

# Using cutting-edge science within the curriculum: balancing body weight



- ✓ Biology
- ✓ Medicine
- ✓ Mathematics
- ✓ Health
- ✓ Human body
- ✓ Metabolism
- ✓ Obesity
- ✓ Ages 15+

Friedlinde Krotscheck



Image courtesy of Eckhard Krotscheck

**Friedlinde Krotscheck** describes how she used a cutting-edge science article from *Science in School* as the main focus of a teaching unit on the human body.

When students are actively involved in their lessons, they always both enjoy and learn more. This article shows how this can be achieved using a cutting-edge science article from *Science in School* that can be used to cover a whole topic of the curriculum.

The work is involved and will challenge many students with mathematics, biology and discussions on health and well-being. The students must feel secure in the classroom before they begin to discuss weight issues and it may be a good idea to mention that personal issues are confidential and should not be discussed outside the room.

The issue of drugs to control weight and promote weight loss is an interesting topic and could be extended to include herbal and over-the-counter products. Students could discuss the social, commercial and ethical issues of weight-loss products and promotions. It should be a fun and interesting way of studying a topic by making it relevant to the students' own lives.

*Shelley Goodman, UK*

REVIEW



For teenagers, school lessons can be of secondary importance. Many students are interested principally in their appearance, their partners and having a good time outside school; they are also very sensitive to the opinions of their peers. When I reviewed an article for *Science in School* about a new potential hormone therapy for obesity (Wynne & Bloom, 2007), therefore, I wondered whether I could use the article and the concerns of teenagers to get my Year 10 students (ages 15-16) more involved in their biology lessons.

The first semester of Year 10 is dedicated to 'the human body'; this is the first and only time the students look at the topic in depth. Over three months, I devoted all 24 biology lessons (45 minutes each) to the sub-topic of 'homeostasis and the human body', focusing on the *Science in School* article, supplemented with video clips from *The Science of Fat* lectures (Evans & Friedman, 2004).

I began by asking my students if they would like to try a different teaching approach, based on a folder I had prepared containing worksheets and tables. The students would work independently and in groups to develop their own portfolios of information (notes, diagrams and essays), present their results to the others and take part in class debates. The students responded enthusiastically to the idea.

During the next three months, the students' enthusiasm for both the topic and the teaching approach continued. They were motivated to study the organ systems, grasp the principle of homeostasis and critically analyse their own lifestyles. I was impressed at how hard they worked on their portfolios – also outside lessons – and at their eagerness to learn more about the science involved, to influence the direction of the teaching unit, to teach each other and to discuss the ethical issues involved.

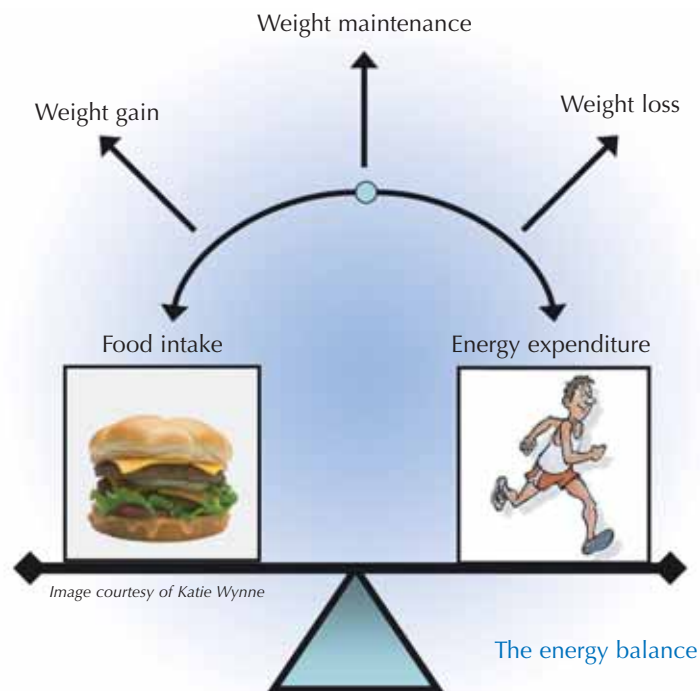
Of course, when addressing the topic of obesity, one concern is how to deal sensitively with any overweight or obese students in the class. Because the teaching unit began with a fairly lengthy consideration of homeostasis and metabolism, the students were quite relaxed by the time we discussed body mass index – and of course the students' individual data were not made public. Once we started discussing obesity and the research article, my two overweight students were elated, realising that their condition was not necessarily their fault – and began to discuss their eating habits openly in class. Other students talked openly about other weight problems, including anorexia and bulimia.

