

Gunther von Hagens'

BODY WORLDS

The Original Exhibition of Real Human Bodies



EDUCATOR'S

(GRADES 9-12) GUIDE

Resource Package
for Secondary School Groups

EDUCATOR'S
GUIDE (GRADES 9-12)

Contents

Planing your Visit 4

Note to Educators 5

Frequently Asked Questions 8

Classroom Activities12

Exhibition Overview45

Additional Resources56

Planing Your Visit

Before

Read the Letter to Educators and Frequently Asked Questions in this guide.

Visit the BODY WORLDS website (www.bodyworlds.com) for a preview, and to request your free BODY WORLDS DVD and brochures.

It is recommended for teachers complete pre-visit activities with students such as those included in this Educator's Guide. This will help prepare your students for what they will encounter within the exhibition.

Discuss the visit with students and explain what they are going to see and why.

Preview the exhibition by reviewing the BODY WORLDS DVD with students and participate in the activities founf in this guide.

Administer permission forms to parents and guardians.

During

Bring the Educator's Guide with you to the BODY WORLDS exhibition.

Consider renting an Audio Guide.

Seek out the Museum Hosts for answers to your questions about the exhibition.

After

Complete the suggested activities with your students.

Consider sharing your students' reaction to BODY WORLDS.

Visit some of the websites listed in the additional resources section.

Note to Educators

Dear Educator:

At the Ontario Science Centre, our mission is to delight, inform and challenge visitors through engaging and thought-provoking experiences in science and technology . Our school programs are an integral part of that mission. BODY WORLDS—The Originalal Exhibition of Real Human Bodies, provides students and visitors with the opportunity to learn about anatomy and health by viewing real, preserved human bodies. More than 25 million people have seen BODY WORLDS worldwide.

BODY WORLDS uses modern plastination technology as a tool to enhance the study of anatomy . Students will understand how the body works when it' s healthy and what happens when it breaks down, as well as the effects of lifestyle choices on the body. For instance, they can see the effects of smoking on the lungs, and how muscles work together during exercise.

Important information to know about BODY WORLDS:

- The BODY WORLDS exhibitions rely on the generosity of body donors: individuals who bequeathed that, upon their death, their bodies could be used for educational purposes in theexhibition. All of the full-body plastinates and the majority of the specimens are from these body donors; some specific specimens that show unusual conditions come from anatomical collections.
- All body specimens are without skin so you can see the bones, muscles, tendons, nerves, blood vessels and organs. Eyes and genitals of the bodies remain. Written descriptions (English only) company all specimens.
- A separate section of the exhibition highlights prenatal development and includes embryos and fetuses. Visitors may choose whether or not to view this area.
- Plastination is a process that replaces the natural fluids in the body with a type of flexible plastic. The use of plastics for preservation means that the specimens are odourless and completely dry. Plastination allows the bodies to be fixed into life-like poses, illustrating how our bodies are structured and how they function when performing everyday activities.
- It is recommended that teachers prepare students for their visit by completing some of the Classroom Activities in this Guide.

Teachers are responsible for distributing and collecting the enclosed parental permission form. By entering the exhibition with your student, you are acknowledging that all of your students have parental permission to view the exhibition. We will not review permission forms, it is not necessary to bring the completed forms on your visit.

Please note that we have ensured that any of our visitors or school groups who do not wish to see BODY WORLDS will still be able to visit the Museum without viewing any part of the exhibition.

If you have any questions about this policy, please contact ????

Permission Form

To learn more about the exhibition and to find the answers to some frequently asked questions, please visit our website at www.bodyworlds.com. After viewing the exhibition, your children may want to discuss what they have seen with you. On the website you will also find a Family Guide to assist you in answering questions that your children may have .

We require that all students in school groups visiting the BODY WORLDS exhibition receive permission from their parents/guardians prior to coming to the exhibition.

By signing this form, you are acknowledging that your child has permission to view the exhibition with a teacher, school supervisor or other school representative. If you do not wish for your child to see this exhibition, please ask the teacher to make other arrangements.

Yes, I give (child's name) _____
permission to view the BODY WORLDS exhibition.

Parent/Guardian's name (please print) _____

Parent/Guardian Signature _____

Date _____

Frequently Asked Questions

What is BODY WORLDS?

The BODY WORLDS exhibitions are first-of-their-kind exhibitions through which visitors learn about anatomy, physiology, and health by viewing real human bodies, using an extraordinary process called Plastination a groundbreaking method for specimen preservation invented by Dr. von Hagens in 1977.

Each exhibition features more than 200 real human specimens, including whole-body plastinates, individual organs, organ configurations and transparent body slices. The specimens on display stem from the body donation program that Gunther von Hagens established in 1983.

The exhibitions also allow visitors to see and better understand the long-term impact of diseases, the effects of tobacco consumption and the mechanics of artificial supports such as knees and hips. To date, nearly 25 million people around the world have viewed the BODY WORLDS exhibits.

What is the purpose of the exhibition?

The BODY WORLDS exhibitions aim to educate the public about the inner workings of the human body and show the effects of poor health, good health and lifestyle choices. They are also meant to create interest in and increase knowledge of anatomy and physiology among the public.

Couldn't I learn just as much from books or models of human anatomy?

Real human bodies show the details of disease and anatomy that cannot be shown with models. They also allow us to understand how each body has its own unique features, even on the inside. Visitors are drawn to real specimens in a way that they are not to plastic models. One of the special features of museums and science centres is that they offer people a chance to see the real thing in a safe and informative environment.

What is Plastination?

Invented by scientist and anatomist Dr. Gunther von Hagens in 1977, Plastination is the groundbreaking method of halting decomposition and preserving anatomical specimens for scientific and medical education. Plastination is the process of extracting all bodily fluids and soluble fat from specimens, replacing them through vacuum forced impregnation with reactive resins and elastomers, and then curing them with light, heat, or certain gases, which give the specimens rigidity and permanence.

Where did the specimens on display come from?**Will we know who the plastinates are or how they died?**

The BODY WORLDS exhibitions rely on the generosity of body donors; individuals who bequeathed that, upon their death, their bodies could be used for educational purposes in the exhibitions. Currently, the Institute for Plastination has a donor roster of 8000 individuals, 490 are already deceased.

All of the whole body plastinates and the majority of the specimens are from these body donors; some specific specimens that show unusual conditions come from old anatomical collections and morphological institutes. As agreed upon by the body donors, their identities and causes of death are not provided. The exhibitions focus on the nature of our bodies, not on providing personal information.

Why are the plastinates posed the way they are?

The poses of the plastinates have been carefully thought out and serve educational aims. Each plastinate is posed to illustrate different anatomical features. For instance, the athletic poses illustrate the use of muscle systems while playing sports. The poses allow the visitor to relate the plastinate to his or her own body.

Will I be able to touch any of the plastinates?

While you will be able to get very close to the plastinates, as a rule, visitors are not allowed to touch them. At a certain area in the exhibition, however, visitors have the option of touching a select group of plastinated organs to better understand both the human anatomy and the process of Plastination.

Are these exhibitions appropriate for children?

Nearly 25 million people, including young children, have viewed the BODY WORLDS exhibitions around the world. It is important to note that the exhibition includes full-body plastinates with exposed genitals.

We recommend the BODY WORLDS exhibits for school groups in Grades 5 and up.

Why is it important for the public to see these exhibits?

We believe that when people understand more about how the body works and how it can break down, they are more likely to choose healthy and sustainable lifestyles. We also hope it will inspire visitors to learn more about the life sciences. Knowledge about what the human body looks like and how it functions is basic life science information that should be available to everyone.

Why are there not more women plastinates in the exhibits?

Sensitive to perceived community concerns, Dr. von Hagens did not want to appear voyeuristic in revealing too many female bodies. Further, he sees himself in the tradition of Renaissance anatomists, whose works traditionally included far more masculine than feminine bodies, since all but the reproductive systems are essentially the same. The musculature of male bodies is generally more pronounced and illustrates more aspects of the muscle system. The organs on display come primarily from the female body donors. However, since opening the exhibits, Dr. von Hagens has received numerous requests from women visitors to see more examples of female anatomy. Based on this, Dr. von Hagens has already added and will add more female plastinates to future exhibits.

How long can I stay inside the exhibits?

You can stay as long as you like. But we recommend allowing yourself about one to two hours. The length of time will vary on how long each visitor wishes to examine each specimen and read the information provided. An audio tour will increase your time in the exhibits.

Can I take photographs or film in the exhibitions?

Photography and filming, including pictures taken with cell phones, are not allowed in the BODY WORLDS exhibitions, except by accredited members of the media.

Are food and drink permitted in BODY WORLDS?

Just as in the rest of the Science Museums hosting the BODY WORLDS exhibits, food and drink are not permitted in the exhibit galleries. The policy helps to protect the artifacts from the museums' collections, as well as the BODY WORLDS plastinates.

Classroom Activities

This sampling of classroom activities, taken from the BODY WORLDS 2 CD-ROM of Classroom Activities, can be used as either pre-visit activities to prepare students for BODY WORLDS 2 or as post-visit activities to help debrief them. Additional classroom activities are available for purchase in the BODY WORLDS shop at the exhibition exit or via the BODY WORLDS website at www.bodyworldshop.com.

Someone you know as a Plastinate

1. Look carefully at the positions of those quoted below .
2. Which arguments can be used respectively for and against the BODY WORLDS 2 exhibition?
3. Are the arguments conclusive? (Test them if necessary by drawing on further reading.)
4. Consider what moves a donor to allow his body to be plastinated for an exhibition.
5. Consider how the friends and relatives of the donor feel.

Positions of visitors and non-visitors ¹

“What tastelessness and irreverence will people come up with next to “get rich quick”? Can they not imagine how the friends and relatives of the deceased feel? But I think that Gunther von Hagens understands nothing of “sympathy”, and “stopping at nothing”. As can be judged by the 780,000 visitors at Mannheim, there are enough sheep everywhere to go along with him. I would advise these people and the exhibitors, if they are so curious to see dead bodies, to go into war zones.”

Gertrud Holzki, Cologne

“I think that the exhibition is simply fantastic because it teaches us about the inner anatomy of the human body. You can read a hundred books on anatomy and look at hundreds of pictures, but how the organs really look, and where and how they are positioned, can only be seen in this genuinely fascinating exhibition. I also think that it’s great that bodies can be conserved for a very, very long time in this way. This is useful for training doctors or even enlightening us, the lay people. We can see ourselves in the plastinates.”

