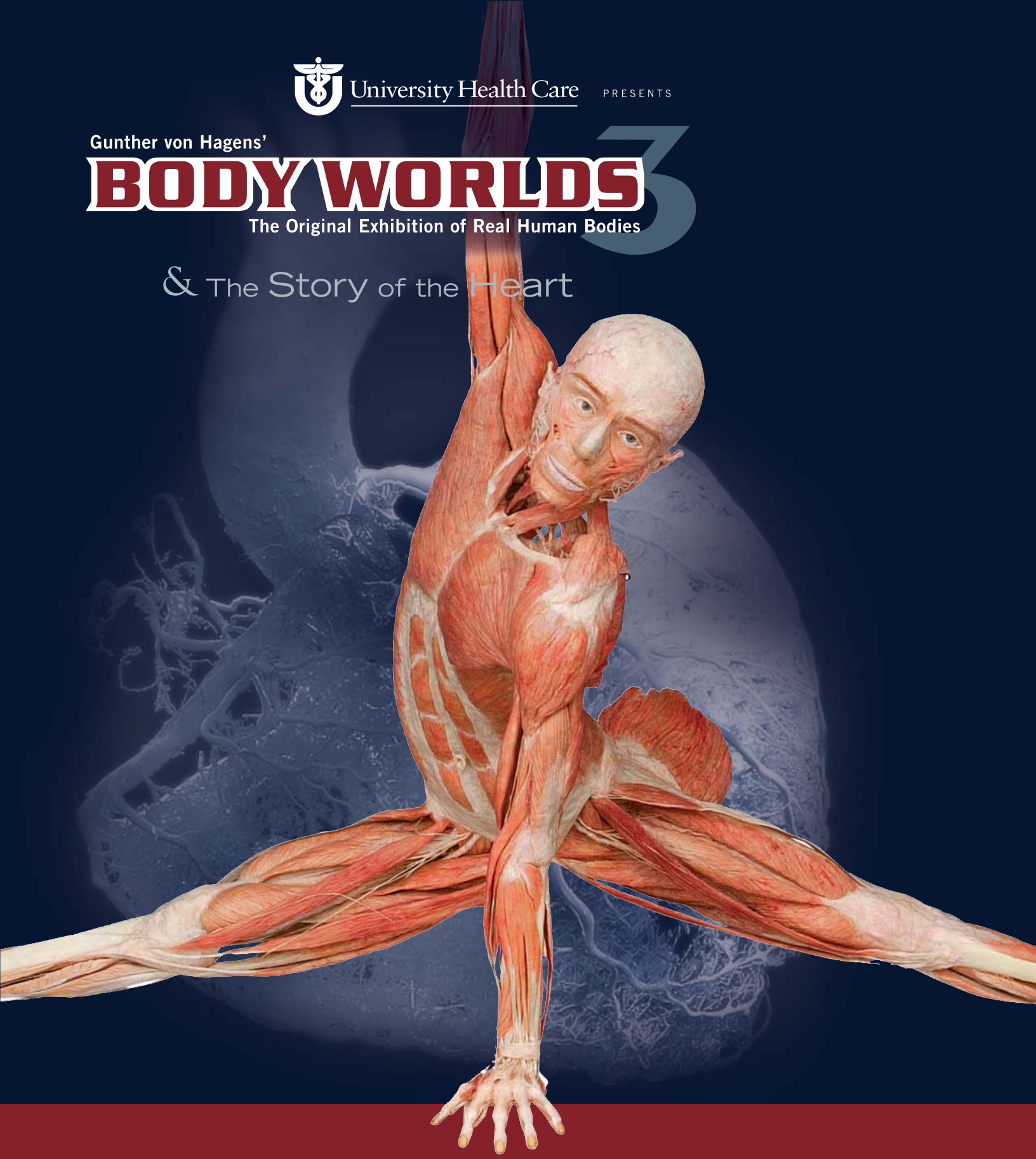
University Health Care PRESENTS

Gunther von Hagens'

BODY WORLDS 3

The Original Exhibition of Real Human Bodies

& The Story of the Heart



CLASSROOM ACTIVITY GUIDE (GRADES 9–12)

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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 3* exhibition?
3. Are the arguments conclusive? (Test them if necessary by drawing on further reading.)
4. Consider what moves a donor to allow her body to be plastinated for an exhibition.
5. Consider how 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, Germany

"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, Germany

"I do not think that it is educational because the bodies are not displayed in natural positions. The way von 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, Germany

"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, Germany

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

"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

"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 showbusiness 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,
(painter based in Cologne, Germany)

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.

