



Gunther von Hagens'

BODY WORLDS 2

The Anatomical Exhibition of Real Human Bodies

SEPTEMBER 30, 2005 - FEBRUARY 26, 2006

Planning a school visit to BODY WORLDS 2: The Anatomical Exhibition of Real Human Bodies? This exhibition is a wonderful opportunity for you and your students to explore, discover and learn together.

Here are some tips for visiting BODY WORLDS 2 with students:

- Review the BODY WORLDS 2 Educator's Guide to prepare yourself for questions that students may have about this experience. It is best to answer questions in an honest and straightforward fashion.
- Send the permission form home with students to their parents/guardians.
- Discuss the visit with your students in advance. Explain what they will see and the purpose of the exhibition. Be prepared to answer more questions during your visit—what they may see may impact your students in unpredictable ways.
- Help your students relate what they see to their own lives (e.g. "Who knew that it requires so many muscles to ride a skateboard?")



EDUCATOR'S GUIDE TO BODY WORLDS 2

Resource Package for Secondary
School Groups (Grades 9-12)



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Planning Your Visit

Before

- Read the Letter to Educators and Frequently Asked Questions in this Guide.
- Visit the Ontario Science Centre website (www.OntarioScienceCentre.ca) for a preview, and to request your free BODY WORLDS 2 DVD and brochures.
- Since students bring a range of life experiences and points of view to the exhibition, teachers should anticipate their students' responses. Many Boards of Education have resource documents, such as the Toronto District School Board's publication, "A Teaching Resource for Dealing with Controversial and Sensitive Topics in Toronto District School Board Classrooms". These documents provide guidelines for teachers to examine their own biases and introduce issues to students.
- It is recommended that 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 2 DVD with students and participate in the activities found in this Guide.
- Administer permission forms to parents and guardians.
- Complement your visit to BODY WORLDS 2 by also booking a school program (*Body Works* or *Human Anatomy and Physiology*) and/or the IMAX® Dome film *The Human Body*.

During

- Bring the Educator's Guide with you to the Ontario Science Centre.
- Consider renting an Audio Guide.
- Seek out the Ontario Science Centre Hosts for answers to your questions about the exhibition.

After

- Complete the suggested activities with your students.
- Consider sharing your students' reactions to BODY WORLDS 2 with the Ontario Science Centre. Send an email to webmaster@osc.on.ca.
- Visit some of the websites listed in the Additional Resources section.

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. The Science Centre's newest temporary exhibition, BODY WORLDS 2: The Anatomical 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 17 million people have seen BODY WORLDS and BODY WORLDS 2 worldwide. BODY WORLDS 2 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.

At the Ontario Science Centre, we also offer a complementary school program: *Human Anatomy and Physiology* (Gr. 9-12) as well as the IMAX film *The Human Body*. We highly recommend linking these school programs and/or the IMAX film with your visit to the BODY WORLDS 2 exhibition.

Important information to know about BODY WORLDS 2:

- 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 exhibition. 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) accompany 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.

The Ontario Science Centre requires that all students visiting the BODY WORLDS 2 exhibition in school groups must receive written permission from their parents/guardians prior to their visit. 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. As the Ontario Science Centre 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 2 will still be able to visit the Science Centre without viewing any part of the exhibition.

If you have any questions about this policy, please contact Educational Sales and Reservations at (416) 696-3140.

Frequently Asked Questions

What is the purpose of the exhibition?

BODY WORLDS 2 aims to educate the public about the inner workings of the human body and show the effects of poor health, good health and lifestyle choices. It is also presented in the hopes that it will stimulate curiosity about the science of anatomy.

Why use real human bodies instead of constructed models?

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.

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 exhibition. 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. As agreed upon by the body donors, their identities, ages and causes of death are not provided. The exhibition focuses on the nature of our bodies, not on providing personal information.

Is this exhibition appropriate for school field trips?

The Science Centre recommends this exhibition for school groups in Grades 5 and up. More than 17 million people, including students, have viewed both BODY WORLDS 2 and the original BODY WORLDS exhibitions. As with all our exhibits, the Science Centre requires that a responsible adult school supervisor accompany students visiting the exhibition and remain with them at all times. Due to the sensitive nature of this exhibition, the Ontario Science Centre also requires that all students in school groups visiting the BODY WORLDS 2 exhibition must receive written permission from their parents/guardians prior to their visit.

What other materials are available for educators?