Rita Gilberg, Koblenz

¹ From: Express “Rheinland Kultur” (“Rhineland Culture”). 21 January 2000, p. 23, and 24 January 2000, p. 24

"I do not think that it is educational because the bodies are not displayed in natural positions. The way Hagens does it, it's not physiologically correct. The people are not just taken apart, but the layers are pulled apart. Afterwards we don't know what the body really looks like from inside. Reality is distorted, and the people are only put on show. This exhibition is about voyeurism, and it has nothing to do with striving after medical knowledge."

Daniela Klinger, Cologne

"I don't agree with the statement that BODY WORLDS is a corpse show. It is a great credit to people when they put themselves at the disposal of science after their deaths. Perhaps this exhibition will cause an increased respect towards service to humans, as offered by doctors, nursing staff or the fire brigade."

Silke Ebert, Cologne

"I am looking forward to this exhibition a lot. Even as a child I looked up in Brockhaus what people look like from inside. I also watch operations on the television for hours at a time. I find it totally fascinating. And the horror effect of a show like this is surely the same as looking at a cathedral crypt in which a dead bishop is buried."

Sascha Arnz (German TV Producer, "Wetten, dass ... ?")

"If respect for the dead is maintained in the display, I find it very interesting. I will definitely be viewing the exhibition. I hope that it will cause people to change their attitude towards the body and perhaps treat it a little better, when they see how often it is abused. A little shock like that can sometimes be helpful. "

Joey Kelly ("Kelly Family")

"No, I am not going to the exhibition. Because death is not for use as a kind of trendy exhibitionism."

"I see this unsuccessful attempt at obscenely making eternal what is transient as nothing more than grave-robbing and show-business with horror under the pretext of breaking down taboos. "

Günter Wallraff, author

"I find an exhibition like this unnecessary. There are enough cut-up bodies, even cross-sections of bodies, for the medically-inclined to see in the anatomical institutes of university clinics. A corpse show like this does nothing for art. It just adds to the horror factor. I don't need to see it."

Heinz Zolper, Cologne-based painter who designed the title page of the millennium edition of EXPRESS newspaper

Other views: The artist himself

The artist: The popes started it ²

Cologne—19 days to go until Gunther von Hagens' grisly plastinated corpses hit the Haymarket. EXPRESS spoke to the "plastinator".

EXPRESS: Herr von Hagens, do you fear for your soul?

G. v. Hagens: No, why?

EXPRESS: Because the Church makes you out to be the devil.

G. v. Hagens: I just don't understand it. If I were the dean of a cathedral, I'd say: "Go forth and marvel at the wonders of human creation!"
And anyway, my exhibition is in the best Christian tradition.

EXPRESS: "Robbing the dead at the Haymarket" is in the Christian tradition?

G. v. Hagens: Almost—in the Middle Ages the popes themselves offered their bodies for dissection. Christianity is by far the most anatomy-friendly religion.

EXPRESS: But your love of anatomy is now going before the courts.

G. v. Hagens: They have already tried that in Mannheim.
The public prosecutor took a good look at everything.

EXPRESS: And?

G. v. Hagens: He didn't admit the charge because under law I don't have bodies, but specimens. Otherwise I would need corpse transport permits for all the specimens.

EXPRESS: There just wouldn't be this sort of trouble with plastic specimens.

G. v. Hagens: But then nobody would come. A Louvre full of copies wouldn't interest anyone either.

² From: Express " Rheinland Kultur " (" Rhineland Culture "). 24 January 2000, p. 24

EXPRESS: But why do you need so much attention? What do they show that plastic doesn't?

G. v. Hagens: I want to give the body back to the layman. I want Grandma to say after the exhibition
"Now I know why the surgeon took five hours over my hip."

EXPRESS: Sure, but Grandma would also get the point with plastic.

G. v. Hagens: But this gives another level of credibility. Here it isn't possible to fake anything.
Besides, I also want death to become something normal again.

EXPRESS: So what do we get out of this ?

G. v. Hagens: Studies have shown that people leave the exhibition with a greater awareness of the body.
To achieve that, I need real bodies.

EXPRESS: How many exactly?

G. v. Hagens: At the Haymarket exhibition, there were 30 donated bodies on display .

*EXPRESS: Too many. After half way through the Basel exhibition, nothing was new any more.
How many sliced-up bodies does a person need ?*

G. v. Hagens: Then maybe you just weren't looking carefully enough...

EXPRESS: ...it's possible. In the end I'm only a layman too...

G. v. Hagens: ...we have built display cases for the eight organ systems. And still we get visitors saying
to us, "We want more specimens". Of gastroscopy and so on.

EXPRESS: Will you let yourself be plastinated after your death?

G. v. Hagens: Of course. Otherwise everything I'm saying to you here would be rubbish.

Other views: A representative of the Church

BODY WORLDS now threatened by lawsuit—Church castigates “freak show” ³

Cologne—The plastinated corpses arrive at the Haymarket on 12 February. No art exhibition has ever divided Cologne as much as BODY WORLDS. Is it all a question of taste? The Church says “no!”—and has declared war against the “plastinator”, Gunther von Hagens. This exhibition has to be stopped—in that, Catholics and Protestants are agreed—even, if necessary, through the courts.

“We are considering taking legal action against it”, the archbishop’s spokesman Manfred Becker-Huberti told EXPRESS. “The exhibition is nothing but a freak show.” Eckart Schubert, Superintendent of the Protestant Church, has an idea of how to put a stop to the plastinator’s work. “He does not have permission to bring the corpses in. The majority are said to come from Kyrgyzstan and China.” But “you need corpse transport permits to take the dead across borders. And he didn’t have those.” The Churches make further claims: It is not at all clear whether this freak show is permissible under law. Besides, says Schubert, “the donors who have had their bodies plastinated cannot exactly make decisions about their own bodies.” For “a corpse has to be buried. The only exception is when the body has been donated to science.”

The plastinator’s argument, that the exhibition of corpses at last gives an insight into the human body, holds no water with the men of the Church. For them, what the pathologist Gunther von Hagens is doing is merely “robbing corpses”. “What we see happening at BODY WORLDS is exactly the same as what could be seen at a “House of Monstrosities” at a 19th century funfair. There, there was a woman with no abdomen, a child with two heads,” thinks Becker-Huberti.

The Protestant Church goes yet one step further, comparing the controversial exhibition with horror videos. “Real bodies, brutally chopped up—that promises a bit of a kick.”

The Catholic and Protestant Churches now want to reach agreement on whether the subject of BODY WORLDS should be raised in church services, and whether circulars should be sent round to parishioners. “There is one thing you have to understand. Here, people are making money by dismembering human beings and putting them on display,” says Schubert. “It is voyeurism and profit-mongering.”

³ From: Express “Rheinland Kultur” (“Rhineland Culture”). 24 January 2000, p. 24

Other views: A doctor

Far from the dripping preparation tables. With plastinates, anatomy has come alive ⁴

Wiesbaden—Running, fencing, playing chess—it's amazing what corpses can do. Quite possibly things they were unable to do in life. Does BODY WORLDS show art, then, or science? Should we see plastination as a particular kind of preparation technique or as creative craftwork? “For me, plastinates are not works of art, as they were created with the specific aim of imparting anatomical knowledge,” is Gunther von Hagens' line on this much-debated issue. Indeed, he sees art, unlike science, as being without purpose. “If the concept of the artist is not exaggerated in the Beuysian sense, then the plastinator is a craftsman, but not an artist.” And this is how Gunther von Hagens argues his point when, again and again, his plastinated figures are described as works of art. “Modern art is a concept that relies on interpretation. So each person reads his own motivation into my endeavours, a motivation that is a product of an artistic and moral viewpoint that is entirely his own.” This is why, at his exhibition, Gunther von Hagens likes to speak of “anatomical art”, precisely because he wants his work to be seen both as an exhibit and as craftsmanship.

Prostrate corpses do not achieve anything

From the perspective of its inventor, what has plastination changed in medicine, in university-level study? “The anatomy of a corpse is in itself completely uninteresting,” says Gunther von Hagens. “It is only important because through it you can study the anatomy of the living, albeit in a limited way. Whereas, since Vesalius's work in the Renaissance, human skeletons have stood upright, the wet, dripping anatomy corpses have to stay on the preparation table. Here, either their front or back is always hidden from the researcher's gaze, so they can never be fully demonstrated.” “Living anatomy” is clearly the trend of the day. As a student at the swimming pool, says Gunther von Hagens, he had problems following the advice of his anatomy professor to make the connection between the pleasing side of the body (aesthetic people-watching) and the useful (the study of surface anatomy). The difference between the stiff, prostrate corpse on the preparation table and the play of the muscles of swimming, running and sitting people was always too great.

Students size each other up

Today, in their favourite subject, “living anatomy”, students are sizing each other up, mapping and drawing the muscles and organs onto each others' skin. And, as Gunther von Hagens sees again and again, they love it. For him, one thing is certain: “The layman in medicine, which includes the student of medicine who is just starting out, is not interested in the anatomy of the dead. Because a friend, their sexual partner or, after all, the patient that budding doctors will later treat is alive, moves, strikes poses. So in this respect it is only logical that whole-body plastinates should be positioned upright, true-to-life, to impart their information in the habitat in which they lived.”

⁴ From: Medical Tribune. 35th year, p. 22. No. 3. 21 January 2000

Digestion

Introduction to the subject

A significant part of our food consists of macromolecules that are insoluble in water. In digestion they are broken down, using water, into compounds that are largely water-soluble. They can then be reabsorbed by the intestinal wall and transported through the body in the bloodstream and lymphatic system. Through this breakdown the nutrients, particularly proteins, also lose their specific structure so that no foreign protein enters the bloodstream.

In digestion:

- Proteins are broken down into amino acids
- Carbohydrates are broken down into monosaccharides
- Fats are broken down into glycerine and fatty acids

For the most part, this breakdown does not occur directly. Instead, it takes place in a series of interim stages involving various complementary enzymes. Vitamins, most inorganic ions and water are absorbed by the body in their original form. Digestive juices form in the glands of the digestive organs. The active components of these digestive juices are enzymes.

In the following experiments, the following enzymes are used:
 α -amylase, pepsin and pancreatin.

