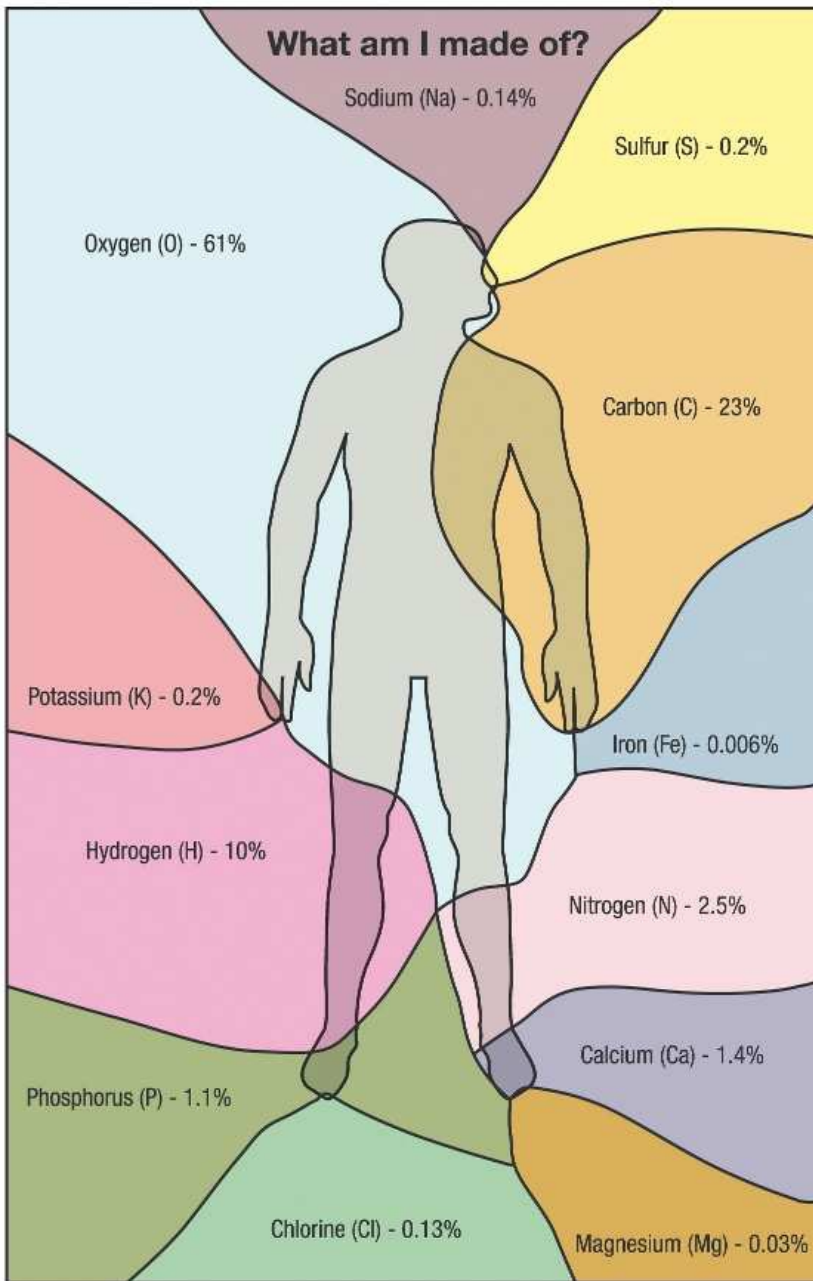
**Source:** Adapted by Elizabeth Devon from an activity in the Earth Science Education Unit's 'Chemistry of me at 16', Teaching KS4 Chemistry. <http://www.earthscienceeducation.com>

**Table 1**

Element	Percentage in the lithosphere	Percentage in the human body	The human body has 'more', 'less' or 'same' as the lithosphere
Oxygen	46.6		
Silicon	27.7		
Aluminium	8.1		
Iron	5.0		
Calcium	3.6		
Sodium	2.8		
Potassium	2.6		
Magnesium	2.1		
Titanium	0.6		
Hydrogen	0.1		
Phosphorus	0.1		
Manganese	0.1		
Sulfur	Less than 0.1		
Carbon	Less than 0.1		
Chlorine	Less than 0.1		
Nitrogen	Less than 0.1		

