2a

> Ada knowledge: The human brain

The brain enables us to think logically, to communicate with others and to learn, and furnishes us with the power of recollection. Yet emotions such as love and sympathy are situated in the brain as well.

This chapter contains:

- Basic information on the brain
- Illustration of a nerve cell
- Recommendations for instruction
- Worksheet
- Transparencies

A: Factual information

The brain directs all thoughts and all active movements

An array of nerves carries information from the sensory organs to the brain where it gets processed. After a decision is reached, motor instructions are then likewise transmitted via nerve fibres to the muscles.

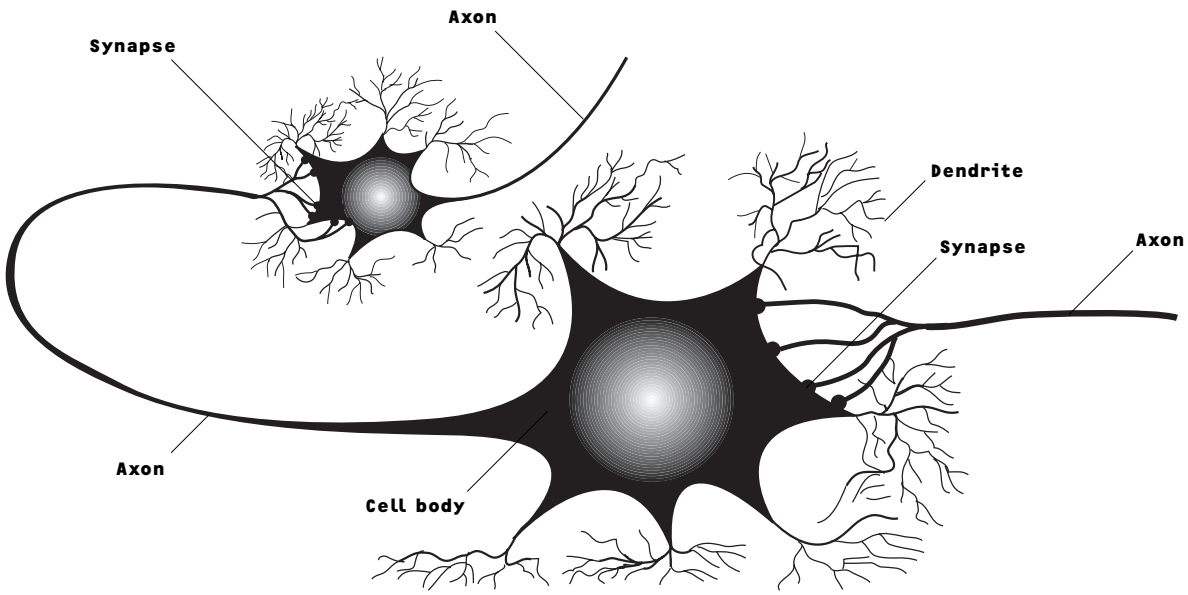
Not all processes occurring in the brain are apparent to us. There are many functions the brain controls automatically, like our breathing, heartbeat and digestion.

The brain contains some 100 billion nerve cells – so-called neurons – that are linked together. A single nerve cell can form up to 10,000 connections, or synapses, with other nerve cells.

Processing data

What's fascinating about the brain is its adeptness at linking nerve cells, which are relatively slow compared to conventional computers, enabling the brain to react within a split-second, such as to altered environmental conditions. Information processing in the brain is based on the electric conductivity of the nerve cells and the existence of neurotransmitters that convey signals from cell to cell. By processing the data received from the surrounding environment, the brain enables a person to adjust his behaviour to the respective situation. When he wants to drink, for instance, he can recognise a glass of water, pick it up and bring it to his mouth, which involves a complex interplay of sensory perceptions and their processing in the brain followed by a series of motor commands (see **Worksheet 2a.5** and **Transparency 2a.6**).