α -Amylase

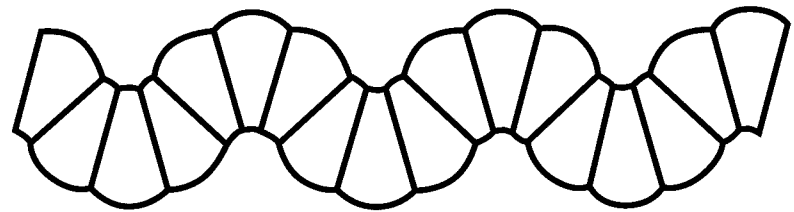
This enzyme breaks starch (amylum) down into maltose:

Starch + Water α -Amylase Maltose

The enzyme attacks the middle part of the starch molecule. At first, this produces larger fragments. But these only last a short time. Very quickly the disaccharide maltose is formed. In the body, amylase is found in particular in saliva and pancreatic juices.



Picture 1: In the polysaccharide starch, cyclic molecules of the monosaccharide glucose form a long chain that coils up into a helix.



Picture 2: In proteins, a number of amino acids combine into a chain, which then forms a spiral-shaped coil.

Pepsin

Pepsin is a major component of gastric juices. Its precursor form, pepsinogen, is produced by the chief cells of the gastric fundus. The fundus cells secrete the pepsinogen into the stomach. Under the influence of gastric acid, the pepsinogen is activated as the active enzyme pepsin. In these acidic conditions the pepsinogen divides into pepsin and a number of peptides. One of the peptides that separates off acts as an inhibitor. In the neutral reaction of digestive juices, it is taken up by pepsin and blocks its action. But in acidic pH conditions the pepsin inhibitor complex divides. The pepsin can now exhibit its enzyme action. Pepsin attacks the protein molecules in the vicinity of the amino acids tyrosine and phenylalanine. This way, only approx. 10% of the peptide bonds in a protein molecule are broken. As part of this process, a mixture of peptides of various chain lengths (molecular mass: approx. 600 – 3000) is formed, as well as a small amount of amino acids.

Pancreatin

This preparation contains those enzymes in the pancreatic juices whose optimal pH is in neutral to weak alkaline conditions. The principal components of pancreatin are :

-Amylase: divides starches (see above)

Proteases: Enzymes that break proteins down to amino acids

Protein + Water Amino Acids

Lipases: divide fats into fatty acids and glycerine

Fat + Water Fatty acids + Glycerine

Most of the experiments we describe below are test tube experiments that can be carried out without much expensive apparatus. While in many cases it is useful to have a chemical oven (temperature 37°C), this is by no means essential. There is also no need for a set of scales as long as you take care to ensure that, in comparative tests, the same amounts of substance are used. The measure “a spoon tip’s worth” is meant to indicate the amount of solid that would fit on the last 2cm of a spatula.

Instructions for storing the enzymes:

If left in a dry place in the fridge (+4°C), the enzyme preparations will keep for several years without any significant decrease in activity.

In the descriptions below, we have only included experiments that are quick to do and are therefore well-suited to demonstrations. However, it is often unavoidable that results—particularly those relating to protein digestion—can only be seen after one or several hours (if egg white is used).

EXPERIMENT:

Digestion of Fat

Materials:

Cooking oil, pancreatin, dilute sodium hydroxide, phenolphthalein solution.
Test tubes, beakers, 1 Erlenmeyer flask with airtight stopper,
300ml (or larger), measuring pipette (e.g. 5 ml).

Preparation:

- I. Fill each of 2 test tubes with the same amount of water (approx. 5ml).
Put approx. 50 mg (1 “spoon tip’s worth”) of pancreatin into one of these test tubes and shake into a suspension.
- II. Put approx. 200 ml of water and approx. 2ml of cooking oil into an Erlenmeyer flask.
Seal the flask and shake it vigorously until an opaque milky liquid forms.
Add 5 drops of dilute sodium hydroxide and 5 drops of phenolphthalein solution to this emulsion,
while swirling the flask. The liquid is now a pink colour .

Method:

Divide the fat emulsion (II) equally between 2 beakers.
Add the pancreatin suspension (I) to one of the beakers.
For comparison, add only an equivalent amount of water to the second beaker .

Observations:

After a short time the contents of the first beaker become colourless, whereas no change can be seen in the second beaker .

Explanation:

Pancreatin contains the enzyme lipase, which breaks up fat. The free fatty acids that result from the process neutralise the sodium hydroxide. In neutral and acidic conditions, phenolphthalein is colourless.

EXPERIMENT:

How Bile Works

Materials:

Cooking oil, dried ox bile, 2 test tubes, 2 shallow dishes (e.g. petri dishes), pipette

Preparation and Method:

Half fill 2 test tubes with water and add 3 drops of cooking oil to each. In addition, put 1 “spoon tip’s worth” (approx. 50mg) of ox bile into one of the test tubes. Seal the test tubes, shake, and pour the contents of each into a shallow dish. Then compare the diameter of the “fat globules” forming in the dishes.

Observations:

The addition of the ox bile causes smaller globules of fat to form.

Explanation:

Ox bile emulsifies fats. It makes fats that are not water- soluble disperse better in water. This leads to a larger number of fat droplets. The greater surface area that results gives lipase a larger target area.

EXPERIMENT:

Fat Digestion with the Aid of Bile

Materials:

Cooking oil, pancreatin, dried ox bile, dilute sodium hydroxide, phenolphthalein solution. Test tubes, measuring pipette.

Preparation:

I. Bile: Dissolve 5 “spoon tips’ worth” (approx. 250 mg) of dried ox bile in 10 ml of water. Divide solution into two equal portions.

II. Pancreatin solution: Dissolve 5 “ spoon tip s’ worth ” (approx. 300mg) of pancreatin in 10ml of water. Divide solution into two equal portions.

Method:

Put 1ml of cooking oil and 5 drops of phenolphthalein solution into each of 3 test tubes.

Then add the following:

1st test tube: 5ml pancreatin solution + 5ml water

2nd test tube: 5ml bile + 5 ml water

3rd test tube: 5ml bile + 5 ml pancreatin solution

Mix the contents of each test tube by shaking them gently. Add dilute sodium hydroxide drop by drop to each test tube in turn, until the contents of all the test tubes are largely the same colour.

Note:

As bile has a strong colour of its own, it is not possible to get exactly the same colour in each test tube, but the results of the experiment are still clear .

If necessary, the reactions can be speeded up by putting the test tubes in a water bath (40°C).

Observations:

1st test tube: slow loss of colour

2nd test tube: no change

3rd test tube: rapid loss of colour

Explanation:

Pancreatin contains the enzyme lipase that breaks down fat. The free fatty acids that are created in this process neutralise the sodium hydroxide. In alkaline conditions, phenolphthalein is red, but in neutral and acidic conditions it is colourless. With the aid of bile, the fat is dispersed more thinly in the water than when bile is not added. Therefore, bile causes the oil droplets to take on a greater surface area, which aids the enzyme action and thereby speeds up the reaction.

PREPARATORY EXPERIMENT:

Digestion of Carbohydrates: Test for Starch and Glucose (Dextrose)

Materials:

Starch, glucose, Lugol's solution (iodine-potassium iodide solution), Fehling's solutions I and II.

Preparation of experiments:

I. Prepare a starch solution by filling a test tube to about a third full with water and adding a "spoon tip's worth" (approx. 100mg) of starch. Warm the suspension carefully over a bunsen or spirit flame, until the solution turns clear. Then cool the solution again under running water .

II. Preparation of glucose solution: Fill a test tube to about a third full with water and dissolve about 2 "spoon tips' worth" of glucose in it.

III. Preparation of the active Fehling's solution: In a test tube, mix in equal parts a few ml each of Fehling's I and II solution. A dark blue copper complex is formed.

Note:

When kept separately, Fehling's I and II solutions will keep for years. However, the ready-to-use solution quite quickly becomes unstable and must be freshly prepared before each use.

EXPERIMENT:

Test for Starch

Method:

Add a few drops of Lugol's solution to half the starch solution and mix. Any observations?
Now warm the solution and then cool it again.

Observations:

Depending on the amount of starch in the solution, it will turn a blue or blue-black colour. The colour disappears when it is warmed and reappears when it is cooled.

Explanation:

Starch molecules have a helix-shaped secondary structure. Inside the helix, substances such as iodine can lodge (forming an inclusion compound). The compound is unstable and decomposes when heated.

EXPERIMENT:

Test for Glucose

Method:

Add 2-3ml of the prepared Fehling's solution to half the glucose solution and mix.
Then warm the sample in the hot water bath or over a flame (slowly and while agitating) .

CAUTION: Fehling's II contains highly caustic sodium hydroxide. If warmed rapidly in a narrow test tube, this can easily spurt out. Do not point the opening of the test tube in the direction of other people!

Observations:

First of all, a yellow cloudiness can be seen. The colour then changes through orange to red.

Explanation:

Glucose contains an aldehyde group that reduces the blue Cu^{2+} compound to red Cu_2O . The same reaction is shown by fructose, maltose and lactose, but not by saccharose (cane sugar).

Control experiments:

Carry out the starch test with the remaining glucose solution and the glucose test with the leftover starch solution.

Observations:

No reaction is seen.

EXPERIMENT:

Starch breakdown using α -Amylase

Materials:

Lugol's solution, starch, α -amylase, pancreatin, glass rod, shallow dish (e.g. petri dish), cotton wool, writing paper (3 pieces, preferably large, e.g. 10x5cm).

Preparation:

I. Starch solution: add 1 "spoon tip's worth" (approx. 100mg) starch to approx. 10ml water and heat until a clear solution is formed.

II. Amylase solution: add 1 "spoon tip's worth" (approx. 100mg) α -amylase to approx. 5ml water and shake.

III. P ancreatin solution: dissolve 1 "spoon tip's worth" (approx. 60mg) pancreatin in 5ml water (shake).

IV. Dilute Lugol's solution: dilute 1-2ml Lugol's solution with approx. 10ml water and pour out into a shallow dish (petri dish).

Method:

Moisten a cotton ball with starch solution (I) and coat 3 pieces of writing paper on one side with the solution. Leave the starch solution to dry slowly. Then transfer a drop of amylase solution (II) onto the surface of the prepared paper with a glass rod (wooden rod, fingertip), and spread it out into a design of your choice. After the amylase solution has had a few seconds to soak in, dip the paper briefly (!) into the dilute Lugol's solution. Then repeat the experiment, but use the pancreatin solution (III) or a drop of saliva instead of the amylase solution.

Observations:

The surface of the paper that was treated with starch turns blue (iodine-starch reaction). But in the places where amylase, pancreatin or saliva have been left to soak in, little or no starch can be seen.

Explanation:

Amylase breaks down starch. As pancreatin also contains amylase, amongst other substances, the same reaction can be seen. This also applies to saliva.