There are displays in BODY WORLDS 2 for which teachers will wish to prepare both their students and their adult supervisors in advance. To prepare a class for this exhibition (in addition to this Educator's Guide) teachers can receive, free of charge, a BODY WORLDS DVD and brochures for their students by filling in the Materials Order Form on our website. There are also several books, a CD-ROM and other materials available for purchase in the BODY WORLDS 2 store at the exhibition exit or via the BODY WORLDS website at www.bodyworldshop.com.

What is plastination?

Plastination is a unique process invented by Dr. Gunther von Hagens to preserve specimens for medical education. The process replaces the body's water tissue with fluid plastics that harden after vacuum-forced impregnation. Hardening the plastic in the specimens allows the bodies to be fixed into life-like poses which illustrate how our bodies respond internally to movements in everyday athletic activities. For more information about Gunther von Hagens, the inventor of the plastination technique and creator of the BODY WORLDS and BODY WORLDS 2 exhibitions, go to www.OntarioScienceCentre.ca.

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

The unique use of authentic specimens shows the details of disease and anatomy in a way that cannot be shown with models, textbooks or photos. In addition, the exhibition allows guests to understand that each and every body has its own unique features, even on the inside. We have also learned with our Anatomical Sections and Prenatal Development exhibits that visitors are drawn to real specimens in a way that they are not to plastic models.

What review process did the Ontario Science Centre go through when considering BODY WORLDS 2?

The Ontario Science Centre thought very carefully before deciding to host BODY WORLDS 2. Before making the decision, senior staff from the Science Centre reviewed the exhibition at the California Science Center. We consulted on the exhibition with other North American science centres. We determined from these discussions that a full ethical review had been completed that ensured all of the full body specimens were from donors who had bequeathed that upon their death their bodies could be used in an exhibition for the public. We have ensured that any of our visitors who do not wish to see BODY WORLDS 2 will still be able to visit the Science Centre without seeing any part of the exhibition. We have prepared this Educator's Guide to assist teachers who are considering bringing their students to the exhibition. We engaged in discussions about BODY WORLDS 2 with the education and medical communities, bioethicists, religious and other community leaders in Toronto to seek advice on the best way to relate BODY WORLDS 2 to the culturally and socially diverse community of Greater Toronto.

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 become more involved in taking better care of themselves to sustain their good health. 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.

What is this exhibition doing at the Ontario Science Centre?

BODY WORLDS 2 supports the mission of the Ontario Science Centre: “To delight, inform and challenge visitors through engaging and thought-provoking experiences in science and technology.”

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 Ponderer” is posed to illustrate the body’s neurological system. 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.

How many plastinates are in the exhibition?

BODY WORLDS 2 presents more than 200 individual plastinates. It adds to the original BODY WORLDS exhibition with another generation of specimens, for example, the “Obesity Revealed” specimen, which shows fat tissue and its ability to shorten life by damaging vital organs like the heart; the “Orthopedic Man,” which demonstrates a variety of surgically implanted orthopedic devices; and “Death Spiral: Elegance on Ice,” which features ice skaters in the popular pairs pose (of the same name) that highlights each individual’s muscular system and juxtaposes the female and male form.

What is the difference between BODY WORLDS and BODY WORLDS 2?

There are two BODY WORLDS exhibitions. BODY WORLDS 2 equals the original BODY WORLDS exhibition in size and proportion, comprising 1500 square metres, and more than 200 plastinated real human body specimens, including more than 25 whole bodies, healthy and unhealthy organs, body parts and slices. Dr. Gunther von Hagens, creator of BODY WORLDS and inventor of the plastination technique, has designed BODY WORLDS 2 to reveal significant insights into human anatomy and health, presenting an unprecedented view of the structure and function of the human body, and offering an unforgettable lesson on the importance of leading a healthy lifestyle.

Why aren't there more women plastinates in the exhibition?

Sensitive to perceived community concerns, Dr. von Hagens did not want to appear voyeuristic in revealing too many female bodies. 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 exhibition, Dr. von Hagens has received numerous requests from women visitors to see more examples of female anatomy.

Is the Ontario Science Centre advocating or supporting body donation or plastination?

The Ontario Science Centre leaves the decision about body donation or plastination entirely up to visitors.

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.

Where can I go for more information on the human body?

You can explore genetics, glands and more in the Science Centre's Human Body hall. Examine a human skeleton and an elephant heart, see how you'll look in the future with our Amazing Aging Machine, use DNA to catch a criminal, and more. Admission to the Human Body hall is included with general admission to the Ontario Science Centre.

What are the Ontario Science Centre's hours for the exhibition?

The Ontario Science Centre is open 364 days a year from 10 a.m. until 5 p.m. (Closed December 25.) In addition to these hours, BODY WORLDS 2 will be available Friday and Saturday evenings in October, and Thursday, Friday and Saturday evenings starting in November.