In the course of history, there have been various notions – including numerous visual depictions – as to what a brain is. The prevailing allegorical symbol for the brain today is the computer. This comparison nevertheless proves inapt, as addressed in the subchapter **>Ada knowledge: Processing data**.



Schematic depiction of a nerve cell

Current state of neuroscience

Through new image-generating methods in the field of science, such as computer tomography and magnetic resonance tomography, the study of the structure of the human brain has been tremendously enhanced. With positron emission tomography, it is even possible to observe which parts of the brain are activated when performing certain tasks. On the other hand, there are other methods that allow us to observe individual cells and study the function of their constituent parts down to the individual molecule level. All over the world, tens of thousands of scientists are conducting research to unlock the secrets of our brain and its mode of functioning.

Central questions

Particularly interesting here are the following questions: How does our brain develop up through birth and afterwards? How do we learn and how are we capable of remembering? How does our brain link data our sensory organs provide at a particular instant with the information that's already been stored so that we are capable of responding appropriately? How do we perceive things and interpret them? How are emotions produced?

Today we understand quite well how data is collected and processed directly in the sensory organs, yet not which processes transpire inside the brain, such as how an overall image of a perceived object is formed. The most widely researched sensory organ is the eye. A significant body of information has also been collected on hearing. In regard to sense of smell and taste, by contrast, relatively little is known. There are extensive findings on how muscles are activated and which ones are needed to perform certain actions. Yet we still do not fully understand how the brain coordinates the interplay of these muscles. Researchers have been quite successful in identifying which regions of the brain are responsible for particular tasks. How the individual regions of the brain depend upon one another and work together, however, is still by and large unknown.

Definition of terms

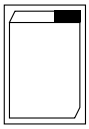
•Neuron
The nerve cell, the so-called neuron, is the fundamental unit of the nervous system. Its function covers the transmission and storage of data. The nerve cell consists of a cell body and numerous processes, the dendrites that conduct signals from other neurons to the cell body, as well as an axon through which signals are passed from one cell to another.

•Computer tomography
Image-generating process utilising X-rays. It shows only the structure

•Magnetic resonance tomography
Image-generating process utilising magnetic fields and radio waves. It shows only the structure and is especially useful for highly detailed images of non-bony tissue.

•Positron emission tomography
Image-generating process utilising radioactive substances that break down in the body, which get measured by detectors. It enables functional examination of the brain, among other uses.

B: Recommendations for instruction



Sheets with border can be copied and distributed to students.

Explanations of **Worksheet 2a.5** and **Transparencies 2a.6**

The worksheet exercises provide a lead-in to questions regarding control of the body. Exercise 1 can be solved with the transparency "Drinking a glass of water." Instructors may choose to expand on this topic, such as by discussing reflexes. An expansion along the same lines as our exercise is suggested by Walder 1989:109, in which a person wishes to pick up a glass of hot water but the hand draws back as a reflex.

Answers

1. *Eyes "see" glass; brain estimates distance; brain issues commands to muscles to pick up glass; sense of touch in the hands reports contact with glass; muscles receive commands to bring glass to the mouth.*

If the eyes are closed, the brain has to rely fully on the sense of touch, whereby it must obviously first "know" there is a glass on the table. As soon as the glass is grasped, however, it proceeds "automatically" since the eyes are no longer needed. Via the position of the muscles and joints, the brain "knows" where the glass and mouth are located.

2. *The brain can handle multiple tasks parallel to one another. While engaging in conversation, the glass is picked up without difficulty and the motions of the boat deck are detected by the organ of equilibrium and continuously transmitted as commands to the hand holding the glass so no water is spilled. If an announcement is made over the loudspeaker at the same time, this also gets registered and, if need be, one's attention is directed to the announcement*

3. *Apart from holding and serving the glass without spilling any water, the robot has to be able to move within the restaurant, avoid bumping into tables, chairs and service personnel and hence be able to see and recognise them. In addition, the robot would have to be able to differentiate between tables with guests and those without and detect whether a glass is already on the table. A practical supplemental function would be if the robot were able to replace empty glasses as requested by restaurant guests (spoken words).*

The transparency "Brain regions and abilities" depicts which parts of the brain are responsible for particular abilities.

