Do children have a holistic view of their internal body maps?

Anthony J. Cuthbert

A study of children aged 7 to 11 indicates little progression in their understanding of bodily systems

The requirements in the revised *National Curriculum for England: Science* (DfEE/QCA, 1999) for teaching the internal organs of the body have been drastically reduced in key stage 2 (ages 7–11). However, children still need to be taught about the functioning of the cardiovascular system, skeleton and muscles. What kind of ideas will the children bring to our lessons and how will these ideas affect their learning of the accepted scientific understanding of the human body map?

Several American studies have shown that children as young as 10 have a fairly good idea of their internal body map (Gellert, 1962; Porter, 1974; Mintzes, 1984; Arnaudin and Mintzes, 1985, 1986). Children in these studies included many different organs and internal structures when asked to draw an internal body map. The organs and structures commonly included were brain, heart, stomach, muscles, bones, lungs, kidneys, and veins. The drawings of these organs often had common characteristics such as the position, size, shape and function. For example, the majority of children drew a playing-card heart shape for the heart and placed it on the left-hand side of the body. This 'valentine heart' is a common symbol in our culture and is seen in valentine cards, sweets and cartoons. It is not surprising that children draw this shape rather than the more complicated shape of a real heart.

Arnaudin and Mintzes (1986) found that many children draw the trachea to the heart and a system of tubes to take air around the body. This is something that I did not find in my preliminary study of 30 year 4 children (aged 8–9) but when the study was widened to 348 children I found a number of different naïve cardiovascular, respiratory and digestive system models.

Osborne, Wadsworth and Black (1992; 29–33) found that few children had a clear idea of how food passes through the body and waste is eliminated, while Tunnicliffe and Reiss (1999) found a similar lack of understanding of the integration of the skeletal system. Both these studies assessed the children's knowledge by analysis of drawings. Tunnicliffe and Reiss make the point that drawings are not necessarily a superior way of assessing children's understanding but they are an effective way of obtaining data with meagre resources within a reasonable time.

Do children see their body maps as integrated systems and how can their models inform our teaching? These are the questions I set out to investigate through two school-based studies carried out in a junior school within a fairly prosperous area of a West Midlands industrial town. In 1999, 95% of the children obtained level 4 or above in their science SAT while 34% obtained level 5.

ABSTRACT

An initial school-based study of 30 year 4 (8–9 year-old) children's views of their internal body maps indicated that the majority of children did not connect tubes and organs in their drawings. A larger study of 348 year 3 to year 6 (7–11 year-old) children confirmed that the majority of children drew relatively small, unconnected and freely suspended organs. The minority of children who did connect tubes and organs used a variety of respiratory, cardiovascular and digestive system models with characteristic features seen throughout the age range.

Preliminary study

A preliminary analysis of 30 year 4 (8–9 year-old) children's drawings, in April 1997, seemed to produce similar results to those of Osborne *et al.* (1992). The children were given an outline of the human body and asked to draw and label what they thought was inside their bodies. There was no intervention by the teacher and the drawing of the body map did not seem to pose a problem for any of the children. The organs most commonly seen in these drawings were heart (97%), brain (93%), arm bones (93%), leg bones (87%), lungs (80%), intestines (60%), ribs (47%), spine (47%), bladder (40%) and stomach (37%). The majority of the children did not connect tubes to organs of their body maps, even though 30% of them included trachea and oesophagus. Few of the children showed any indication that they knew where tubes went in their bodies. Only 13% of the children connected the windpipe to the lungs and 13% (not necessarily the same children) connected the food pipe to the stomach. None of these children connected trachea to the heart.

'Valentine hearts' were drawn by 37% of the children, and although 27% of the children included veins none of them connected them to the heart.

Many of the children had problems with the size, shape and position of organs. Most organs were drawn small and freely suspended within the body cavity. When asked what was in the space around the organs the children responded with blood, air or nothing. When their attention was drawn to a plastic model and to the fact that its organs filled all the body cavity this

Table 1 Percentage of children including various organs in their drawings (main study).

