

# Chapter 7

## Natural Sciences



### 7.1 Physics, Elementary School

We have chosen a section dealing with the “the celestial bodies in the solar system, and their movements in relation to each other” as an example of a text in science for elementary school (students aged around 10 to 12 years). This particular text deals with how to explain day, night, months, years, and seasons, which is a central content area for Swedish school children of this age. Here we will make a close reading of a couple of pages in the textbook *PULSFysik och Kemi* (Sjöberg and Öberg 2011) (Eng. “Physics and Chemistry”), and a chapter called “Astronomi—ett himla stort ämne” (approximate translation into English to preserve a wordplay: “Astronomy—a subject full of space”).

To start with, we can conclude that to be able to grasp this content, the student must have an abstract understanding of the celestial bodies that we can experience in a concrete way in our everyday lives (the earth, the moon, and the sun). Therefore, in the close reading of this text, we will mainly concentrate on the *general structure and setting* and *the interaction between parts of the text*. We will, however, also comment briefly on figurative language presented in writing, since metaphors are central for science.

#### 7.1.1 General Structure and Setting

Together, the images in Figs. 7.1 and 7.2 constitute an introductory book spread of the chapter. As regards the setting of the spread, we may note that the pages consist of a variety of text resources (various headings, an introductory paragraph, running text, etc.). The illustrations, comprising a photograph and some drawings, are prominent, and they take up a large part of the book pages. The drawings show, on the one hand, children (they reappear in the whole textbook, as interested experiencers, thinkers, etc.), on the other hand schematic images of the movements of celestial bodies.



**ASTRONOMY** – a subject full of space

Since ancient times, we have used the stars, the sun and the moon to keep track of the time. The sun rises in the morning, moves across the sky during the day, and sets at night. In this chapter, we will take a closer look at how the sun, the earth, and the moon move in relation to each other, why we get day and night, and how different seasons arise. We will also become familiar with other parts of the solar system.

(approximate translation of the bolded introductory paragraph)

**Fig. 7.1** Astronomy, elementary school. *PULS. Fysik och kemi 4–6 grundbok* (Sjöberg and Öberg 2011, p. 90, illustrations by Jenny Karlsson; re-printed with permission from Natur & Kultur)

Even from a quick description like this, it is evident that these are quite typical book pages considering the subject and the intended readers. We can also note that illustrations appear to be important, both for illustrating the subject-specific content, such as the drawings of day and night on the earth, and for alleviating the visual appearance (the children who are given various roles, at the same time as the readers can identify themselves as becoming scientists through them).

The chapter is structured *thematically*, in ways that give the reader an overview of the content, stated in the introductory paragraph in bold. Here, the point of departure is the reader's presumed everyday experiences of sunrise and sunset. Also, it gives a historical perspective, informing the reader that humans through history have used the celestial bodies to keep track of time. Such a historical perspective reappears in parallel to the scientific content all through the chapter. In Swedish curriculum documents, it is commonly stated that all subjects should give a historical perspective to the content area in question. The scientific content in this book spread describes how the earth is rotating around its axis, and how this rotation regulates day and night.

## Jorden snurrar runt

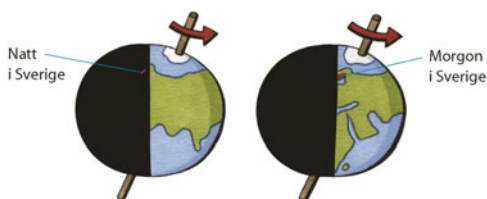
Det var Nicolaus Copernicus (1473–1543) från Polen som först föreslog att jorden rörde sig runt solen i stället för tvärtom. Det var ett djävrt förslag eftersom det inte stämde med kyrkans läror.

Solen ser ut att röra sig över himlen. Men i själva verket är det inte solen utan jorden som rör sig. Den snurrar runt, och eftersom vi står på den snurrande jordens yta, ser solen ut att röra sig. Och det gäller inte bara solen. Under natten tycks månen och hela stjärnhimlen röra sig på samma sätt.

Jorden roterar ett varv runt sin egen axel på ett dygn.

Vi kan tänka oss jordens axel som en lång pinne från Nordpolen till Sydpolen.