Variations on this experiment:

You can also carry out the above experiment in a test tube:

Add 2ml amylase or pancreatin solution (II or III) or saliva to the starch solution. Shake! At short intervals, use a glass rod to take a series of samples (1-2 drops is enough). Transfer these onto a sheet of glass and mix with 1 drop of Lugol's solution. After a few minutes, the iodine-starch reaction becomes increasingly weak, until it stops. This shows that the starch has been fully broken down.

EXPERIMENT:

Test for the by-products of starch

Materials:

Starch, α -amylase, pancreatin, Fehling's solutions I and II, test tubes.

Preparation:

I. Starch solution : see above, Preparation no. I

II. Pancreatin solution: dissolve 1 "spoon tip's worth " of pancreatin in approx. 5ml water.

III. Fehling's reagent: see above, Preparation no. III

Method:

Mix the starch solution (I) with 1-2ml of pancreatin solution or saliva, as appropriate, and leave for a few minutes to react. Then carry out the Fehling's test (see glucose test).

Observations:

The Fehling's test is positive.

Explanation:

Pure starch solution does not reduce Fehling's reagent (cf control experiment). Under the influence of amylase, starch is broken down to maltose, which causes the typical Fehling's reaction.

Note:

To show that the pancreatin preparation is sugar-free, you can carry out the Fehling's test with the remainder of the solutions. They should not cause the typical change in the reagent.

EXPERIMENT:

Protein digestion. Protein digestion using pepsin

Materials:

Gelatine, casein, 1 hard-boiled hen's egg, as required, dilute hydrochloric acid. Test tubes, small beaker, measuring pipette, pipette aid.

Note:

Gelatine is a protein extracted from the collagen in bones. Casein is the most important protein component in milk. It is composed of a number of different proteins. It is insoluble in both pure water and acidic pH conditions. However, it is soluble in alkalines.

Preparation:

I. Put 10ml water into a test tube, add 3 "spoon tips' worth" of pepsin and dissolve by shaking gently . The result is an approximately 1-2% pepsin solution.

II. Pipette 3ml of dilute hydrochloric acid into a small beaker (corrosive, so use a pipette aid!) and add 30ml of water . A dilute hydrochloric acid results. This has a concentration roughly the same as that of human gastric acid.

Method:

First, put 1 rectangular piece of gelatine (approx. 1x3cm) into each of 5 test tubes. The experiment can also be done using casein instead of gelatine, using 2 "spoon tips' worth" of casein per test tube. Also very suitable for protein digestion experiments is the coagulated egg white of a hard-boiled egg. Put a piece about the size of a pea in each test tube.

Set the test tubes up in the following way:

1st test tube: 10ml water + 2ml water

2nd test tube: 10ml dilute hydrochloric acid (II) and 2ml water

3rd test tube: 10ml water + 2ml pepsin solution (I)

4th test tube: 10ml dilute hydrochloric acid (II) + 2ml pepsin solution (II)

5th test tube: like 4th, but boil the pepsin solution (I) thoroughly before it is added.

If, at this stage, the experiments are left to stand at room temperature, the gelatine and casein tests can be evaluated after some 30-60 minutes. However, if egg white is used, it is approx. 1-2 days before the pepsin's digestive effects can be clearly seen. But with the aid of a chemical oven or a water bath (37°C) you can speed up the casein or egg protein digestion. This procedure is not appropriate for gelatine digestion as gelatine dissolves in warm water.

Observationss:

1st test tube: no change. After a few days decomposition sets in, particularly if egg white is used (it smells!).

2nd test tube: no change, even after a few days or weeks.

3rd test tube: as for 1st.

4th test tube: Even after only a short period of time, the gelatine shows "signs of disintegration". After 30-60 minutes the gelatine has "disappeared". The casein is however not completely broken down but, in comparison to the 2nd test tube, a clear reduction in the amount of undissolved casein can be seen. There is a particularly clear difference if the contents of the test tube are stirred up and the comparative observations made when the test tubes are held up to the light. The egg white has been largely broken down.

5th test tube: as for 2nd.

Explanation:

1st test tube: Proteins that are insoluble in water do not change at first. After a few days, bacterial breakdown (decomposition) can be seen.

2nd test tube: Dilute hydrochloric acid alone cannot digest protein. However, it has a sterilising effect that prevents decomposition.

3rd test tube: Pepsin alone cannot break down protein. Without the sterilising effect of hydrochloric acid, bacterial breakdown (decomposition) occurs after a few days.

4th test tube: In the presence of dilute hydrochloric acid, pepsin can digest protein.

5th test tube: Boiling destroys the enzyme structure. Through this, the enzyme becomes inactive.

The effects of temperature on digestive processes

The dependence of digestive processes on temperature can be shown using the protein digestion experiment. An additional 3 test tubes are filled with the contents of the 4th test tube from the initial stage of the experiment. They are then kept at differing temperatures (fridge, room temperature, 37°C). In line with the rule that states that reaction speed depends on temperature, the protein is more rapidly broken down under higher temperatures than under lower ones. The optimum temperature for pepsin activity is 37°C.

Comment:

Egg white should be used as the protein.

EXPERIMENT:

Protein digestion in the pancreas

Amongst other substances, pancreatin contains protein-busting enzymes that become active in the neutral or mildly acidic conditions of the stomach.

Materials:

Pancreatin, gelatine, 1 hard-boiled hen's egg, as required, dilute sodium hydroxide, test tubes, pipette.

Preparation:

I. Pancreatin solution: Mix 10ml water with 1 "spoon tip's worth" (approx. 60mg) of pancreatin and dissolve, shaking gently .

II. Cut up 2 pieces of gelatine (approx. 1x3cm) or cut 2 pieces of egg white to the size of a pea.

Method:

Set up the following test tube experiments:

1st test tube: Mix 10ml pancreatin solution with 1 drop of dilute sodium hydroxide (caution:caustic!) and add 1 piece of gelatine.

2nd test tube: Mix 10ml water with 1 drop of dilute sodium hydroxide and add 1 piece of gelatine (for comparison).

Analyze after approx. 1-2 hours. The experiment only works at room temperature. When warmed, gelatine disintegrates, giving misleading results .

Instead of gelatine, we also recommend using boiled egg white in the form of pieces the size of a pea. At room temperature, these can be analyzed after 1-2 days. The rate of the experiment can be speeded up by raising the temperature to approx. 40°C (water bath, chemical oven).

Observations:

1st test tube: As was the case with pepsin, after a short time gelatine also shows "signs of disintegration" when in the presence of pancreatin. After an hour or so, a large proportion of the gelatine has been broken down. If an egg is used as the protein source, decomposition takes considerably longer.

2nd test tube: This part of the experiment acts as a control. Even after a long period of time, no change is seen. After a few days the test tube contents begin to rot.

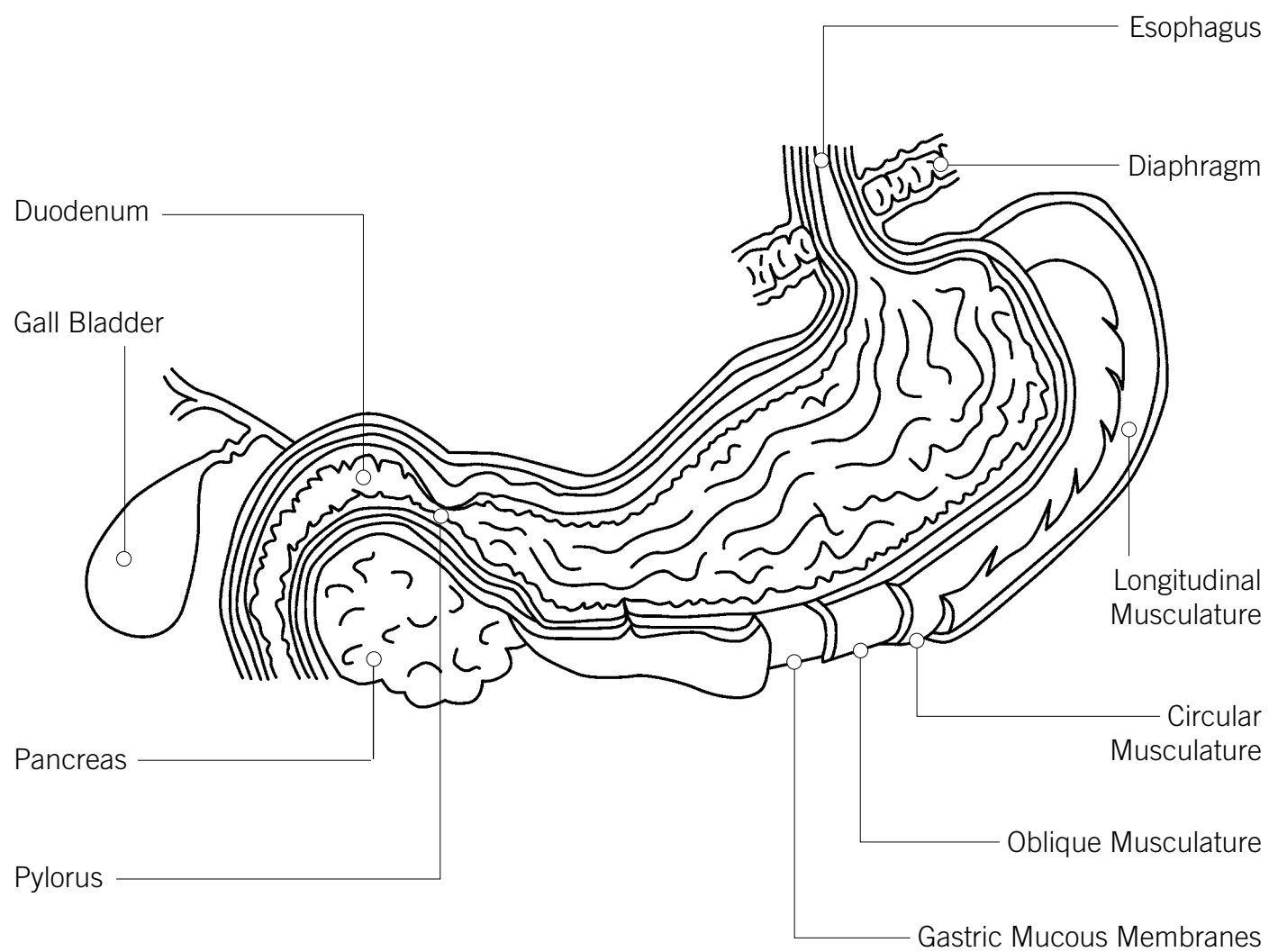
Explanation:

1st test tube: In mildly alkaline conditions proteolytic enzymes break down proteins to amino acids.