How do I get tickets to see BODY WORLDS 2?

Tickets to see BODY WORLDS 2 at the Ontario Science Centre are available now on the Science Centre website (www.OntarioScienceCentre.ca) or by calling 416-696-1000. School bookings are available by calling the School Booking office at 416-696-3140.

Is the exhibition wheelchair accessible?

The Ontario Science Centre and BODY WORLDS 2 are fully accessible by wheelchair. Please note that the exhibition is located on two floors of the Science Centre—both floors are accessible via elevators.

Can I take photographs or film in the exhibition?

Photography and filming are not allowed in BODY WORLDS 2, except by accredited members of the media. We thank you for your understanding and apologize for any inconvenience.

Where has BODY WORLDS 2 been exhibited?

BODY WORLDS exhibitions have been viewed by more than 17 million people throughout the world. BODY WORLDS 2 has travelled extensively through European cities including London, Berlin, Brussels, Munich, and Vienna; through major Asian destinations including Seoul, Singapore and Taipei; and has recently toured the US.

Why isn't the exhibition included in the Science Centre's general admission price?

As a non-profit organization and in order to ensure that the Science Centre is able to bring world-class exhibitions to its visitors, occasionally the Science Centre has to charge an additional fee.

Dear Parent or Guardian:

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. The Science Centre's newest temporary exhibition, BODY WORLDS 2: The Anatomical Exhibition of Real Human Bodies, provides students and visitors with the opportunity to learn about anatomy and health by viewing real, preserved human bodies.

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At the Ontario Science Centre, we also offer two very popular school programs in biology: *Body Works* for grades 5-8, and *Human Anatomy and Physiology* for grades 9-12. Both programs are directly linked to meet the expectations of the Ontario science curriculum. As well, we will be featuring *The Human Body* as an exhibit-related IMAX film. Your child may be involved in both the school program, and/or the IMAX film in addition to the BODY WORLDS 2 exhibition, for a unique learning experience.

Important information to know about the BODY WORLDS 2 exhibition:

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- 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 accompany 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.

To learn more about the exhibition and to find the answers to some frequently asked questions, please visit our website at www.OntarioScienceCentre.ca or 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.

The Ontario Science Centre requires that all students in school groups visiting the BODY WORLDS 2 exhibition receive permission from their parents/guardians prior to coming to the Science Centre. 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 2 exhibition at the Ontario Science Centre.

Parent/Guardian's name (please print): _____

Parent/Guardian Signature: _____

Date _____

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-visitors¹

“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

“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

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

“In my opinion, the reality between sickness and health, between life and death should be displayed. Many people are not familiar with the human anatomy. That is to say, they don't know much about themselves. Until a few years ago this kind of enlightenment was reserved for doctors or medical personnel.

“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 it²

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.

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.

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

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 alive⁴

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 Vesal’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:

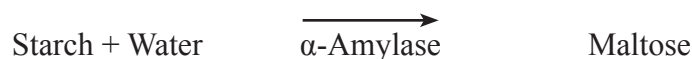
- Proteins are broken down into amino acids
- Carbohydrates are broken down into monosaccharides
- Fats are broken down into glycerine and fatty acids

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 pancreaticin.

α -Amylase

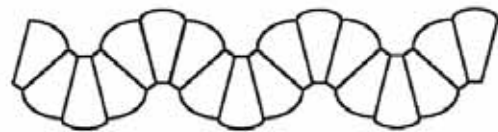
This enzyme breaks starch (amylum) down into maltose:



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:

α -Amylase: divides starches (see above)

Proteases: Enzymes that break proteins down to amino acids
 $\text{Protein} + \text{Water} \longrightarrow \text{Amino Acids}$

Lipases: divide fats into fatty acids and glycerine
 $\text{Fat} + \text{Water} \longrightarrow \text{Fatty acids} + \text{Glycerine}$

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.

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).

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.

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 tips’ 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 EXPERIMENTS**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 left-over starch solution.

Observations:

No reaction is seen.

EXPERIMENT: Starch breakdown using 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. Pancreatin 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 (II) 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

(A reaction that normally takes place in the stomach)

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.

Observations:

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.