Below are guidelines for reproducing the teaching unit. I used it to introduce (with the students' agreement) a different approach to biology lessons, similar to the way scientists work. It also made my students realise that basic factual knowledge is important for understanding cutting-edge research.

If you are not able to devote such a long time to the topic, you could just use small parts of the project, or individual worksheets.

### 1) The daily life of a student

Start the first lesson with the simple question "How are you?" Discussing the students' answers and separating them into polite answers and honest reflections of their current state of



	Food intake		Energy expenditure		
Day	Food description	ml or g	Activity	Time	Distance

**Table 1:** Food intake and energy expenditure. Each day, record what you eat, how much you eat, what type of physical activity you do and for how long



## BACKGROUND

## Editor's note

If you have used one of our science articles in your lessons, please tell us how. Contact: [editor@scienceinschool.org](mailto:editor@scienceinschool.org)

emotions (e.g. sad, happy, tired, bored) should lead to factors that influenced their answers, for example:

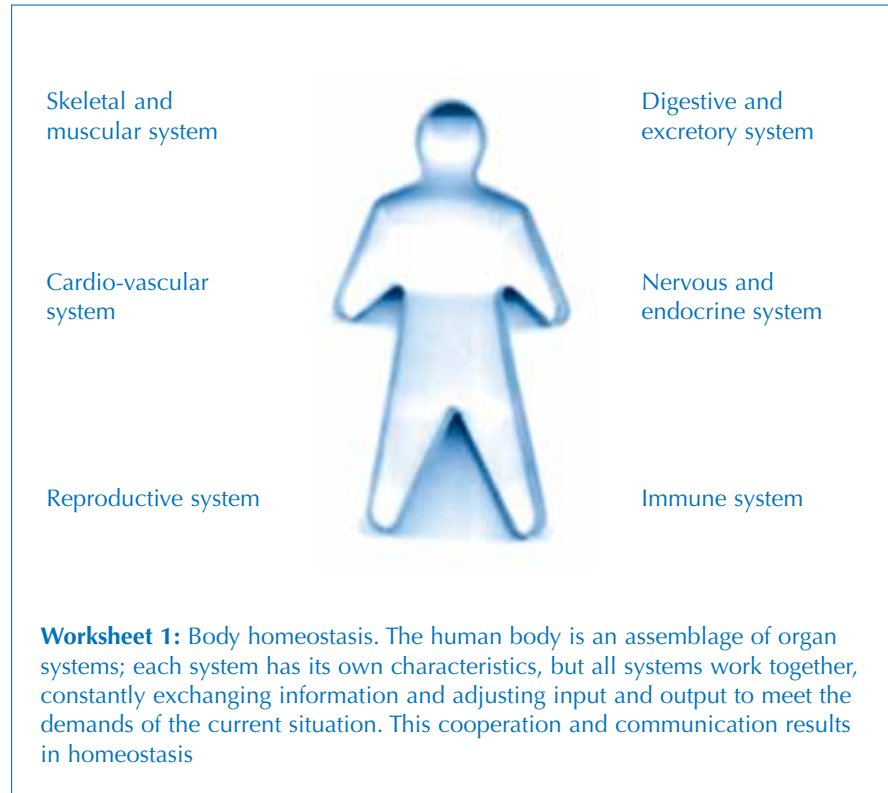
- Whether they like school
- Whether they are hungry or thirsty
- How much food or what type of food they have eaten
- How much sleep they have had.