**Table 1 completed**

Element	Percentage in the lithosphere	Percentage in the human body	The human body has 'more', 'less' or 'same' as the lithosphere
Oxygen	46.6	61	more
Silicon	27.7	none	less
Aluminium	8.1	none	less
Iron	5.0	0.006	less
Calcium	3.6	1.4	less
Sodium	2.8	0.14	less
Potassium	2.6	0.2	less
Magnesium	2.1	0.03	less
Titanium	0.6	none	less
Hydrogen	0.1	10	more
Phosphorus	0.1	1.1	more
Manganese	0.1	none	less
Sulfur	Less than 0.1	0.2	more
Carbon	Less than 0.1	23	more
Chlorine	Less than 0.1	0.13	more
Nitrogen	Less than 0.1	2.5	more



*Jigsaw puzzle and Tables reproduced with permission from the Earth Science Education Unit Keele University*

**When this jigsaw puzzle has been correctly completed, the human outline shows the relative proportions of the major elements in the human body - so we have nearly a leg-full of hydrogen but only a nose of sulfur.**

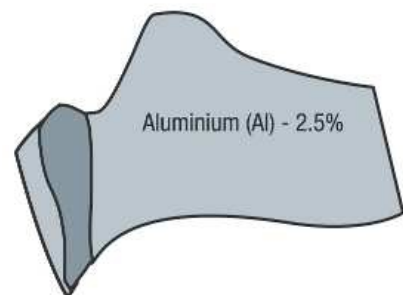
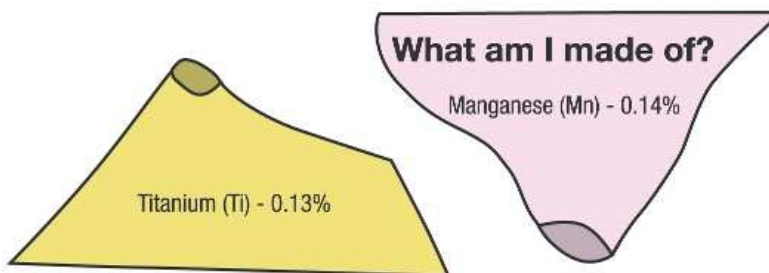
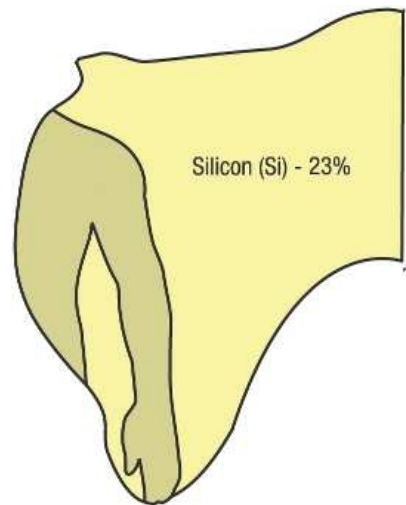


Table 2

Element	Atmosphere average %	Lithosphere average %	Hydrosphere average %	Human Body average %
Oxygen	21	46.6	86	61
Carbon	0.008	less than 0.1	a trace*	23
Hydrogen	Varies*	0.1	10.8	10
Nitrogen	78.03	less than 0.1	a trace#	2.5
Calcium	0	3.6	0.04	1.4
Phosphorous	0	0.1	a trace +	1.1
Potassium	0	2.6	0.04	0.2
Sulfur	0#	less than 0.1	0.08	0.2
Sodium	0	2.8	1.07	0.14
Chlorine	0	less than 0.1	1.92	0.13
Magnesium	0	2.1	0.13	0.03
Iron	0	5.0	0	0.006
Aluminium	0	8.1	0	0
Silicon	0	27.7	0	0
Titanium	0	0.6	0	0
Manganese	0	0.1	0	0
	* depending on whether air is damp or dry		* as carbonate ions	
	# unless sulfur dioxide present due to burning of fossil fuels		# as nitrate ions + as phosphate ions	

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