Bilderna visar hur jordens vridning gör att vi får natt och dag.



Var vi än är på jordytan rör vi oss åt öster. När platsen där vi är kommer ut ur skuggan ser vi hur solen går upp. Det blir ljus. Men så småningom kommer vi in i skuggan igen. Då går solen ner och det blir natt.

### Olika slags tid

Ju längre österut du befinner dig, desto senare på dagen har det hunnit bli. Du vet säkert att klockan kan vara olika mycket i olika länder. Men även inom Sverige märks det skillnad. Solen går upp lite tidigare i Stockholm än i Göteborg.

I mitten av 1800-talet började man använda ångbåtar och tåg och behövde därför trycka tidtabeller. Då var det opraktiskt att ha olika tid i olika delar av landet. År 1879 införde man därför normaltid, som är lika i hela Sverige.



### Sommartid

Sommartid innebär att vi ställer fram klockan en timme under sommarhalvåret. På så sätt kan vi få njuta av en extra timme dagsljus på kvällen.

**Fig. 7.2** The earth is spinning around. *PULS. Fysik och kemi 4–6 grundbok* (Sjöberg and Öberg 2011, 91, illustrations by Jenny Karlsson; re-printed with permission from Natur & Kultur)

## 7.1.2 Interaction Between Text Resources

Regarding the interaction between the different parts of the text, a number of aspects are worth focusing on, not least in relation to *spatial proximity and coherence* between different types of written texts (text boxes, headings, captions, etc.) and other textual representations. The illustrations on the first page are only loosely connected to the

introductory paragraph and the running text. The only clear connection between the resources on that page is the one between information in the introductory paragraph and the drawing of a squatting girl looking at a sundial. For a reader with no previous experience of sundials, this connection might not be clear.

On the introductory page, there is also a caption, placed between the two illustrations: “The earth and the moon move around the sun. When the moon comes in between the sun and the earth, there is a solar eclipse. Here we can see the shadow of the moon as a dark patch on the earth.” There is no indication as to what illustration the caption refers to. For several reasons, it is possible that the “novice” will interpret the caption as part of the illustration of the sundial and the girl. First, that illustration is prominent, as regards placement, colors, and composition, while the section from the satellite image is diffuse and may be difficult to interpret. In the first sentence of the caption, three elements are mentioned. For the novice who is not yet familiar with the content, these three elements can be connected to three prominent parts of the illustration with the child and the sundial, namely, the sun, the child, and the sundial. To be able to read three elements into the section of the satellite image, the reader must imagine both the moon and the sun, and also their placement in relation to each other. The part of the text in the caption that says “Here we can see the shadow of the moon as a dark patch on the earth” (p. 90) clarifies that the text relates to the satellite image, and it is also clarified that the image depicts the earth. It is worth noting that the caption contains information about how solar eclipses arise, though this is not mentioned anywhere else in the chapter.

As said, the diffuse section of the satellite image can be challenging to interpret. However, using a photograph, which in this case is intended to show a solar eclipse, is an opportunity to depict a phenomenon which could be hard to grasp otherwise (the fact that the moon casts a shadow on the earth when placed between the sun and the earth). If the caption had been more explicit about the fact that the image was in fact a satellite image of the earth seen from far away, this could have supported the student trying to interpret the image.

The next page deals with the earth’s rotation around its axis. Here the illustration has a concretizing function, where day and night are represented by two globes. Combined with the two stylized globes is an analogy that the earth rotates around an imaginary axis. In this case, the rotation around the axis is concretized through a stick supplemented with a curved arrow pointing in the direction of the rotation. Through this illustration, the student is supposed to imagine that the two stylized globes represent the earth at two different times, but also that the stick does not represent a concrete physical phenomenon. Instead, the reader is supposed to understand that the stick has been added as a way of visualizing the tilt of the earth in relation to the sun, as well as the way in which the earth rotates. Thus, the reader is supposed to not to take the stick into account as a real object. Another complication is the fact that the tilt of the earth is not real—there is no up and down in the infinite space to relate to. Instead this tilt concerns the relation between the earth and the sun, which, by the way, is not present in the illustration.