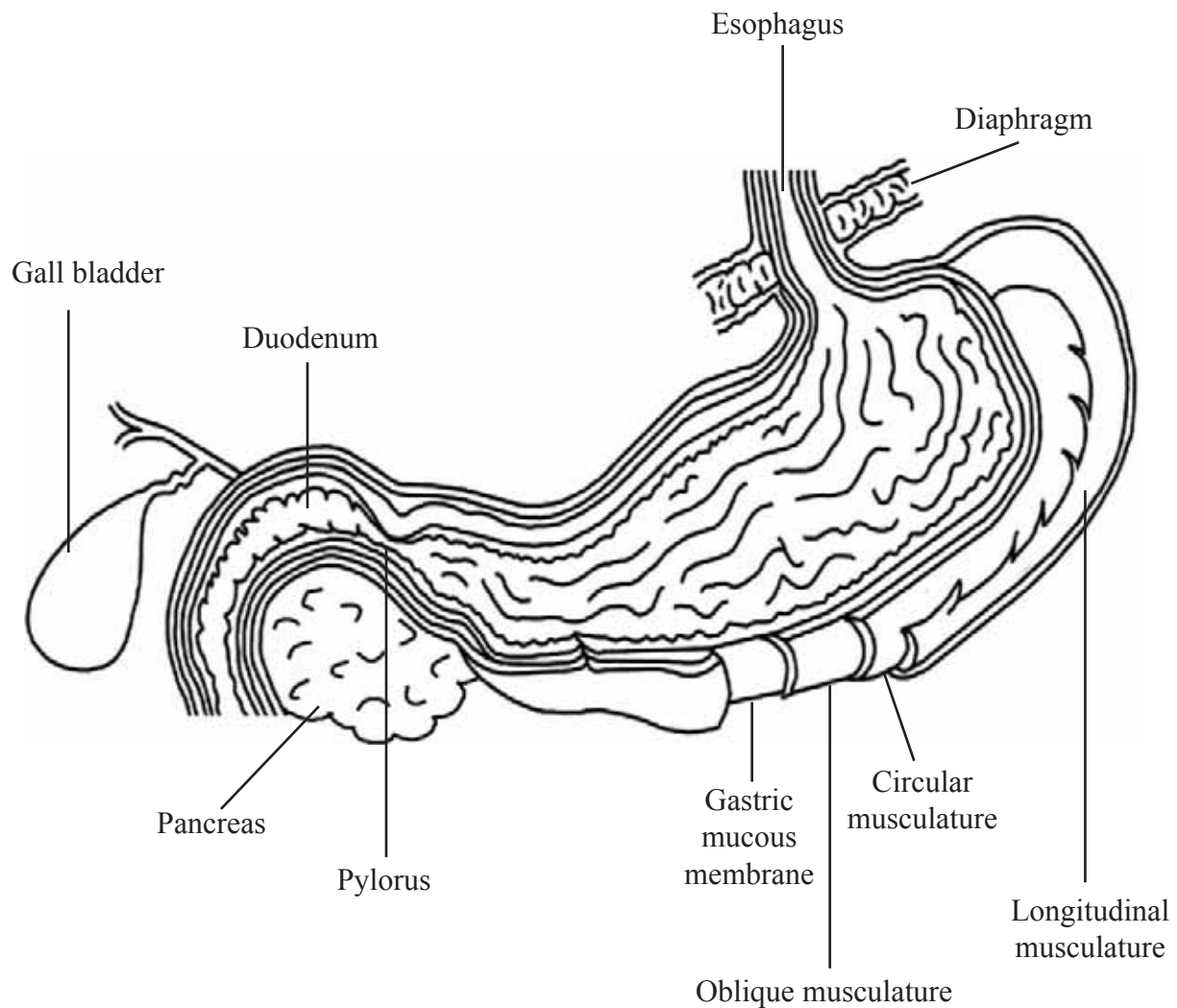
Additional written exercise:

Stomach

Exercise:

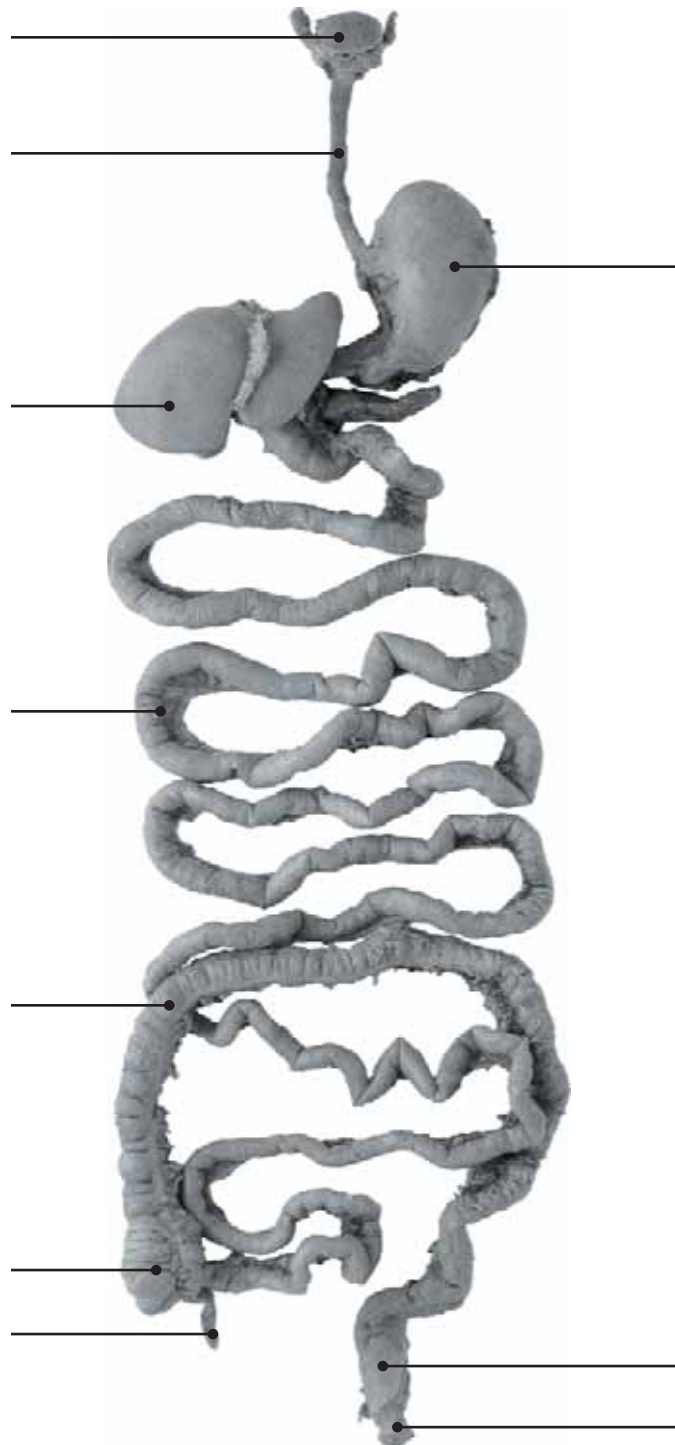
1. Write the biography of a stomach (from beginning to end)
2. While doing so, think about its consequences for the body.

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 the individual sections of the gastro-intestinal tract.

Fill in the table:

| Organ | Functions |
|-------|-----------|
| | |
| | |
| | |
| | |

The route that food takes **FOR TEACHERS ONLY**

1. Name the organs displayed in the illustration which are involved in digestion.
2. Summarize the functions of the 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 | Juices from the liver and the stomach's salivary glands are added, digestion of the three basic materials (carbohydrates, proteins and fat), absorption 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 (see also Catalogue p. 93, fig. 5.8)



Picture 2: Section of large intestine (colon) (see also Catalogue p. 93, fig. 5.9)

Summarize the differences in a table.

| Small intestine | Feature | Colon |
|-----------------|----------------------|-------|
| | Position | |
| | Length | |
| | Inner surface area | |
| | Functions | |
| | Passing on the chyme | |

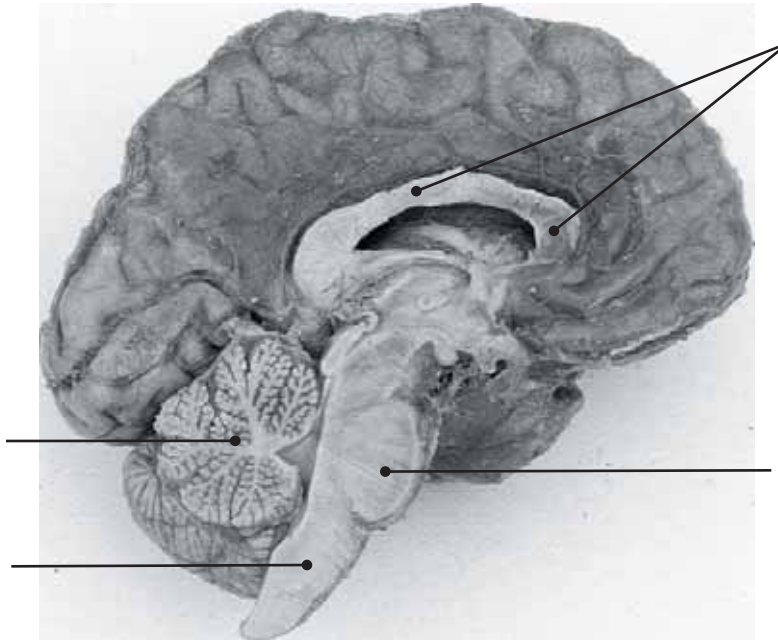
Comparison of the small intestine and the colon **FOR TEACHERS ONLY**

Summarize the differences in a table.