Organ	*Year 3 (n = 82) /%*	*Year 4 (n = 90) /%*	*Year 5 (n = 87) /%*	*Year 6 (n = 89) /%*
Brain	100	92	69	90
Heart	81	92	100	96
Arm bones	37	36	6	17
Leg bones	33	40	7	24
Ribs	28	41	26	47
Veins	22	42	30	20
Oesophagus	21	16	29	9
Lungs	20	38	91	75
Muscles	18	17	53	18
Stomach	16	42	49	62
Skull	16	11	10	9
Trachea	13	20	35	36
Kidneys	5	20	56	67
Intestines	5	19	40	65
Spine	5	14	1	19
Liver	4	13	46	60
Pulse	1	2	3	3
Bladder	0	8	23	52
Womb	0	0	0	6
Nerves	0	4	0	6
Ovaries	0	0	0	5
Gall bladder	0	0	0	1
Pancreas	0	0	0	1
Appendix	0	2	0	0
Tonsils	0	0	6	0
Voice box/Adam's apple	0	2	13	9
Free floating and unconnected	71	68	66	71

did not seem to worry them. They did not alter the size of their organs, but rather drew in missing organs, still leaving spaces. Some of the children drew horizontal bones in the legs and arms and one of the children drew a horizontal trachea.

Although the children found it difficult to place the organs correctly in their body map, thoracic organs such as lungs and heart were usually placed above abdominal organs such as intestines, kidneys and bladder. The children found the positioning of the liver and stomach a little more problematic.

The sample size of the preliminary study was small (n = 30) so a larger sample (n = 348) was used in the second study.

Methodology of the main study

For the main study all the year 3–6 children (ages 7–11) who were in school on the day of the study were sampled (n = 348). The main concern of this study was to look at the holistic integration of vessels, tubes and organs. The children were again each asked to draw what they thought was inside their body and to label their drawings. They were given an outline of the human body, pencils and rubbers. There was no other intervention by the teachers.

Analysis of the drawings

The majority of the children (69%) drew organs that were relatively small, unconnected and freely suspended in the body cavity (Table 1). Several year 3 children drew arms or legs filled with the colour red and labelled blood. Together with evidence from the preliminary study this may indicate that some children believe organs are free floating in a medium of blood.

There was some evidence that language is important for the children's understanding of their body maps. Some of the year 3 and 4 children drew a rib cage as a cage of horizontal and vertical bones (Figure 1). Several children drew the Adam's apple in the shape of an apple and the voice box as a square (Figures 1 and 2). Two or three children in all year groups seemed to think that the pulse was an organ and drew it as a circular organ in the wrist or the neck (Figure 2).

Respiratory system models

Relatively few children included the trachea in their body and even fewer connected it to the lungs (Y3 6%, Y4 6%, Y5 14%, Y6 27% – Table 2). The children who included a connected trachea used several

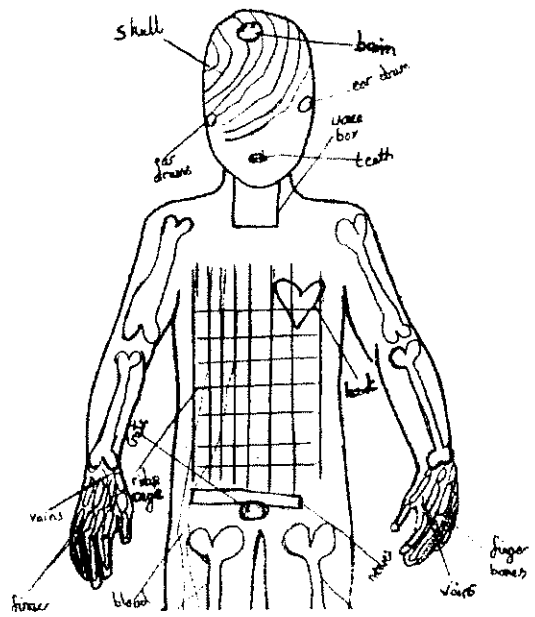

Figure 1 This year 4 child has drawn a square voice box and a rib 'cage'.