The *congruence* between the information given in writing and that given in illustrations is more apparent than on the previous page. First, in the running text there is

an explicit connection to the illustration through the words “The images show how the rotation of the earth gives us night and day” (approximate translation, p. 91). Second, in writing, too, the analogy between the axis of the earth and that of the stick going from the North Pole and the South Pole is made explicit.

Apart from the assumption that the tilt of the earth should be seen in relation to the sun, there are other potential challenges both in illustrations and writing, and in the relationship between them. Here we will comment on a couple of such challenges. In the illustration there is a slightly curved arrow, a conventionalized symbol to depict a direction or movement.<sup>1</sup> The arrow points towards the right and is therefore intended to show the direction of the rotation of the earth. In this case, the reader is supposed to make the connection between the arrow and a comment in the caption that we always are moving towards the east, as well as information in the running text about “the twist of the earth” (Sw. *jordens vridning*). The caption also says that we are either in or outside of the “shadow” (Sw. *skuggan*). How this shadow emerges is not made explicit, however, neither in writing nor in the illustration. Instead, the reader must imagine the sun and its position in relation to the earth. Furthermore, the reader is supposed to understand that the illustration is not supposed to depict two different globes, but instead that it is supposed to depict the earth at different points of time.

On the same page, there is also a toned text box. Text boxes are often used as a kind of “short facts” in pedagogical texts where the reader can expect to find key content. Here, however, the text box gives some “extra information”. In this case the information deals with summer- and winter-time, which is used in large parts of the world, although this fact is not taken up in illustrations or in the running text.

### 7.1.3 *Figurative Language*

We have mentioned the use of an analogy between the axis (in itself a figurative description) of the earth and a stick through the globe. Here the authors have chosen to integrate the analogy in both the running text and the illustration. The choice to actually draw the analogical axis could be seen as a way of concretizing natural phenomena in science, to facilitate learning. In this case, in writing it is clearly expressed, through an explicit simile, that this is an analogy “we can think of [...] as a stick”, while in the illustration the depiction of the stick is integrated as a natural part of the earth.

It may be doubted whether the fact that the axis of the earth specified as a stick actually facilitates meaning-making related to the analogy. Instead, it is possible that the illustration makes the analogy more challenging, since it is unnecessarily concrete. Yet the fact that the analogy is explicitly explained in writing may be assumed to facilitate meaning-making for the student. The risk of coming to the wrong conclusion, that there is actually some kind of stick going through the globe, will then be diminished.

---

<sup>1</sup>Among other things, an arrow can also depict a process, such as the transformation from one thing to another, or a temporal relationship between entities.

The conventionalized use of “axis”—a metaphor which is integrated in scientific discourse—is less clear in the text. There is in fact no axis, but instead the term is used *as if* there was an axis going from one pole to another. Yet another complication is that in Swedish the word axis is homonymous with the word for shoulder (Sw. *axel*). In a Swedish context, it is likely that children of this age are only familiar with the word *axel* as part of the body. This is an example of how subject-specific terminology with another use in everyday language can be a challenge for meaning-making around subject content. It is especially important to be aware of such challenges regarding students who learn in a second or foreign language.

### 7.1.4 Classroom Focus

From an educational point of view, a number of aspects in this text are worth devoting attention to in the classroom. Already the general structure of the layout and the graphical choices open up for things to discuss in the classroom, in ways that can function as a model for how to approach new texts. A starting point can be a mutual examination of illustrations and text elements on the pages. In relation to such a general overview, the teacher can point to the usefulness of benefiting from one’s previous ideas and knowledge about text resources such as introductory paragraphs, headings, text boxes, illustrations, or captions. It may be worth noting that such textual resources can be used in similar ways across texts, but also that they can have different functions in different texts.