2nd test tube: A mildly alkaline solution alone cannot break down proteins.

Stomach:

1. Write the biography of a stomach (from beginning to end)
2. While doing so, think about its consequences for the body.
3. Draw pictures to accompany your biography to make a poster.



The route that food takes:

1. Name the organs displayed in the illustration which are involved in digestion.



2. Summarize the functions of individual sections of the gastro-intestinal tract. Fill in the table:

ORGAN	FUNCTIONS

ANSWER KEY

- 1. Name the organs displayed in the illustration which are involved in digestion.
- 2. Summarize the functions of individual sections of the gastro-intestinal tract.

ORGAN	FUNCTIONS
Mouth	Reducing the food pieces in size, insalivation, starch digestion, transportation of the food pulp through the esophagus
Stomach	Collection, mixing, gastric juice is added here, killing of bacteria, digestion of proteins
Small intestine	Juice from the liver and the stomach's salivary glands are added, digestion of the three basic materials (carbohydrates, proteins and fat), absorbing into the blood
Colon	Removal of water, transportation of the indigestible remnants, expulsion through the anus

Comparison of the small intestine and the colon



Picture 1:
Section of small intestine showing relief of membranous lining.

Picture 2:
Section of large intestine (colon).

Summarize the differences in a table.

Small intestine	Feature	Colon
	Position	
	Length	
	Inner surface arwea	
	Functions	
	Passing on the chyme	

ANSWER KEY

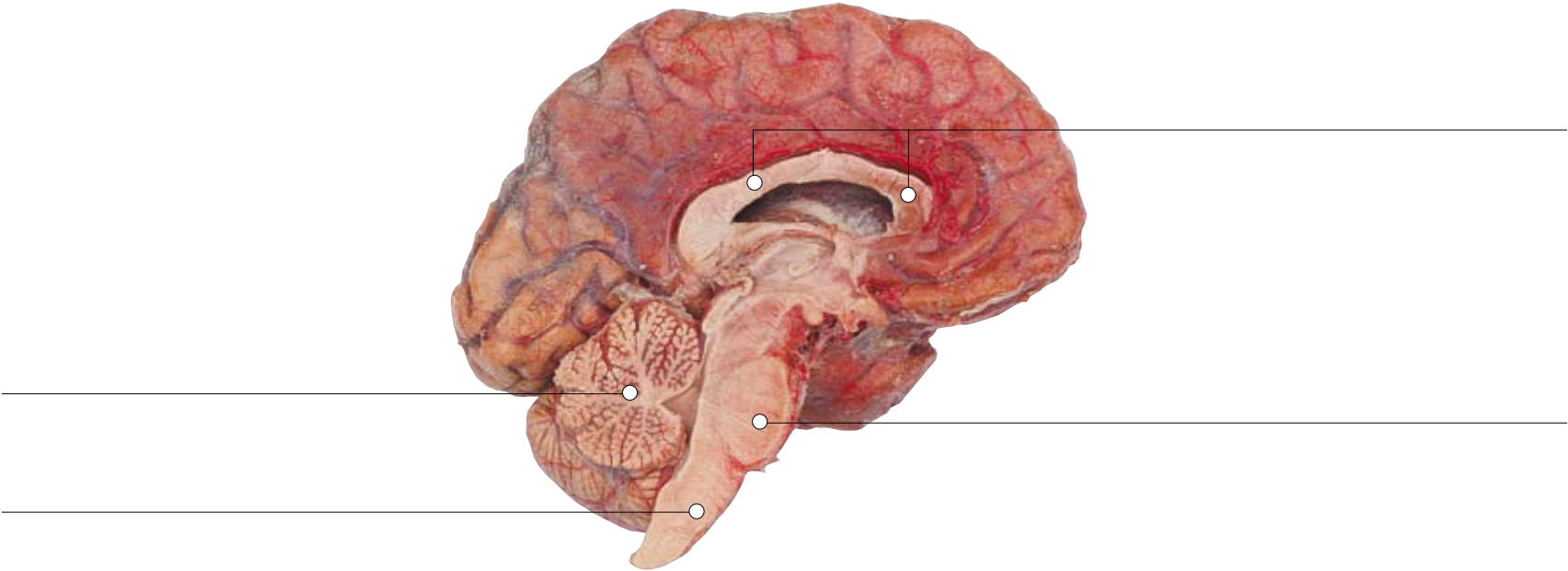
1. Comparison of the small intestine and the colon

Summarize the differences in a table.

Small intestine	Feature	Colon
<i>Connected to the stomach</i>	Position	<i>On the right side of the stomach, rises up to the liver</i>
<i>4 to 6 meters</i>	Length	<i>1.5 to 2 metres</i>
<i>Made greater by intestinal villi, ring-shaped folds, and epithelial cells</i>	Inner surface area	<i>Made greater by crescent shaped folds</i>
<i>Decomposition of the food into the end products of digestion, absorption</i>	Functions	<i>Regaining of water</i>
<i>Peristaltic movements</i>	Passing on the chyme	<i>Kneading movements of the colon musculature</i>

The nerve centre—the brain

1. The illustration shows the left side of the brain.
Name the individual areas of the brain and indicate what functions they have.



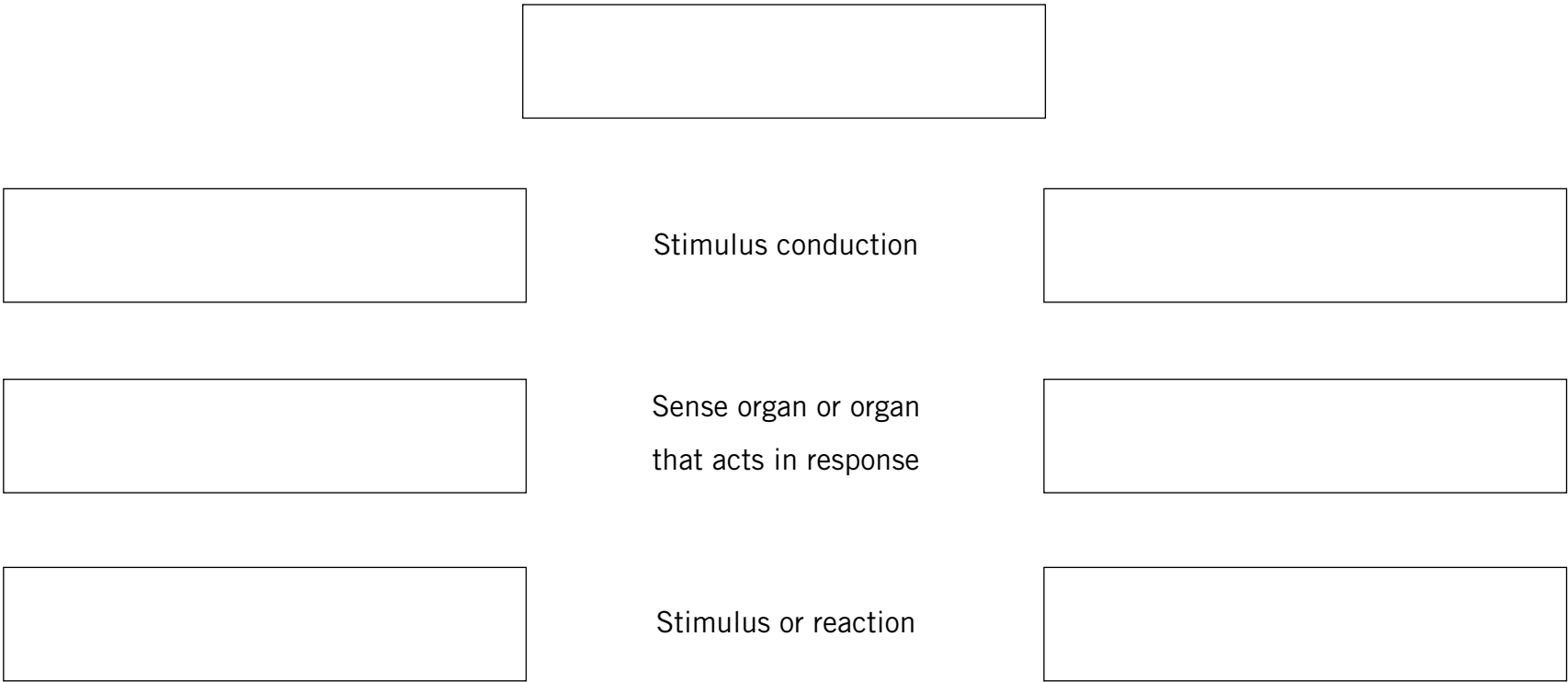
DESCRIPTION	FUNCTION

2. What is a reflex?

3. Describe a goalkeeper's reaction when the ball comes towards him.



4. To explain this, draw up a stimulus-reaction chain.



5. Complete the following text:

Excitations run from the organs through the spinal cord to the brain or from the brain through the spinal cord to the organs. The brain and the spinal cord together form the

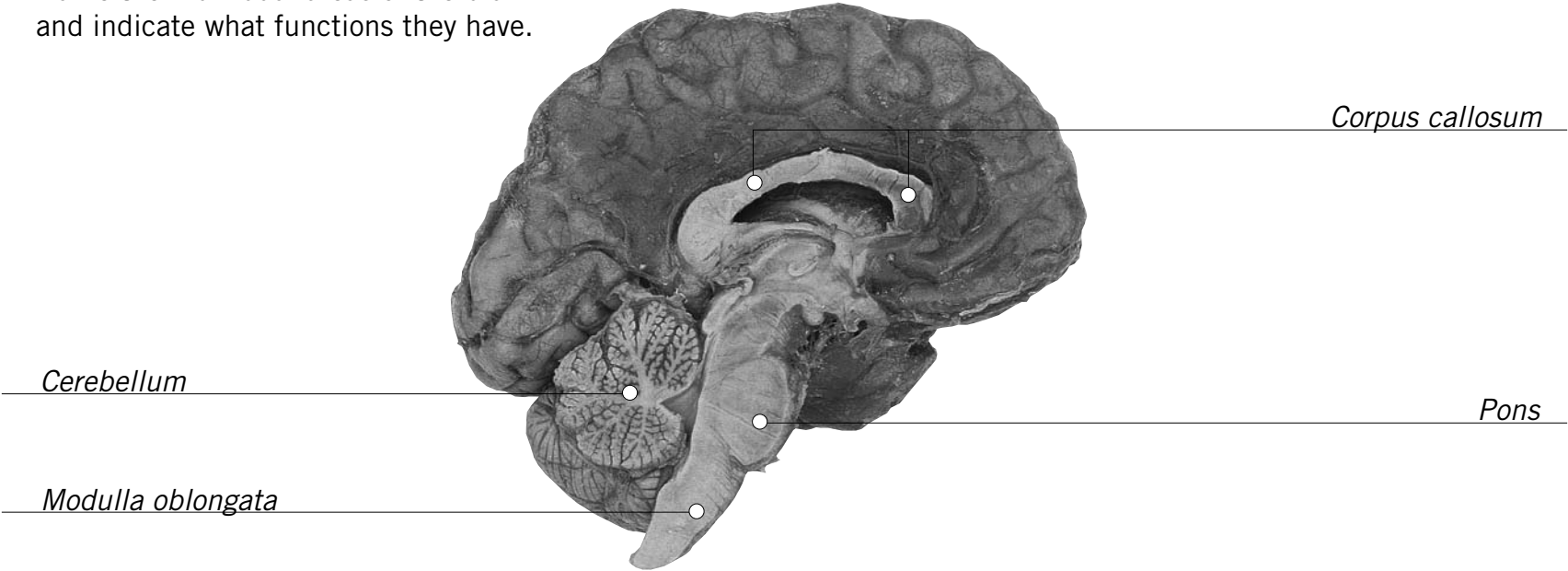
6. Name the two parts of the vegetative nervous system and, for each, add the effects on the organs to the table.