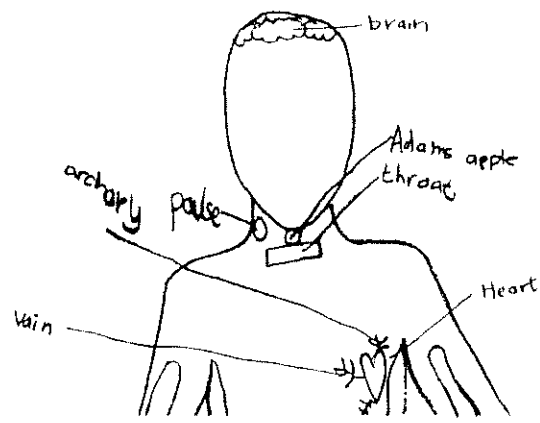

Figure 2 An organ called the pulse is placed in the neck by this year 5 child.

different respiratory models and these models had similarities in each year group. The most naïve respiratory system models were seen primarily, although not exclusively, in year 3 and included drawings of either one or two tubes labelled lungs. These tubes pass from the head, rather than the mouth, into the body cavity, some terminating in the thorax and others in the abdomen. A similar model involved two tubes leaving the head terminating in bag-like organs labelled lungs.

Table 2 Percentage of children connecting internal organs (main study).

	Year 3 (n = 82)/%	*Year 4 (n = 90)/%*	*Year 5 (n = 87)/%*	*Year 6 (n = 89)/%*
Respiratory system				
Trachea connected to lungs	6	6	14	27
Two tubes from head to lungs	6	1	8	1
Trachea connected to heart	5	9	9	1
Unconnected dumb-bell lungs	5	6	14	3
Digestive system				
Oesophagus connected to stomach	9	12	17	8
Oesophagus connected to stomach via lungs	0	2	8	1
Stomach connected to intestines	0	0	10	4
Intestines connected to anus	4	3	14	7
Complete flow through	0	0	2	3
Urinary system				
Kidneys connected to bladder	0	0	1	3
Nervous system				
Nerves connected to brain	0	4	0	2

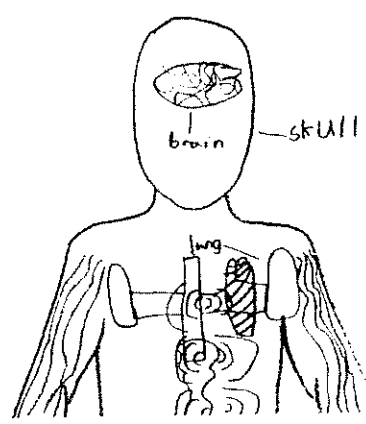

Figure 3 A typical year 3 'valentine heart' placed on the left-hand horizontal tube from the unconnected trachea.

In some of the children's models the trachea is not connected to the head but has two arms that pass to the lungs, giving a dumb-bell shape (Figure 3). Other pictures (Y3 5%, Y4 6%, Y5 14%, Y6 3%) included unconnected dumb-bell shaped lungs usually placed in the thorax (Figure 4).

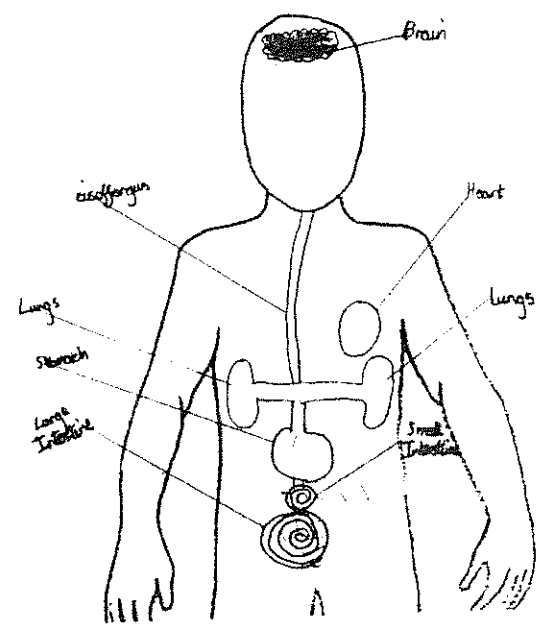

Figure 4 A year 5 picture showing dumb-bell lungs.