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 anymore. 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.

2 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[3]

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 craft work? "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 favorite 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 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."[3]

3 From: Medical Tribune. 35th year, p.22.No.3.21 January 2000

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 realized 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 mold 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. 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."

DIGESTION

Introduction:

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: alpha-amylase, pepsin and pancreatin.

alpha-Amylase
This enzyme breaks starch (amylum) down into maltose:

Starch + Water alpha–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:

alpha-Amylase:	Divides starches (see above)
Proteases:	Enzymes that break proteins down to amino acids
	Protein + Water → Amino Acids
Lipases:	Breaks down fats into fatty acids and glycerine
	Fat + Water → Fatty acids + Glycerine

Most of the experiments we describe 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 3/4 inch of a spatula.

EXPERIMENTS

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 more 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 1: 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:

1. Fill each of 2 test tubes with the same amount of water (5ml). Put 50 mg of pancreatin into one of these test tubes and shake into a suspension.

2. Put 200 ml of water and 2 ml 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 color.

Method:

Divide the fat emulsion (2) equally between 2 beakers. Add the pancreatin suspension (1) 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 colorless, whereas no change can be seen in the second beaker.

Explanation:

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

Experiment 2: 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, add 50 mg 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 3: Fat digestion with the aid of bile

Materials:

- cooking oil
- Pancreatin
- dried ox bile
- dilute sodium hydroxide
- phenolphthalein solution
- test tubes
- measuring pipette

Preparation:

1. Bile: Dissolve 250 mg of dried ox bile in 10 ml of water. Divide solution into two equal portions.
2. Pancreatin solution: Dissolve 300 mg of pancreatin in 10 ml 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: 5 ml pancreatin solution + 5ml water
- 2nd test tube: 5 ml bile + 5 ml water
- 3rd test tube: 5 ml 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 color.

Note:

As bile has a strong color of its own, it is not possible to get exactly the same color 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 color
- 2nd test tube: no change
- 3rd test tube: rapid loss of color

Explanation:

Pancreatin contains the enzyme lipase that breaks down fat. The free fatty acids that are created in this process neutralize the sodium hydroxide. In alkaline conditions, phenolphthalein is red, but in neutral and acidic conditions it is colorless. 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.

CARBOHYDRATES
Preparatory Experiments
Digestion of Carboyhdrates: Test for Starch and Glucose (Dextrose)

Materials:

- starch
- glucose
- lugol's solution (iodine-potassium iodide solution)
- fehling's solutions 1 and 2.

Preparation for experiments:

1. Prepare a starch solution by filling a test tube to about one third full with water and adding a 100mg of starch. Warm the suspension carefully over a Bunsen flame, until the solution turns clear. Then cool the solution again under running water.

2. Preparation of glucose solution: Fill a test tube to about one third full with water and dissolve about 200mg of glucose in it.

3. Preparation of the active Fehling's solution: In a test tube, mix in equal parts a few ml each of Fehling's 1 and 2 solutions. A dark blue copper complex is formed.

Note:

When kept separately, Fehling's 1 and 2 solutions will keep for years. However, the ready-to-use solution quite quickly becomes unstable and must be freshly prepared before each use.

Experiment #1: 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 color. The color 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 #2: 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 2 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 color then changes to orange and then red.

Explanation:

Glucose contains an aldehyde group that reduces the blue Cu2+ compound to red Cu20. 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 #3: Starch breakdown using amylase

Materials:

- lugol's solution
- starch
- shallow dish (petri dish)
- alpha-amylase
- pancreatin
- glass rod
- writing paper (3 pieces, approx. 10x5cm)
- cotton wool

Preparation:

1. Starch solution: add 100 mg starch to 10 ml water and heat until a clear solution is formed.
2. Amylase solution: add 100 mg
3. Pancreatin solution: dissolve 60 mg pancreatin in 5 ml water (shake).
4. Dilute Lugol's solution: dilute 1-2 ml Lugol's solution with 10 ml water and pour into a shallow dish (petri dish).