Organs	Part	
Pupils		
Lungs		
Heart		
Small intestine		
Emptying the bladder		

ANSWER KEY

The nerve centre—the brain

1. The illustration shows the left side of the brain.
Name the individual areas of the brain
and indicate what functions they have.



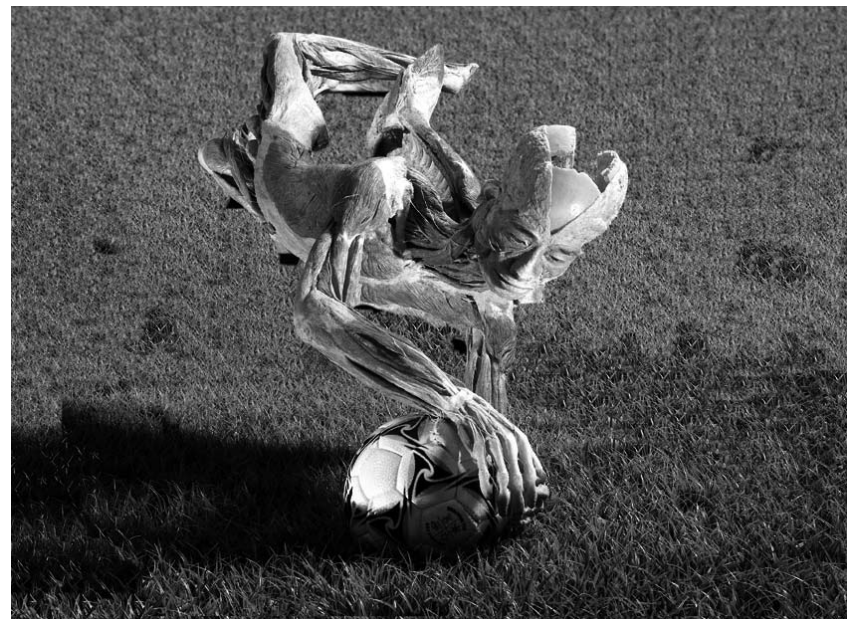
DESCRIPTION	FUNCTION
Cerebrum	perception, thinking, behaviour, feeling, consciousness
Corpus callosum	connect the two halves of the cerebrum
Cerebellum	controls balance and movement
Medulla oblongata	regulates breathing and circulation

2. What is a reflex?

A reflex is a fast reaction that takes place subconsciously, i.e. without the involvement of the cerebrum.

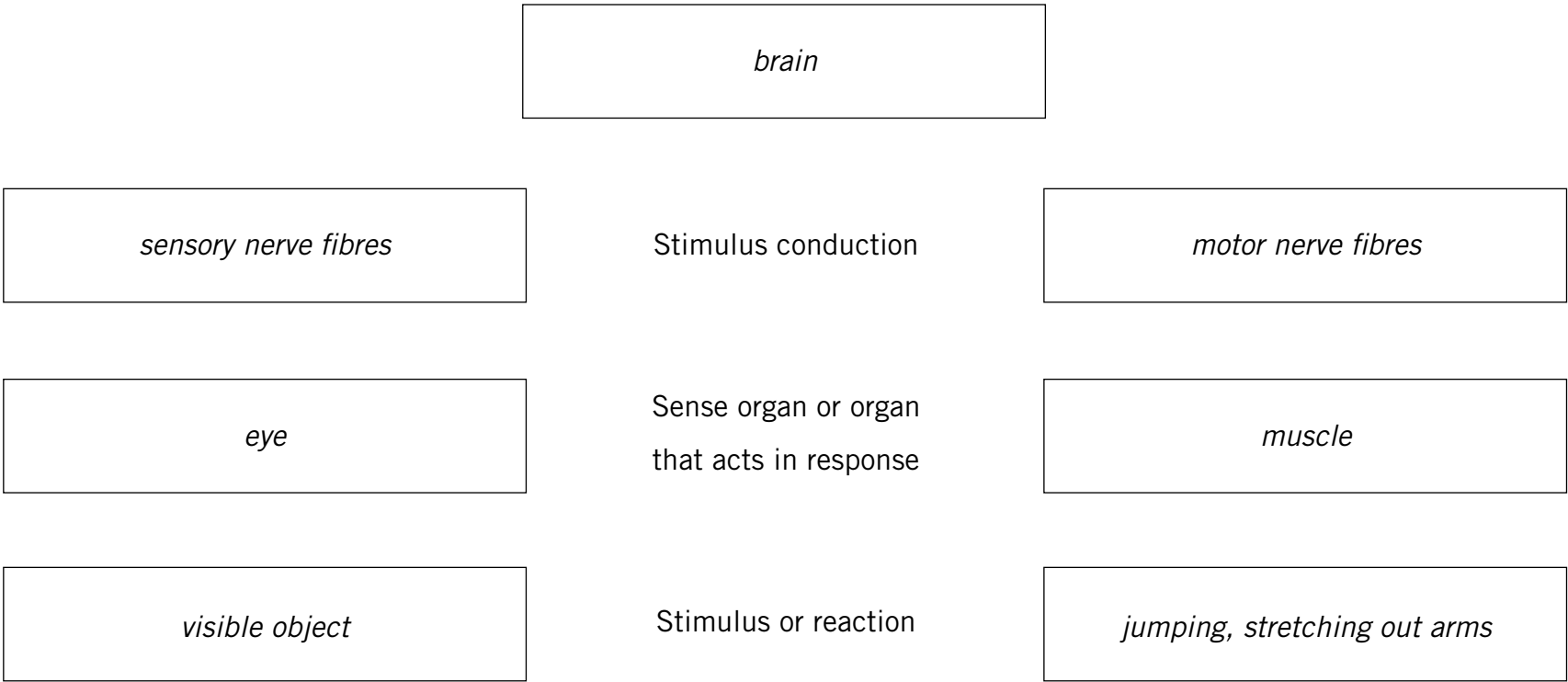
A reflex cannot be triggered consciously ...

3. Describe a goalkeeper's reaction when the ball comes towards him.



Goalkeeper sees the ball, stretches out his arm, dives in the direction of the ball, tries to catch the ball. ...

4. To explain this, draw up a stimulus-reaction chain.



5. Complete the following text:

Excitations run from the organs through the spinal cord to the brain or from the brain through the spinal cord to the organs. The brain and the spinal cord together form the

central nervous system.

6. Name the two parts of the vegetative nervous system and, for each, add the effects on the organs to the table.

Organs	Part	
	<i>Sympathetic system</i>	<i>Parasympathetic system</i>
Pupils	<i>Widening</i>	<i>Narrowing</i>
Lungs	<i>Widening</i>	<i>Narrowing</i>
Heart	<i>Stimulating</i>	<i>Inhibiting</i>
Small intestine	<i>Inhibiting</i>	<i>Stimulating</i>
Emptying the bladder	<i>Inhibiting</i>	<i>Stimulating</i>

Welcome

A letter from BODY WORLDS

Dear Students,

Have you ever watched a professional basketball player seem to float in air as he or she leaps up to dunk the ball in the basket? Or maybe you watched skiers and skaters competing at the Olympics, and wondered “How did they do that?”

Well, our bodies are pretty amazing. And the more we learn about ourselves and how our bodies work, the better we can take care of ourselves and others. And, the healthier we will be—making us better on the ice rink, basketball or tennis court, jumping hurdles, or just walking down the street.

“Gunther von Hagens’ BODY WORLDS: The Original Exhibition of Real Human Bodies” was developed by a German doctor and anatomist to help people understand how their bodies work by letting them look inside real human bodies. When you visit with your school or family, you will see exactly how your brain and your heart look and what happens to them when certain diseases take over. You will see how smoking destroys your lungs, and how your bones, muscles and ligaments all work together so you can shoot baskets, dance, or figure skate. The activities inside this guide will help you learn more about the human body.

Then come visit us to see BODY WORLDS.

You’ll really get to know yourself!



Angelina Whalley
Dr. Angelina Whalley

Conceptual Designer for BODY WORLDS and Managing Director
of the Institute for Plastination

Exhibition Overview including Human Facts



Gunther von Hagens' BODY WORLDS exhibits use the science of Plastination to let visitors see how human bodies are put together. The exhibit also teaches how different anatomical systems work in the human body. This special student supplement also explores several of the systems featured in the exhibit, including the locomotive system, the respiratory system, the digestive system, the nervous system and the cardiovascular system.

The Locomotive System

Makes motion happen

The locomotive system is the system in the body that makes movement possible. It consists of the bones that make up the skeleton, the joints that hold the bones together and the muscles that contract and relax to actually make you move.

The skeleton is the framework of the body, and it is made up of bones and cartilage. Bone is made mostly of calcium, which is why it is important to drink milk to keep your bones strong. Milk is a food that is rich in calcium.

Inside the bone is sponge-like matter called bone marrow. This makes bones light so people can move easily, but strong enough to support body weight. Bone marrow also produces red and white blood cells. Red blood cells have hemoglobin and carry oxygen. White blood cells produce antibodies to attack bacteria, infections and diseases.