Cardiovascular system models

In some of the children's drawings the heart is placed on the left-hand side of the dumb-bell as in Figure 3 or nested in the left-hand lung. Other models had either

one or two tubes drawn from the head to the heart (Y3 5%, Y4 9%, Y5 9%, Y6 1%) (Figure 5). A third model involves two tracheae terminating in lungs but having a tube leaving one of the tracheae passing to the heart. This evidence seems to support the finding of Arnaudin and Mintzes (1986) that some children think the trachea is connected to the heart.

Most children included a heart in their pictures (Y3 81%, Y4 92%, Y5 100%, Y6 96%) and most put it on the left-hand side and in the thorax (Table 3). The majority of the left-hand hearts were 'valentine hearts', particularly in the earlier year groups. Virtually all the hearts that were drawn on the right-hand side of the body were 'valentine hearts'. The children who drew the heart in the middle of the thorax were just as likely to draw a 'valentine heart' in years 3 and 4, whereas in years 5 and 6 more children drew oval hearts. Overall, 47% of all the children drew a 'valentine heart'.

Only a few children connected veins to the heart (Y3 4%, Y4 5%, Y5 15%, Y6 5%) and only 5% of all the children showed any evidence of arteries being connected to veins in a circulatory system.

Digestive system models

In some of the children's models, it was very difficult to separate the respiratory, digestive and cardiovascular systems. The children seem to integrate them into a single system depending on the internal body-map model they have developed.

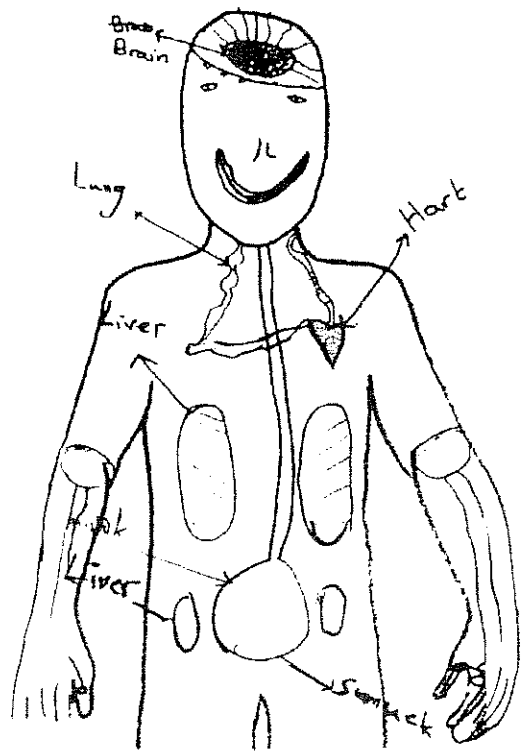

Figure 5 An example of the trachea-to-the-heart model from year 4.

Table 3 Percentage of children including various types of heart and cardiovascular connections in their drawings (main study).

	Year 3 (n = 82)/%	*Year 4* (n = 90)/%	*Year 5* (n = 87)/%	*Year 6* (n = 89)/%
Heart present	81	92	100	96
'Valentine heart'	71	62	41	18
Heart on left-hand side	42	51	68	49
'Valentine heart' on left-hand side	34	28	29	10
Other-shaped heart on left-hand side	7	23	39	39
Heart on right-hand side	15	15	3	12
'Valentine heart' on right-hand side	15	14	3	5
Other-shaped heart on right-hand side	0	1	0	8
Heart in middle	24	28	29	34
'Valentine heart' in middle	22	20	9	3
Other-shaped heart in middle	2	8	20	30
Veins connected to heart	4	5	15	5
Veins connected to arteries	1	5	13	3