Method:

Moisten a cotton ball with starch solution 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 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 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). 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, as well as 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 2 ml amylase or pancreatin solution 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 #4: Test for the by-products of starch

Materials:

- starch
- alpha-amylase
- pancreatin
- fehling's solutions 1 and 2
- test tubes

Preparation:

1. Starch solution: (see "Starch breakdown using amylase")
2. Pancreatin solution: dissolve 1 "spoon tip's worth" of pancreatin in approx. 5ml water.
3. Fehling's reagent: (see "Starch breakdown using amylase")

Method:

Mix the starch solution 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 "Test for glucose").

Observations:

The Fehling's test is positive.

Explanation:

Pure starch solution does not reduce Fehling's reagent. 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.

PROTEINS

Experiment #1: Protein Digestion Using Pepsin

(A reaction that normally takes place in the stomach)

Materials:

- gelatin
- casein
- 1 hard-boiled hen's egg,
- diluted hydrochloric acid
- test tubes
- small beaker
- measuring pipette
- pipette aid

Note:

Gelatin 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:

1. 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.
2. 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 gelatin (approx. 1x3cm) into each of 5 test tubes. The experiment can also be done using casein instead of gelatin, using 2 "spoon tips' worth" of casein per test tube. Also very suitable for protein digestion experiments is the coagulated egg white of a hardboiled 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 (2) and 2ml water

3rd test tube: 10ml water + 2ml pepsin solution (1)

4th test tube: 10ml dilute hydrochloric acid (2) + 2ml pepsin solution (1)

5th test tube: like 4th, but boil the pepsin solution (1) thoroughly before it is added.

If, at this stage, the experiments are left to stand at room temperature, the gelatin 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 gelatin 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 gelatin shows "signs of disintegration". After 30-60 minutes the gelatin 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 sterilizing effect that prevents decomposition.

3rd test tube: Pepsin alone cannot break down protein. Without the sterilizing 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). Inline 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 #2: 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
- gelatin
- 1 hard-boiled hen's egg, as required,
- dilute sodium hydroxide
- test tubes
- pipette

Preparation:

1. Pancreatin solution: Mix 10ml water with 1 "spoon tip's worth" (approx. 60mg) of pancreatin and dissolve, shaking gently.
2. Cut up 2 pieces of gelatin (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 gelatin.

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

Analyze after approx. 1-2 hours. The experiment only works at room temperature. When warmed, gelatin disintegrates, giving misleading results. Instead of gelatin, 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 gelatin also shows "signs of disintegration" when in the presence of pancreatin. After an hour or so, a large proportion of the gelatin 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.