The skeleton has many jobs. It provides protection to internal organs, it supports the body and gives it its shape, and it provides a place for muscles to attach. Bones are important to almost every movement we make. Bones couldn't move a pencil, though, without help from muscles. Muscles consist of cells that contract.

Muscles and bones are connected by tendons, which are something like ropes. When a muscle contracts, it pulls the tendon, which then tugs on the bone, and everything moves.

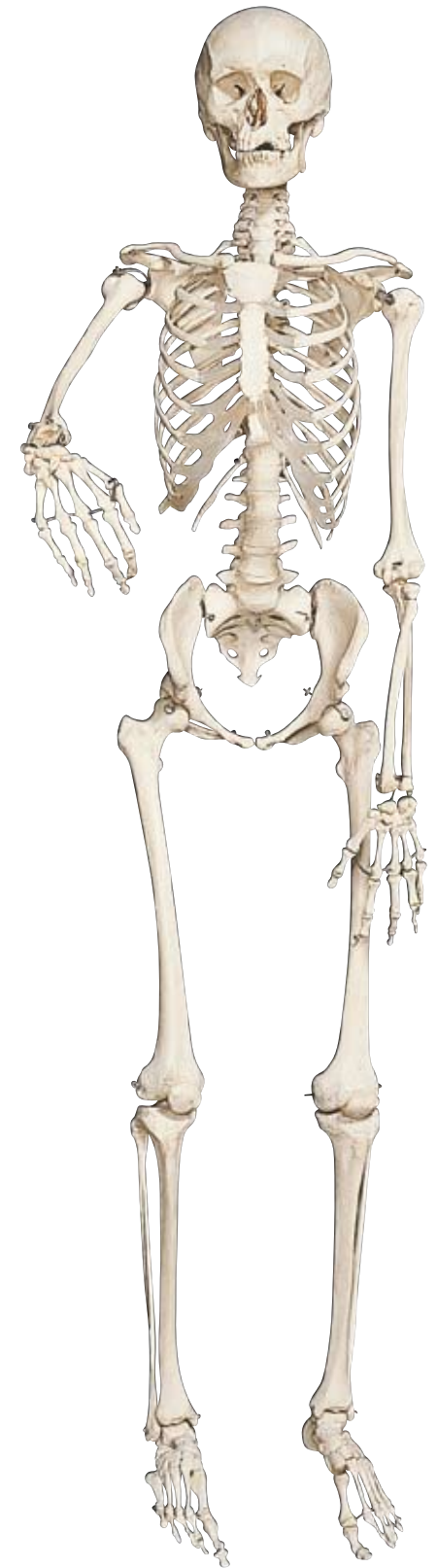
Although it may seem easy to do something like throw a ball, it's actually complicated when looked at inside the body. To make the motion of throwing, many muscle groups in the shoulders, arms, chest, abdomen and even legs must be used! Each of these groups must work together with nerves in order for motion to occur. And all this happens in a fraction of a second!

COOL FACT

At birth, humans have 300 bones. As a baby grows, however, many of the smaller bones fuse together so that adults have just 206 bones.

Voluntary muscles are used when you throw a ball. These are the muscles we can control. People also have involuntary muscles, which we cannot control, such as the heart and the stomach.

Another important part of the locomotive system are the joints. Joints are positioned between major bones that come together and help you to move and bend.



There are different kinds of joints, including ball and socket joints in the hips and hinge joints at the knees and elbows. Joints are surrounded by capsules containing fluid that help the bones move smoothly.

Learn with BODY WORLDS

The bones of the human skeleton give the body both strength and structure. A strong and healthy skeleton is important for every person for both work and recreation. Think of three things that you do every day that involve the use of certain bones.

The Nervous System

The messenger and the Boss

The nervous system is the system of the body that controls movements, thoughts and emotions throughout the body. Without it, you wouldn't be able to function!

There are two parts to the nervous system: the central nervous system and the peripheral nervous system.

The central nervous system includes the brain and the spinal cord. They work together with nerves to send messages back and forth between the brain and the rest of the body.

The brain is the boss. It has five parts: the cerebrum, the cerebellum, the brain stem, the pituitary gland and the hypothalamus. The cerebrum is the biggest part of the brain and controls thoughts, language and voluntary muscles, which are the muscles you can control. You also use the cerebrum when you think hard in school

COOL FACT

The nervous system carries messages from the brain to other parts of the body at more than 100 miles per hour.

and when you need to remember things.

The cerebellum is a lot smaller than the cerebrum, but still very important.

It controls balance, movement and coordination. If it weren't for the cerebellum, you wouldn't be able to stand without falling!

The brain stem connects the rest of the brain to the spinal cord. It's the part in charge of major things that keep you alive like breathing, blood pressure and digesting food. Unlike the cerebrum, the brain stem controls the involuntary muscles—the ones that work without you thinking about it, such as the heart and stomach.

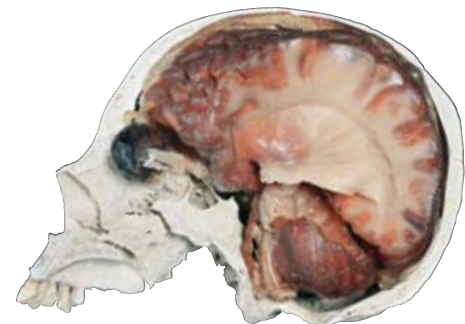
The tiny pituitary gland produces and releases hormones into the body—hormones like those that help you grow and change.

Finally, the hypothalamus regulates your body temperature, your emotions and hunger and thirst.

The brain has many jobs, but it needs help from nerves and the spinal cord, too. Every action you do happens because your brain, your nerves and your spinal cord work together.

The nervous system includes millions and millions of neurons, which are microscopic cells. When you do something, messages travel from the neurons to your brain.

The peripheral nervous system is composed of the nerves and neurons that go outside the central nervous system to operate the body's limbs and organs. It is here that everything gets connected.



Next time you take a test, drink a glass of water, laugh or do anything at all, thank your nervous system. Actually, you can thank it right now since it just helped you read this!



Learn with BODY WORLDS

The nervous system carries messages to the brain that make it possible for the body's five senses to work. The five senses are touch, taste, hearing, sight and smell. Explore the five senses by writing about one of your favorite things for each sense. For example you may say that you enjoy listening to classical music, because it helps you concentrate. This relates to your sense of hearing.

The Respiratory System

Oxygen in, carbon dioxide out

The organs of the respiratory system work together, along with other body systems, to ensure that the cells of the body receive the oxygen they need to live.

When you breathe in, the muscles of your chest expand. Your diaphragm lowers, and creates lower air pressure in your lungs than in the world outside. This causes air to enter through the nose or mouth.

Once air enters, it travels past your esophagus, sometimes called the “foodpipe,” and is moistened as it goes down the trachea, or “windpipe,” into the lungs. As the air enters the lungs, the lungs expand outward.

Once inside the lungs, the air travels through tubes called bronchi, into smaller tubes called bronchioles, which get smaller and smaller until they reach alveoli, which are sacs about the size of a grain of sand.

It is through the walls of the alveoli that the oxygen in the air you breathe enters the body’s blood, which flows past the alveoli. The blood receives the oxygen, and in return passes carbon dioxide into the alveoli.

The cells of your body need oxygen to live, and carbon dioxide is the waste of things the cells do. Your red blood cells are little workers that carry the oxygen to the cells, and take the carbon dioxide away.

Smoking, as we all know, makes the lungs less healthy, and can lead to death.

One of the reasons for this is that smoking makes little structures called cilia stop working. Cilia move within the lungs to help clear things out that enter the lungs. Smoking disables or even kills them. Then harmful particles stay in the lungs.

Another bad effect of smoking is that chemicals from cigarettes will build up in the lungs, and the delicate alveoli can become thickened, swollen, and unable to exchange oxygen and carbon dioxide with the blood in a healthy way. This condition leads to emphysema.

Think about it

Plants take the carbon dioxide that we release and use it, creating oxygen, which we need. We in turn take oxygen and turn it into carbon dioxide, which plants need. This is what is called a symbiotic relationship—one that is good for both organisms. Try to think of other ways in which humans interact with nature in symbiotic relationships.

COOL FACT

Your left lung is a bit smaller than the right, to leave room for your heart.



Learn with BODY WORLDS

A healthy respiratory system makes it possible for people to live active lives. Smoking causes problems for the respiratory system. Make a list of five reasons why you shouldn’t smoke.

The Cardiovascular System

The body's great pump

Images of hearts are often used to symbolize romance or love.

But actually—and more importantly—the heart is the central organ of the cardiovascular system, and it doesn't look much like the drawings found on Valentines.

Cardio means heart, and the cardiovascular system is essential to our survival.

The cardiovascular system is sometimes referred to as the circulatory system because it's responsible for the circulation of blood through the body.

COOL FACT

At every stage of life, your heart is about the size of the fist you make when you close your hand.

It consists of the heart, which is a

muscular pumping device, and a closed system of vessels called arteries, veins and capillaries.

The cardiovascular system's vital role is to provide a continuous and controlled movement of blood through the thousands of miles of microscopic capillaries that reach every tissue and cell in the body. Human survival depends on the circulation of blood to the organs, tissues and cells of your body.

Arteries carry blood enriched with oxygen away from the heart, and veins carry blood that has used up its oxygen back to the heart. Through the heart and lungs, the blood gets a fresh supply of oxygen and delivers it to the rest of the body.



Twenty major arteries make a path through the tissues of the body. Then they branch out into smaller vessels called arterioles. These branch further into the capillaries, most of which are thinner than a hair—some so tiny, in fact, that only one blood cell can move through at a time.

Once the blood in capillaries delivers oxygen and nutrients, it picks up carbon dioxide and other waste. Then blood moves back through wider vessels, called venules. These eventually join to form veins, which deliver the blood back to your heart to pick up oxygen.

If all the vessels of this network were laid end to end, they would extend about 60,000 miles, far enough to circle Earth more than twice!

Because all the tissues in the body rely on it, the cardiovascular system appears early in developing embryos—in the fourth week after fertilization—and reaches a functioning state long before any other major organ system.

Learn with BODY WORLDS

The cardiovascular system is a delicate system and can be affected by many things. Fats and cholesterol, for example, can slow or even block the flow of blood in the body. Fats and cholesterol enter the body through foods people eat, and that is one reason people are encouraged to limit the amount of fatty or oily foods they eat. Think of ten fatty foods and ten healthier options. For example, you may think of a doughnut as a fatty food and toast as an alternative.



The Digestive System

Converting food into energy

The body's digestive system converts the food you eat into the energy you need to live.