Link

Images of the brain
http://faculty.washington.edu/chudler/image.html

Bibliographic information

•Benner, Klaus-Ulrich: **Der Körper des Menschen.** Das Wunderwerk des menschlichen Körpers. Aufbau, Funktionieren, Zusammenwirken, Abläufe und Vorgänge. Augsburg 1996.
•Claus, Roman u.a. (Hgg.): **Natura 2 und 3. Biologie für Gymnasien.** Zug 2000.
•Conlan, Roberta (Hg.): **Geist und Gehirn.** Faszination menschlicher Körper. Amsterdam 1994.
•Cruse, Holk/Dean, Jeffrey/Ritter, Helge: **Die Entdeckung der Intelligenz oder Können Ameisen denken?** Intelligenz bei Tieren und Maschinen. München 1998.
•Düweke, Peter: **Kleine Geschichte der Hirnforschung.** Von Descartes bis Eccles. München 2001.
•Fonds Jahr des Gehirns 1999 (Hg.): **Das menschliche Gehirn.** Aufbau, Funktionsweisen und Fähigkeiten eines erstaunlichen Organs. Wien, München 1999.
•Goleman, Daniel: **Emotionale Intelligenz.** Aus dem Amerikanischen von Friedrich Griese. München 1997.
•Knodel, Hans: **Linder Biologie. Lehrbuch für die Oberstufe.** Hannover 1998.
•Lathe, Wolfgang: **Nervensystem und Sinnesorgane.** Fachliche Inhalte und Übungsaufgaben (12. und 13. Schuljahr). Mannheim 2000. (Duden Abiturhilfen)
•Miram, Wolfgang/Scharf, Karl-Heinz (Hgg.): **Biologie heute SII.** Ein Lehr- und Arbeitsbuch. Stuttgart 1997.
•Roth, Gerhard: **Fühlen, Denken, Handeln.** Wie das Gehirn unser Verhalten steuert. Suhrkamp, Frankfurt a.M. 2001.
•Walder, Paul: **Bau und Funktion unseres Körpers.** Zürich 1989.

>**Ada knowledge: The human brain** (Worksheet)

1. Describe precisely the information a person receives and processes as well as the commands issued by the brain when he wants to bring a glass of water to his mouth.

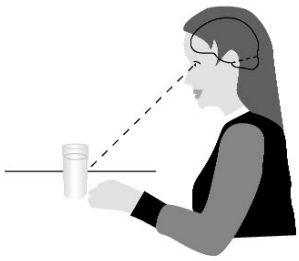
What changes when the person closes his eyes?

2. What can be said about the way the human brain functions if we expand the situation in Exercise 1 as follows:

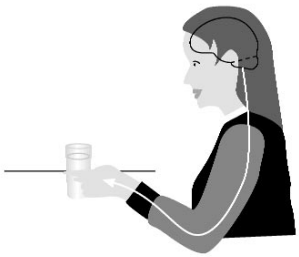
The person drinking water is sitting on the deck of a rocking boat and talking with the captain, as seagulls squawk in the background. Then an announcement is suddenly made over the loudspeaker.

3. What abilities must a robot possess in order to serve a glass of water to each guest in a restaurant?

Drinking a glass of water



The eyes report the location of the glass to the brain.



The brain sends motor impulses to the muscles of the arm to move it toward the glass.

The hand's sensory receptors detect the glass and report this to the brain.

Motor impulses of the brain command the arm muscles to grasp and lift the glass.

Sensory data from the eyes and arm inform the brain about the position of the arm.

Sensory impressions of the lips notify the brain that the glass has reached the mouth.

Brain regions and abilities