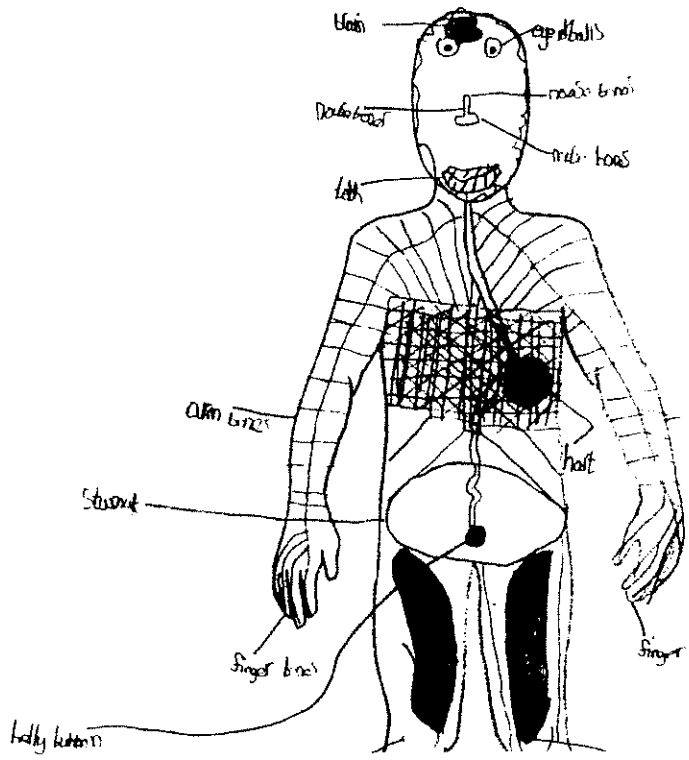

Figure 6 A year 4 child's drawing showing a tube from the head to the heart and a tube from the heart to the stomach.

The simplest model of the digestive system included an oesophagus, usually labelled food pipe, terminating in a circular shaped or lollipop stomach, with no outflow tube (Figure 5).

Another integrated hypothesis involved one tube passing to the heart and/or lungs and then to a lollipop stomach (Figure 6). Typically, there is no exit tube from the stomach. In some of the most complex models, children combine the dumb-bell lung, lollipop stomach and the trachea-to-the-heart hypothesis.

Very few of the children have an outflow tube from the stomach to the intestines, the largest number (10%) being in year 5 (Table 2). Slightly more children connect the intestines to the anus. Only year 5 (2%) children and year 6 (3%) children showed complete flow through the digestive system (Figure 7).

Other systems in the body

Many children include the kidneys and the bladder but, as might be expected at this age, these are rarely connected. Only one child in year 5 and three in year 6 connected the bladder and kidneys correctly.

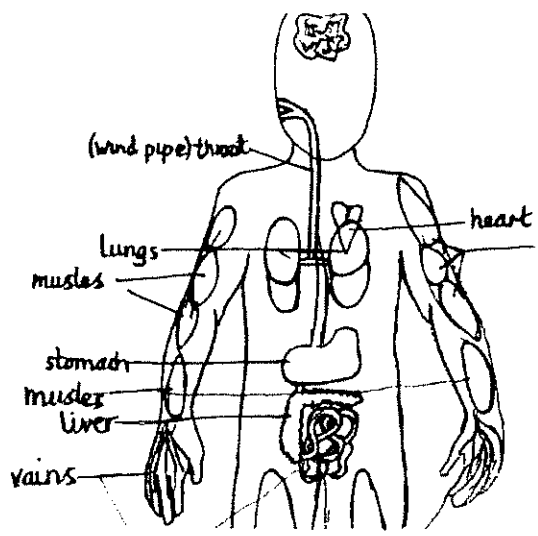

Figure 7 A year 6 drawing showing complete flow through the digestive system.

A large number of children included various bones in their bodies and placed them more or less in their correct positions. Many children used a stylised 'dog bone' shape (Figure 1). The children who drew bones did not include ligaments and there was no indication of how bones are joined. Free-floating organs labelled muscles were included by some (Y3 18%, Y4 17%, Y5 53%, Y6 18%) but they were not seen attached to bones in any of the children's drawings and there were no tendons present (Figure 7).

The majority of the children drew brains in their body maps but very few included nerves (Y3 0%, Y4 4%, Y5 0%, Y6 6%). Only 4% in year 4 and 2% in year 6 connected nerves to the brain in any way. Several children drew eyes and ears connected to the brain.

The only children to include any organs of the reproductive system were in year 6 and were all girls. Although uterus (6%) and ovaries (5%) were included, none of the girls included a fallopian tube.