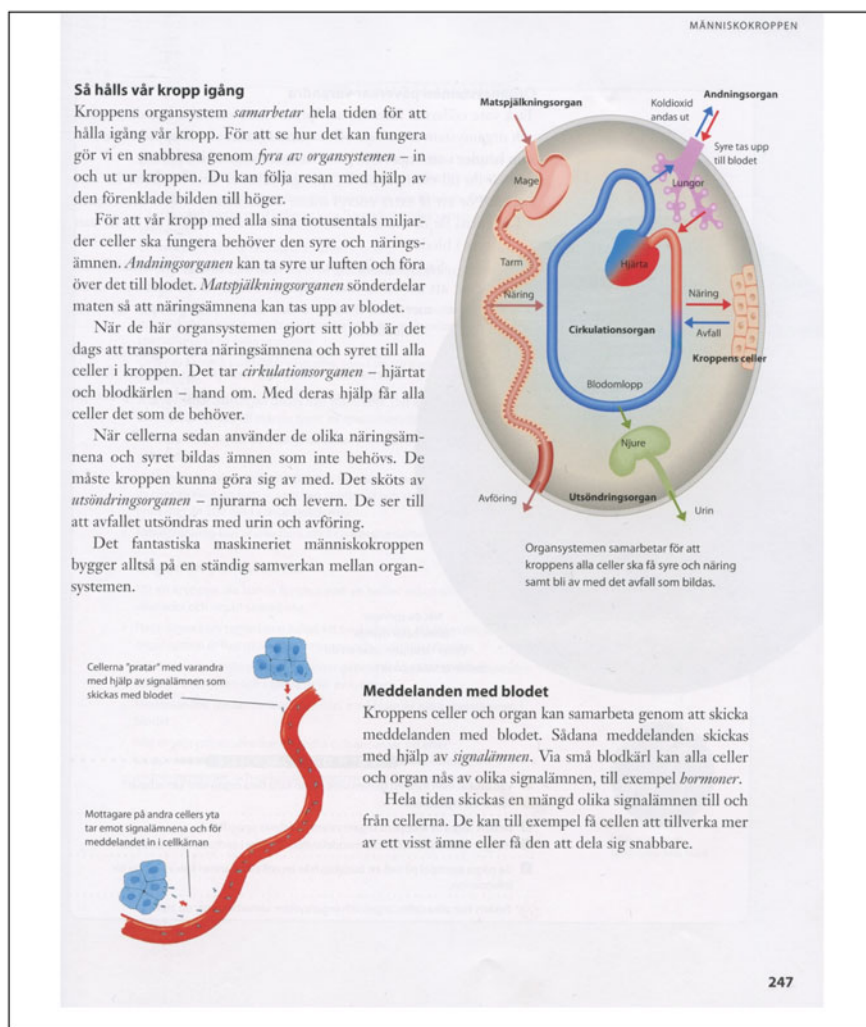
With regard to the various illustrations, a starting point can be to try to make out what they might depict, and how the illustrations can connect to the content in question, in this case “astronomy”. Our close reading above pointed out a number of potential challenges regarding the interaction between different text resources. One way of dealing with that could be to read the caption together to find out which illustration the caption relates to, and how to arrive at that conclusion.

For all of the illustrations that are connected to the subject content, it is important to examine how the running text and captions are connected to the illustrations. One aspect to highlight can be what is expressed through the different resources and if they give the same (overlapping), or competing, or perhaps even contradictory, information. In all texts where figurative language is used (in this case the axis of the earth which is compared to a stick), it is worthwhile reasoning about how far the analogy reaches: which parts of the analogy are relevant and which are not?

## 7.2 Biology, Secondary School

Here we will examine another Swedish textbook, *Spektrum Biologi* (Fabricius et al. 2011) which is a fairly extensive book, dealing with areas like “Life on earth”, “Bacteria and viruses”, “Ethology”, “Our environment”, and “Drugs”. We have examined

a couple of pages from the section “The human body”. In a section on circulation in the human body we find the heading “The organs cooperate” (Sw. *Organen samarbetar*). At the left side of the book spread, the different organ systems are described. Here we take a closer look at the right side of the book spread, which is shown in Fig. 7.3.



**Fig. 7.3** The human body as a system. *Spektrum Biologi* (Fabricius et al. 2011, p. 247, with permission from Liber)

### 7.2.1 *General Structure and Setting*

Just like the bottom part of the page, the upper part, which dominates the page, consists of writing combined with an image. Both images on this page are prominent, the upper one perhaps because of its shape and the red color. To the left of this illustration, under the heading “This is how our body works” (Sw. *Så hålls vår kropp igång*) a quite long written text dealing with the ways in which the organic systems of the body “cooperate”. This text is connected to a gray, egg-shaped illustration to the right. The image depicts four organic systems in quite an abstract fashion: digestion, perspiration, circulation, and secretion. The blood system is mainly depicted in blue, as opposed to the red color of the blood in the image at the bottom of the page. The gut and the intestines have, for some reason, the same color as the body cells.