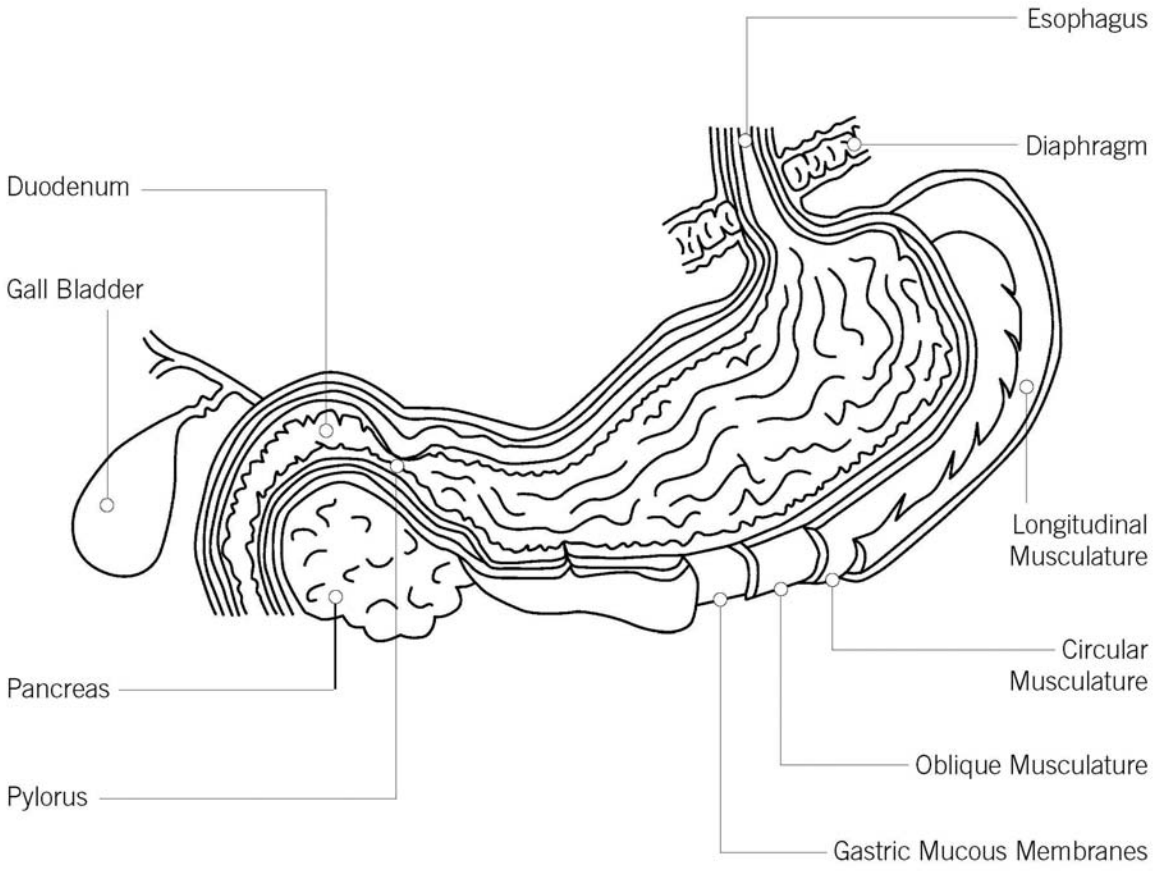
Explanation:

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.