From there, lead the discussion on to human metabolism and one of the diagrams (the energy balance, left) from Wynne & Bloom (2007). As homework, the students should complete Table 1 each day for a week, listing what they eat and what exercise they take. All tables and worksheets needed for the unit can be downloaded from the *Science in School* website<sup>w1</sup>.

### 2) The organ systems

To address the topic of metabolism, the students need to understand the organ systems of the body and how they work together to maintain homeostasis. Over the course of the whole unit, the students should gather a portfolio of information about the diverse functions of the organ systems, working either in groups or individually, in the classroom or at home. It is important that the teacher is only the provider of materials (textbooks, websites, models, diagrams and other information

Image courtesy of Friedlinde Krotscheck



about the different organ systems); the students should gather the facts by themselves. I gave my students very little guidance about which facts to collect – providing support mostly for the weaker students. Other teachers may prefer to provide more structure.

Each group of students could concentrate on one organ system and

then give a 15 minute presentation, providing their audience with a quiz to complete.

Once they have collected information about all the organ systems, the students should use Worksheet 1 to:

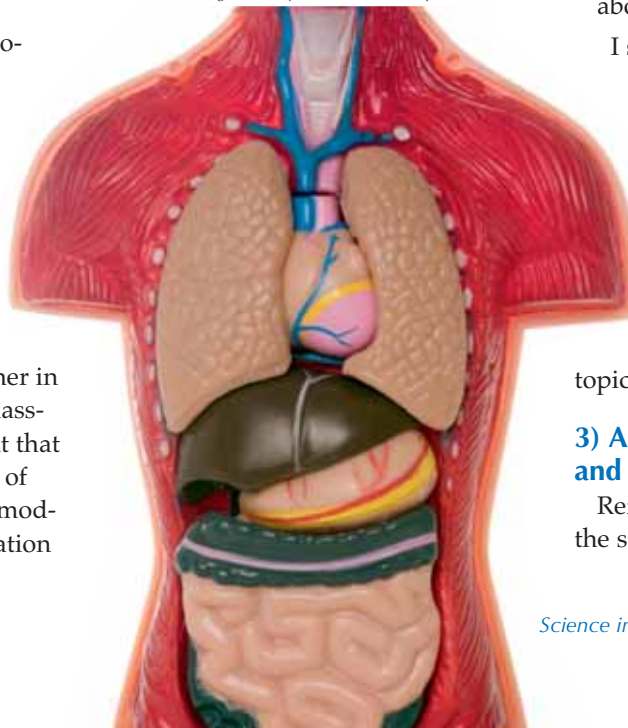
1. Describe the functions of each system and name the organs belonging to it.
2. Use arrows and labels to describe the influence that the organ systems above have on each other.

I spent 12 lessons on the first two parts of the teaching unit, after which my students had a basic understanding of the organ systems, how they depend on each other and what homeostasis is. The only teacher lecture I gave was about the central nervous system; otherwise all the topics were student-led.

### 3) An evaluation of food intake and activity

Referring to their data in Table 1, the students should each state a

Image courtesy of scol22 / iStockphoto



Food intake minus energy expenditure			
Day	+ kJ (food intake)	- kJ (energy expenditure)	Energy balance

**Table 2:** Food intake and energy expenditure balance

hypothesis about their own energy balance (e.g. weight loss or weight gain). They should then consider how their results can be compared quantitatively to those of their classmates – and arrive at the idea of using the body mass index (BMI).

$$\text{BMI} = \frac{\text{body mass (kg)}}{(\text{height (m)})^2}$$

Using the equation or an online BMI calculator<sup>w2</sup>, each student should calculate his or her own BMI. The first of *The Science of Fat* holiday lectures ('Deconstructing obesity' by Jeffrey M Friedman) can be used to introduce some of the limitations of BMI, in particular that it does not apply equally well to everybody.