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

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?

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



3b. To explain this, draw up a stimulus-reaction chain.

| | | |
|--|--|--|
| | | |
| | Stimulus conduction | |
| | Sense organ or organ that acts in response | |
| | Stimulus or reaction | |

4. 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

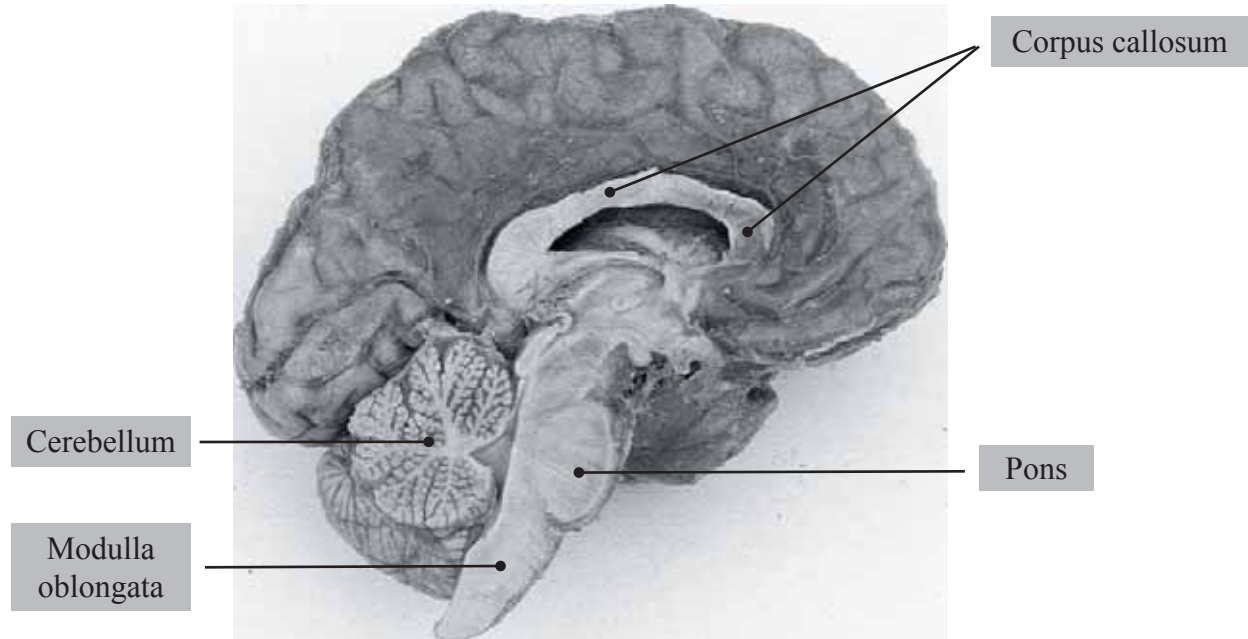
_____.

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

| Organs | Parts | |
|-----------------------------|--------------|--|
| | | |
| Pupils | | |
| Lungs | | |
| Heart | | |
| Small intestine | | |
| Emptying the bladder | | |

The nerve centre—the brain **FOR TEACHERS ONLY**

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 | connects the two halves of the cerebrum |
| Cerebellum | controls balance and movement |
| Medulla oblongata | regulates breathing and circulation |