Discussion

The most noticeable and common characteristics of the children's drawings were isolated, free-floating and unconnected organs. This model is still prevalent in year 6 and will be taken with them into secondary education. There was little evidence that these children knew how food passed through the body or how the respiratory system worked.

While veins and heart were common items in the children's drawings very few of the children connected them or indicated that they knew how the heart helps to circulate the blood. The problems that this raises, particularly those of explaining how the blood circulates around the body, are not easily resolved. Children drew unconnected veins particularly where they can be seen in the wrist area of their arms (Figure 7). Most of the children labelled their blood vessels as veins and very few included blood vessels labelled arteries. If we expect that looking at the veins in the wrist would enable the children to generalise a circulatory system involving closed vessels connected to a pumping heart then we are being optimistic, particularly when some of the children think that the pulse is a pumping organ and others think that blood fills the cavities between organs. There is little evidence that many of the children understand a cardiovascular system in terms of blood being confined in vessels that extend from the heart to the organs and then return.

As Tunnicliffe and Reiss (1999) found, while many of the children included bones in their drawings, there was little evidence that they knew about the connections of ligaments, tendons and muscles and how these integrate with the bones to cause movement. There also seems to be a lamentable lack of knowledge about the reproductive system, even in year 6.

Evidence from the first study leads me to believe that plastic models of the internal organs are not much help in developing understanding of the body map. Wall charts and pictures would seem to have even less impact. Tabards with attachable cloth body parts are popular but they may reinforce the children's floating-organ model. Educational television programmes, which include footage of real organs inside people, may help with the children's understanding.

The concepts involved in understanding the internal body map are of necessity abstract because the children cannot see inside their bodies. They have to take the evidence that is available and use it to make the best guesses about how things are connected. This study indicates that the majority of children do not see the body as an integrated connected system. The integrated models that are developed by the minority of children can be quite sophisticated but rarely reflect a textbook body map (less than 1% in this study).

To some extent, the development of the children's models is based on the everyday language used in explanations; the terms rib cage, Adam's apple and voice box, and the common use of symbols such as the 'valentine heart' and the stylised 'dog bone'.

The children's models do not display smooth development from simple to complex depending on the age of the children. The learning seeming to be non-linear and chaotic, with some year 3 children producing relatively advanced models whilst many in year 6 are still using the floating-organ model. The purpose of studies like this is to observe the children's understanding and not to provide data to support spurious ideas about the developmental progress of children's learning. This study does not produce any evidence of a progressive understanding of the body map or any noticeable difference between the boys' and girls' body maps.

These initial models, developed while the children are very young, seem to be tenacious and difficult to change. If we can intervene at an early stage, probably in years 3 and 4, a more scientifically acceptable model of the internal body map could be developed and this may prevent the development of misconceptions that get in the way of further scientific learning.

References

Arnaudin, M. W. and Mintzes, J. J. (1985) Students' alternative conceptions of the circulatory system: a cross-age study. *Science Education*, **69**, 721–733.

Arnaudin, M. W. and Mintzes, J. J. (1986) The cardiovascular system: children's conceptions and misconceptions. *Science and Children*, **23**, 48–51.

DfEE/QCA (1999) *The National Curriculum for England: Science*. London: Department for Education and Employment/Qualifications and Curriculum Authority.

Gellert, E. (1962) Children's conception of the content and functions of the human body. *Genetic Psychology Monographs*, **65**, 293–405.

Mintzes, J. J. (1984) Naive theories in biology: children's concepts of the human body. *School Science and Mathematics*, **84**, 548–555.

Osborne, J., Wadsworth, P. and Black, P. (1992) *Primary SPACE research reports: Processes of life*. Liverpool: Liverpool University Press.

Porter, C. (1974) Grade school children's perceptions of their internal body parts. *Nursing Research*, **23**, 384–391.

Tunnicliffe, S. D. and Reiss, M. J. (1999) Students' understandings about animal skeletons. *International Journal of Science Education*, **21**, 1187–1202.

Tony Cuthbert is a year 4 class teacher and science coordinator at Uplands Junior School in Wolverhampton. E-mail: tony.cuthbert@talk21.com