The journey through your digestive system is a long one for food. It starts in the mouth, where teeth grind and tear the food into small pieces. Saliva then wets and softens the food, and begins to dissolve carbohydrates. Once the food is properly mashed and wet, it is pushed by muscle action into the pharynx, or throat, and down the esophagus, which leads to the stomach.

COOL FACT

Your mouth makes about half a quart of saliva each day, and you produce a total of about seven quarts of digestive juices.

When food reaches the stomach it is mixed and broken down further by acids the stomach produces. The stomach protects itself from these acids by secreting a layer of mucus that lines the inside of the stomach.

Some things, such as water and sugars, can be absorbed right out of the stomach and into the bloodstream.

The things that need more digestion have further steps ahead of them. When the stomach has made the food a liquid, the

food passes through a valve into the small intestine.

The small intestine has a large surface area because it contains villi. Villi are tiny little structures like very short hairs that stick out into the small intestine.

Through the walls of the villi nutrients from food pass into the bloodstream. The bloodstream carries the nutrients to your cells so they can live.

Once all the useful nutrients have been taken from food in the small intestine, the unusable parts pass into the large intestine, or colon.

In the large intestine, water is extracted from the waste and the material hardens into feces. The feces are passed out of the body when you go to the bathroom.

Digestive helpers

The pancreas, liver and gallbladder are all organs that do things important to the digestive system. The pancreas makes enzymes that help digest proteins, fats and carbohydrates. The liver makes bile, which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. Enzymes and bile travel into the small intestine through ducts. Interestingly, people don't really need the gallbladder. If it is removed, the bile just flows right into the small intestine and does its job.



Learn with BODY WORLDS

The digestive system breaks down the food that supplies the human body with energy. What foods would you eat if you needed energy for sports or active recreation?

Pick five foods you think would be good sources of energy. Then pair off and research your foods. Were they all healthy choices for getting the energy you needed?

Art in Science

The beauty of the body

The BODY WORLDS exhibits teach a great deal about the science and anatomy of the human body.

They also teach about the form and art of the human body.

Studies of anatomy have always been a key part of art education. Artists who know how the human body is put together, and how its muscles work, are better able to portray people in painting, sculpture and other art forms.

This knowledge is important, even if artists choose to represent the human form in abstract ways rather than realistic representation.

In the BODY WORLDS exhibits, Gunther von Hagens has positioned human figures to reveal how the body is put together and how it performs different tasks. He also has presented human figures in ways that highlight different body systems.

A group display called “The Blood Vessel Family,” for example, reveals the human form through its network of blood vessels. The scientific choices he has made give visitors a new way to understand how human bodies work. At the same time, he has revealed how beautiful the form and systems of the human body are.

As visitors go through the exhibits, they learn the science and biology of anatomy. They also get to experience the artistic qualities of anatomy.

This gives the exhibits appeal to all students, not just those in science classes.

Think like an artist

Like Gunther von Hagens, artists sometimes like to focus on one aspect of a figure. In art, this may be done by emphasizing one feature of a person, or showing the subject from an unusual angle or perspective.

Explore this idea by thinking about someone in your family. Reflect on what this person is like, or what you admire about him or her. Then think about what you would focus on if you were to portray this person in an artwork. Draw a sketch of your artwork and explain your ideas to the class.

Photos as art

Newspaper photographers often are asked to take photo portraits of people in the news. These portraits often could be considered photographic artworks. Look through the news and features sections of The newspaper for several days and clip photos portraying people. Pick the one you like the most and explain to the class what makes the portrayal effective or artistic in your eyes. Finish by giving the photo a title, and explain it to classmates.

Sports anatomy

Coaches need to know how to evaluate the physical skills and talents of players. These talents often are based on anatomy. Pick an athlete you admire. Then think about the different body systems explored in this guide. Write out which systems contribute most to the success of this athlete.



Learn with BODY WORLDS

Understanding how the body works is important in many professions. Think about what you may want to be when you grow up, and write a short sentence or paragraph explaining what about anatomy is important in the job, and why.

Would you do it?

Thoughts about Plastination and your body

All specimens in Gunther von Hagens' BODY WORLDS exhibits are authentic. They belonged to people who declared during their lifetime that their bodies should be made available after their deaths for the instruction of doctors and the education of the public. "BODY WORLDS is most of all a collaboration between the donors and myself, and all those who view the exhibit," von Hagens says. "All of humanity owes the donors a great deal, for without them, there would be no BODY WORLDS."

To ensure that donors make the decision willingly, von Hagens' Institute for Plastination requires that all donors sign an official consent form.

In the form, the donors must declare that they have made the decision "freely and voluntarily" to donate their body "for the purpose of anatomical research and education ... for students and especially for the general public."

In addition, they must check off answers to specific questions that have been raised by Plastination so there is no doubt they fully understand their decision.

"I agree for my body to be used for any purposes, provided it is to do with medical research or training" reads one example. Or "I agree that my plastinated body can be used for the medical enlightenment of laypeople and, to this end, exhibited in public (e.g. in a museum)."

Or "I agree that my body can be used for an anatomical work of art."

Or "I agree that lay people be allowed to touch my plastinated body" in some exhibits.

Donors to the Institute for Plastination have the option to donate all useable organs to save lives before their bodies are plastinated.

COOL FACT

Plastination takes a very long time. A whole body can take up to 1500 hours to prepare.

Talk about it

As a class, discuss whether you would want to have your body, or the body of a relative, plastinated for education or display. Then discuss whether you think it is a good idea to exhibit plastinates for the general public. To ease discussion, you can set up a "For Chair" and an "Against Chair" to sit in at the front of the room when offering your opinion.

In your discussion:

- Consider what motivates a donor to allow his/her body to be plastinated for education or an exhibit.
- Consider how the friends and relatives of a donor might feel.
- Imagine that a member of your immediate family wanted to be plastinated.
- Consider what you might learn—or did learn—about your own body from viewing the BODY WORLDS exhibits.

Learn with BODY WORLDS

After holding the class discussion, summarize the general feelings of the class in a news story of the style found on the front page of a newspaper. Talk about how newspaper reporters must weigh all information before making a general conclusion. Then compare summaries written by different members of the class. How similar were they? What were some differences? What was the source of those differences?

What is Plastination?

The method of Plastination explained

Plastination is a relatively simple process designed to preserve the body for educational and instructional purposes. Plastination, like many revolutionary inventions, is simple in concept:

Embalming and Anatomical Dissection

The first step of the process involves halting decay by pumping formalin into the body through the arteries. Formalin kills all bacteria and chemically stops the decay of tissue. Using dissection tools, the skin, fatty and connective tissues are removed in order to prepare the individual anatomical structures.

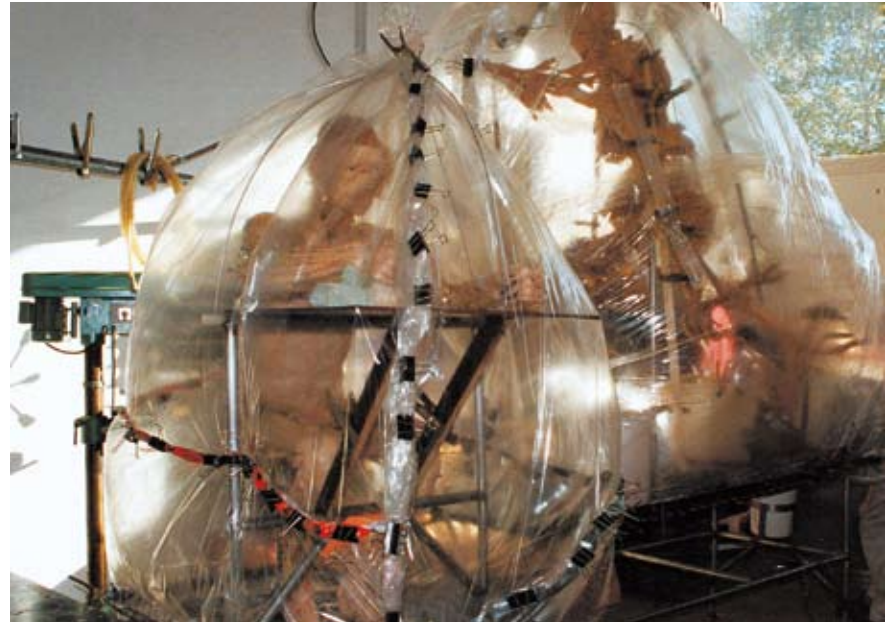
The Plastination process itself is based on two exchange processes:

Removal of Body Fat and Water

In the first step, the body water and soluble fats are dissolved from the body by placing it into a solvent bath (e.g., an acetone bath).

Forced Impregnation

This second exchange process is the central step in Plastination. During forced impregnation, a reactive polymer, e.g., silicone rubber, replaces the acetone. To achieve this, the specimen is immersed in a polymer solution and placed in a vacuum chamber. The vacuum removes the acetone from the specimen and helps the polymer to penetrate every last cell.



Specimens plastinated with silicone are cured with a special gas.

Positioning

After vacuum impregnation, the body is positioned as desired. Every single anatomical structure is properly aligned and fixed with the help of wires, needles, clamps, and foam blocks.

Curing (Hardening)

In the final step, the specimen is hardened. Depending on the polymer used, this is done with gas, light, or heat.

Dissection and Plastination of an entire body requires about 1,500 working hours and normally takes about one year to complete.

Sheet Plastination


Sheet Plastination is a special form of Plastination. For this process, the body is deep frozen and cut into slices of 2 to 8 mm in thickness (1/12 to 1/3 inch). Instead of silicone, polyester resin or epoxy resin are used for impregnation.

Learn with BODY WORLDS


The BODY WORLDS exhibits reveal how human bodies work when people take part in activities like sports, dance, chess or teaching. Different displays focus on different systems in the body. In today's paper, find a photo of a person involved in an activity that interests you. Think about what the body has to do for that activity. Then write a paragraph describing what part or system of the body you would like to show if you could create a plastinate in action.

Additional Resources

National Institutes of Health—The Visible Human Project

 http://www.nlm.nih.gov/research/visible/visible_human.html

BBC Science and Nature—The Human Body and Mind

 http://www.bbc.co.uk/science/humanbody/body/index_interactivebody.shtml

Kids' Health Organization

 <http://www.kidshealth.org/>

Discovery Communications—The Yuckiest Site on the Internet Teacher Guide

 <http://yucky.kids.discovery.com/teachercenter/pg000064.htm>

www.bodyworlds.com



Institute for Plastination