2. What is a reflex?

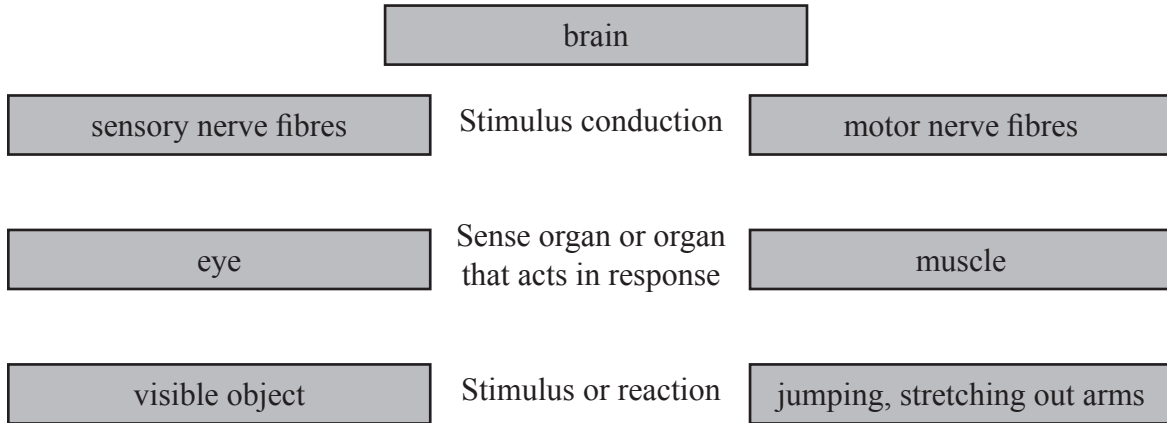
A reflex is a fast reaction that takes place subconsciously, i.e. without the involvement of the cerebrum. A reflex cannot be triggered consciously. ...

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



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

3b. To explain this, draw up a stimulus-reaction chain.



4. 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**.

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

| Organs | Parts | |
|-----------------------------|--------------------|------------------------|
| | Sympathetic system | Parasympathetic system |
| Pupils | Widening | Narrowing |
| Lungs | Widening | Narrowing |
| Heart | Stimulating | Inhibiting |
| Small intestine | Inhibiting | Stimulating |
| Emptying the bladder | Inhibiting | Stimulating |

The mind of the inventor

Gunther von Hagens is the creator of plastination. For more than 20 years he has worked in this field, inventing various methods to make possible something completely new. He describes what he does as follows:

During the twenty years I have worked on plastination, I have produced a whole host of individual inventions. I am always being asked how I think up such ideas and how I take each of them forward. How I come up with inventions relating to the development of plastination corresponds to the four usual stages of invention: identifying the problem, analyzing it, working out solutions and, finally, putting them into practice.

1. Identifying the problem:

I basically question everything. Even good things can be improved upon, as “good” can always be made “better”. So, in inventing plastination, I realised there was one key problem. Saturating specimens in synthetic substances had to be an improvement on the usual practice up to that point of laying them in blocks of synthetic material.

2. Analyzing the problem:

I try not only to identify the problem at hand but also to imagine what additional questions it could provoke. Part of that process involves studying manuals, textbooks, literature on patents and company brochures, as well as regularly visiting trade shows.

3. Solving the problem:

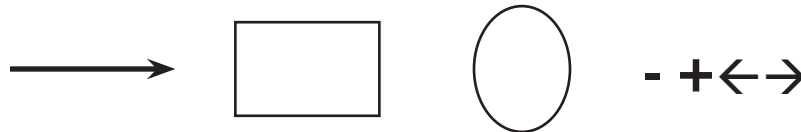
I am never completely satisfied with any solution. Instead, I always follow a number of trains of thought; you should allow three to five possible solutions to compete for a while. It is also important not to fix on one particular solution too early. When I am pursuing the beginnings of a solution, I have complete faith in the fact that the solution I am working on will succeed, even if, from a purely factual point of view, that is rubbish. You have to keep returning to the problem and factoring in your own mistakes. When discussing possible solutions with experts, I often evaluate them in the following way: the more emotional it would be to reject a given solution, the more likely it is to be revolutionary and, in principle, possible.

4. Putting the solution into practice:

At this stage, studying company brochures and visiting trade shows is again important. You cannot afford not to be constantly improving your technical knowledge and repeatedly thinking through possible ways of putting ideas into practice. So I spend almost all my time thinking about plastination: even before getting up, when thinking about my plans for the day in the shower, while driving, when doing the shopping. Only through this can the blancmange mould become the skull, the meat slicer a machine to slice up the brain, the machine that turns chips a machine that turns brain sections, the price tag holder in the shop window the clips for the plates that flatten plastinated sections, and the aquarium pump a spray for gas hardening techniques. This process of adapting and exploiting established technology is the lifeblood of invention.⁵ I often try the impossible or the downright ludicrous. Often it is in trying out nonsensical ideas that I have crucial thoughts. So I permit myself mistakes or even make them on purpose. The strangest experiments, mistakes and accidents lead to inventions.

Exercises:

1. Read the above text. Pick out the individual steps of an invention. Present them graphically on a sheet of paper or on a poster. Use the following symbols:



Of course you can also use, or invent, your own symbols!

2. List what Gunther von Hagens uses for his inventions:

- a. Logic
- b. Imagination
- c. ...
- d.
- e.
- f.
- g.
- h.