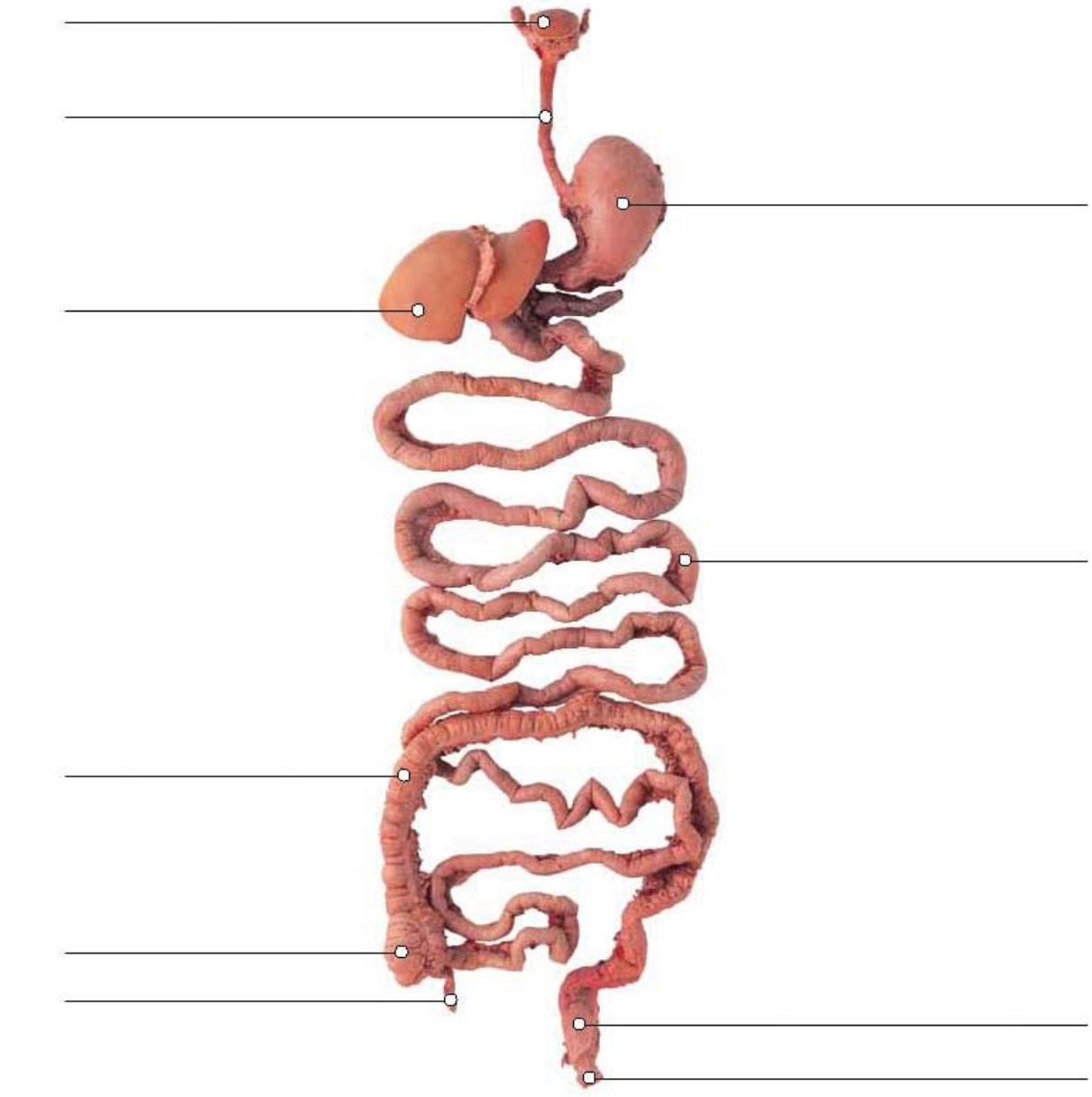
THE STOMACH: BIOGRAPHY OF A STOMACH

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.



THE ROUTE THAT FOOD TAKES – CONTINUED

2. Summarize the functions of the individual sections of the gastrointestinal tract. Fill in the table:

ORGAN	FUNCTIONS

THE ROUTE THAT FOOD TAKES: ANSWER KEY
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 gastrointestinal tract.

Fill in the table:

ORGAN	FUNCTION
Mouth	Reducing the food pieces in size, in salivation, 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

SMALL INTESTINE AND COLON
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 below.

SMALL INTESTINE	FEATURE	COLON
	Position	
	Length	
	Inner surface area	
	Functions	
	Passing on the chyme	

COMPARISON OF THE SMALL INTESTINE AND THE COLON: ANSWER KEY

For Teachers Only

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 below.

SMALL INTESTINE	FEATURE	COLON
Connected to the stomach	Position	*On the right side of the stomach, rises up to the liver*
4 to 6 meters	Length	*1.5 to 2 meters*
Made greater b folds, and epithelial cells y intestinal villi, ringshaped	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*

ABOUT THE LEONARDO

Inspired by the spirit of ingenuity that guided Renaissance master Leonardo da Vinci, The Leonardo is an educational and cultural center fusing science, technology, and the arts in experiences that inspire human creativity and innovation. When the center permanently opens its doors in a few years, The Leonardo will be part of Library Square, a vibrant civic and educational hub that already draws over three million visitors each year.

A NEW APPROACH

The Leonardo's multidisciplinary approach integrates traditional science exhibits with historical and contemporary developments in the world of arts and culture. By offering myriad pathways to explore each topic, visitors can learn in ways that are more personally engaging, meaningful, and inspiring.

BEYOND HANDS-ON

The Leonardo will also allow visitors to reach beyond the traditional "hands-on" science center experience and actively explore topics of their own choosing. Workshops, on-site experts, and classes will ensure visitors encounter fresh, exhilarating realms of understanding.

YOU MAKE THE MUSEUM

Visitors to The Leonardo will help shape the experience. Each person who comes through our doors brings a different understanding and set of skills. By archiving and sharing visitor input, The Leonardo will become a living gallery, library, and lab, where the conversation is continually developing in unexpected and thought-provoking directions.

CURRENTLY AT THE LEONARDO

Although it will not permanently open its doors on Library Square for several years, The Leonardo will continue to offer exhibits, workshops, public dialogs and educational outreach programs to the community. One of these programs, The Leonardo on Wheels-Science, brings hands-on science to junior high and middle schools across the state. Each year, the program travels to over 20 schools and serves about 8,000 students. The Leonardo on Wheels-Science features interactive science, engineering and mathematics activities that support Utah state curriculum standards. Most school visits also include a Community Night for parents and families.