At the lower part of the page, to the right, there is a short written text about “signal substances” under the heading “Messages with the blood” (Sw. *Meddelanden med blodet*). The wording of the heading and what it actually relates to is unclear. The illustration to the left of the text depicts a section of a blood vessel which looks like a red flood, with blue cells constituting some kind of end points.

What are the most prominent parts of the text on this page? Different emphasis is shown in different resources. In the upper part of the written text to the left, all of the different organic systems are italicized (*perspiration, circulation, etc.*). In the illustration to the right, on the other hand, the heart and blood circulation are centrally placed. Their prominence is further enhanced through the bright blue color. The other organs have been placed on the periphery of the “egg”, in a somewhat paler pinkish-brown tone, green, and lilac, respectively. The fact that the blood system is prominent on this page is further enhanced by the vivid red color of the blood vessel at the lower part of the page.

We may presume that the author and the illustrator of this text want to enhance aspects that they perceive as especially prominent or important, within the different “systems”. Naturally, not everything can be told or described, but the selection of information—in the form of facts in writing and illustrations—is not particularly easy to interpret in this text. Therefore, let us now go on to examine the interaction between different textual resources.

### 7.2.2 *Interaction Between Text Resources*

As mentioned previously, illustrations can be both facilitating or challenging for making sense of a text. In one sense, the “egg” in the upper right part of the page is concrete, since it depicts the interaction between *systems* in our body. But at the same time, the illustration is highly abstract, since it does not show what the organs look like, or their placement in relation to each other. Instead, the focus is on how the “systems cooperate”.



The various systems have been placed side by side, with relative proportions which bear no resemblance to their real size. The small and the large intestines are placed at one side of the body, while the heart and the blood circulation system are shown as a more or less closed system in the middle of the illustration. Arrows placed between the blood circulation system and, for example, a kidney or intestine, reveal that there is some kind of connection or interchange between the parts. The body cells—where the size of each cell corresponds to approximately a fifth of a kidney—have been placed to the right in the illustration. Through their placement and heading style, they appear to be one organic system among the others.

From the right part of the illustration, it seems as if nutrition and secretion are connected, on the one hand, to the body cells, on the other hand, to the heart and blood circulation. At the same time, we find a digestive organ to the left, where something which gets into the intestines from the outside disappears as excrements down to the left. However, a kidney which is connected to the blood circulation through an arrow, and an arrow pointing towards the word “urine” (Sw. *urin*) can be found down to the right, though they do not seem to be connected to any kind of food or liquid intake. Eventually, the reader might realize that what is called the “secretion organ” (Sw. *utsöndringsorgan*) has something to do with the purification of the blood.

In the illustration, the word “blood circulation” (Sw. *blodomlopp*) is given, though in the text the word “blood vessel” (Sw. *blodkärl*) is used. Where the text mentions the circulation organ “heart–blood vessels”, the illustration depicts the circulation organ “heart–blood circulation”. Thus, here the text is in conflict with the *principle of congruence*.

Not only form, but color, too, carries information in the illustration. In this case, it can result in further challenges in the meaning-making process. The digestion organs to the left are depicted in a pinkish-brown color, just like the cells to the right. Here there is a congruence in the color coding, but does this mean that there is a connection between the digestion organs and the body cells? In line with the conventions of the particular subject area, it can be assumed that the red color depicts blood which is rich in oxygen, while blue depicts blood with a low level of oxygen.

The lungs have a pale lilac tone, while the kidney (why just one?) is light green. However, what does the gray shade in the background mean? Is it presumed to be a neutral background meant to separate the illustration from the white book page, or is it a depiction of “the body”? Thus, we can state here that even though color to some extent appears to carry meaning, this is not always the case.