3. Put the areas you named in Task 2 onto a small 'Thought Map'. You can decide how big to make it. Then briefly describe what view of the human thought process underpins an inventor's work.

⁵ Gunther von Hagens: "Anatomie und Plastination" ("Anatomy and Plastination"). See also Catalogue p. 28-30

The Human Facts

Human body facts to share with your students during your visit to BODY WORLDS 2:

Musculoskeletal (Locomotive) System

(See full body plastinates such as the Ballet Dancer and the Javelin Thrower to discover what makes us move.)

- On average, 40 percent of your body weight is muscles.
- You have 640 muscles that move you.
- Muscles cannot push, they can only pull (they work in pairs).
- You have more than 30 facial muscles that create looks like surprise, happiness, sadness and frowning.
- Eye muscles are the busiest muscles in the body. Scientists estimate they may move more than 100,000 times a day!
- The largest muscle in the body is the gluteus maximus muscle in the buttocks.
- The human hand has 27 bones; your face has 14!
- The longest bone in your body? Your thighbone, the femur—it's about 1/4 of your height. The smallest is the stirrup bone in the ear, which can measure 2.5 millimetres.
- Did you know that humans and giraffes have the same number of bones in their necks? Giraffe neck vertebrae are just much, much longer!
- You have more than 230 moveable and semi-moveable joints in your body!

Nervous System

(See the full body plastinate The Ponderer for an excellent look at nerve pathways.)

- The brain weighs approx 1.5 kg—2 percent of a total human's weight.
- There are around 100 billion neurons in the brain.
- A nerve cell can transmit 1000 nerve impulses each second.
- The average spinal cord is 45 cm long in men and 43 cm long in women. The spinal cord weighs approximately 35 g.
- Some information travels in the nervous system at a rate of 431 km/hour—about as fast as the world's fastest sports car.
- A baby's brain grows almost 3 times its size at birth during its first year.
- Humans have the most complex brain of any critter on earth!
- Your brain is divided into two sides. The left side of your brain controls the right side of your body; and the right side of your brain controls the left side of your body.

Respiratory System

(See lung plastinates—smoker's and non-smoker's lungs.)

- You breathe in about 20 times a minute.
- Your lungs contain almost 2414 kilometres of airways and more than 300 million alveoli.
- Every minute you breathe in 7 litres of air. When you are doing physical activity this number increases to 57 litres of air per minute.
- Plants are our partners in breathing. We breathe in air, use the oxygen in it, and release carbon dioxide. Plants take in carbon dioxide and release oxygen.
- The wind produced from your sneeze is about 200 km/h—equivalent to wind speeds observed during a tornado!

Cardiovascular System

(Look for a plastinate that displays the heart, arteries, veins and capillaries; look for the damage caused by arterial plaque.)

- Your heart is a muscle about the size of your clenched fist.
- Strung together end-to-end, your blood vessels could circle the globe 2 1/2 times!
- The body of an adult contains over 96 000 km of blood vessels.
- An adult's heart pumps nearly 18 173 litres of blood each day.
- Your heart beats some 30 million times a year.
- The average three year-old has 1.1 litres of blood in their body; the average adult has at least five times more.
- A "heartbeat" is really the sound of the valves in the heart closing as they push blood through its chambers.

Digestive System

- How long are your intestines? At least 7.5 metres in an adult. Be glad you're not a full-grown horse—their coiled-up intestines are 27 metres long!
- Chewing food takes from 5-30 seconds.
- Digestion from mouth to anus takes about 72 hours.
- Food sloshing in the stomach can last 3-4 hours.
- It takes 3 hours for food to move through the intestine.
- Food drying up and hanging out in the large intestine can last 18 hours to 2 days.
- In your lifetime, your digestive system may handle about 50 tons.
- The average person eats about 1.4 kg of food per day.

Reproductive System

(Visitors may choose to view this area to see how prenatal development looks in the womb.)

- Each sperm is extremely small: only .05 millimetres long.
- Each ejaculate contains between 75 and 900 million sperm.
- Human eggs and sperm are drastically different in size; sperm measure 2.5 - 3.5 microns wide by 5 - 7 microns long and a tail measuring 80 microns; eggs measure 120 - 150 microns (1 mm = 1000 microns).
- The fertilization process takes about 24 hours.
- About 250 metres of seminiferous tubules are packed in each testis.
- At birth, each female carries of lifetime supply of eggs (approx 400 - 500 eggs).

Sources:

<http://yucky.kids.discovery.com/>

<http://faculty.washington.edu/chudler/what.html>

www.kidshealth.org

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>

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