On the whole, we may note that the relation between writing and image is complex in this text. Since the illustration in itself is quite abstract, the reader needs to have quite an advanced content knowledge to be able to interpret the illustration in relation to the fact-oriented information given in writing. The connection between the information in image and writing might be simple to make for anyone who is already familiar with the function of the organs of the body. However, for someone who comes across a text like this without previous knowledge, the information can appear to be incomplete, and to some extent even contradictory.

### 7.2.3 *Figurative Language*

This text contains an abundance of figurative language, not least metaphors, perhaps due to a presumption that the reader will be supported through connections to everyday experiences. However, such usage can also be potentially challenging. The text says that “the organs *cooperate*”, and “[w]hen the digestive organ have *done their job*, it is time to *transport* the nutrition and oxygen to all body cells”, which is “*taken care of*” by the circulation system”. But what, for instance, does it mean that the digestive organs have “done their job”? And are the circulation organs waiting for a delivery from the digestive organ?

Further, the text says that the body is “a fantastic machinery” (Sw. *ett fantastiskt maskineri*). But a biological body is an organism governed by other principles than mechanical clocks or digital systems in a computer. In line with this, researchers in the area of brain research have left the analogy of the brain as a computer. Instead the brain is discussed in terms of a live organism which is dependent on a biological body which actively chooses and sorts information (Edelman 2006). Some adequate questions to pose in relation to this text are, for example: What are the gains of using the machine metaphor for the body, and what are the limitations? What possible misunderstandings can the machine metaphor give rise to?

At the bottom of the page, to the left, there is an illustration depicting how cells “talk” (Sw. *pratar*) to each other, a metaphor in line with the 1940s communicative model by Shannon and Weavers (1998). Here it is said that signal substances are *sent* to the other side, where there is a “*receiver* [...] who *takes* the signal substances into nucleus of the cell”. Here, the signal substances have become “messages” which are actively “taken care of” by a “receiver”, who in turn “brings” the message into the nucleus of the cell (cf Pettersson et al. 2020, who showed how students used logistics metaphors to talk about the digestive system in a national test). The text humanizes the organs, thus depicting the body parts as having intentions. Such anthropomorphisms, as they are called, are known to create challenges for students, since the students sometimes mistakenly perceive natural phenomena as actually having intentions and feelings (for further discussions, see for instance Danielsson et al. 2018; Tibell and Rundgren 2010).

### 7.2.4 *Values*

In this text, no values are expressed explicitly. But are there any implicit values? In one sense, you can say that there is an underlying principle for organizing the subject content: a functionalistic model with cooperating entities possessing intentions.

Of course, it might be reasonable to use metaphors to present the function of our organs to the students. At the same time, such use can lead to other obstacles since the organs and their different parts are depicted as active objects. In one sense, such

a depiction weakens the value of the system model presented at the beginning of this section of the textbook.

## References

- Danielsson, K., Löfgren, R., & Pettersson, A. J. (2018). Gains and losses. Metaphors in chemistry classrooms. In K-S. Tang & K. Danielsson (Eds) *Global Developments in Literacy Research for Science Education* (pp. 219–235). Cham, Switzerland: Springer.
- Edelman, G. M. (2006). *Second Nature. Brain Science and Human Knowledge*. Yale University Press.
- Pettersson Jahic, A., Danielsson, K., & Rundgren, C.-J. (2020). ‘Traveling nutrients’: how students use metaphorical language to describe digestion and nutritional uptake. *International Journal of Science Education*, 42, 1281–1301.
- Shannon, C. E., & Weaver, W. (1998/1949). *The Mathematical Theory of Communication*. Chicago, IL: University of Illinois.
- Tibell, L., & Rundgren, C.-J. (2010). Educational challenges of molecular life science: Characteristics and implications for educational research. *Life Sciences Education*, 9, 25–33.

## Textbooks

- Fabricius, S., Holm, F., Mårtensson, R., Nilsson, A., & Nystrand, A. (2011). *Spektrum. Biologi* (3rd ed.). Liber.
- Sjöberg, S., & Öberg, B. (2011). *PULS. Fysik och kemi 4–6 grundbok* Third edition [*PULS. Physics and Chemistry*]. Stockholm: Natur & Kultur.

**Open Access** This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