Then, using Table 2 and the data from Table 1, each student should calculate his or her energy balance each day and average the data over the week to see in which direction his or her energy balance tips. To do this, the students will need the teacher's guidance to convert the data in Table 1 into kilojoules. There are also many websites that do the calculations or provide the necessary information<sup>w3</sup>.

The calculated energy balance will vary from student to student – and may differ from the hypotheses made at the beginning of this section. On the 'energy balance' diagram (see page 20), fill in the energy balance (in kJ) calculated for each student and discuss the results. The students will realise that total energy expenditure can be divided into the energy that the body uses for metabolic processes when at rest (our basal metabolic rate)

and the energy used during activity. However, Table 2 only includes the energy expenditure during activity – and the basal metabolic rate will vary from student to student.

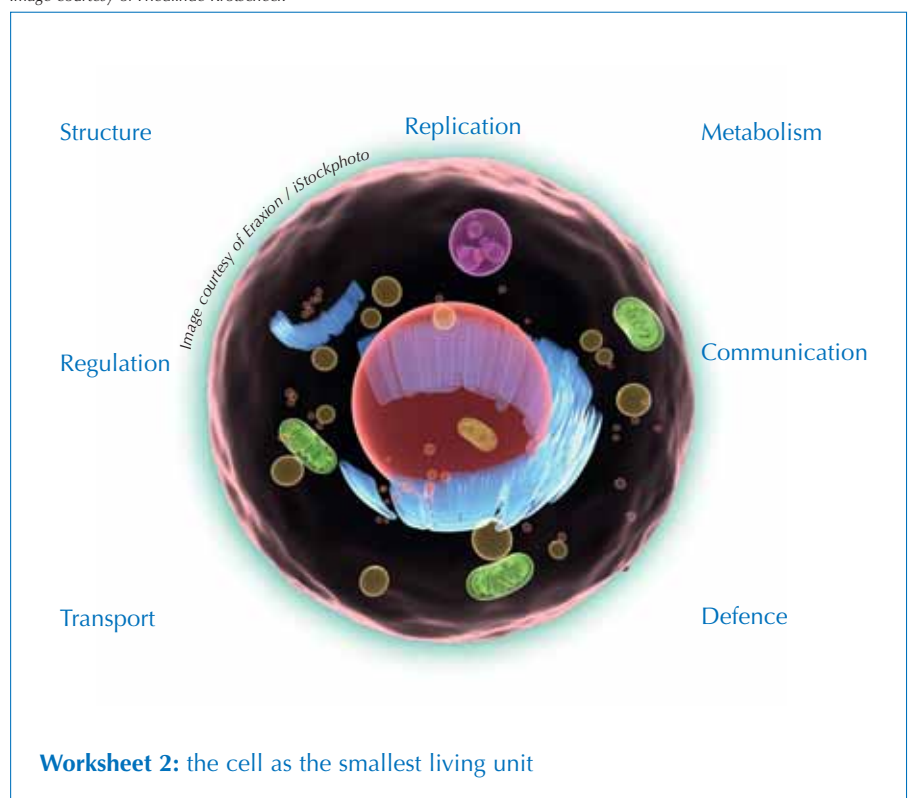
Our metabolic energy expenditure can be estimated, based on our height, weight, sex and age<sup>w4, w5</sup>. The students could estimate their basal metabolic rate and include it in the calculation of their energy balance in Table 2. How does this change the students' positions on the 'energy balance' diagram (see page 20)?

At this point, metabolism at the level of the cell can be introduced using Worksheet 2. The students should use their textbooks to answer the following questions, making the connection between our own energy balance and the activities of the cells, tissues and organs.

1. List the cell structures and organelles involved in each of the functions in the diagram.
2. In Worksheet 2, use arrows to show the interdependency of these functions.
3. Compare your knowledge about cell functions with the homeostasis of the human body. Describe any parallels you see.

Among my students, this led to a discussion of the fact that our phenotype – for example, whether we are tall or whether we are fat – is affected by how the cells in our organs function. Sometimes these cells are present but they do not function properly. My students then concluded that home-

Image courtesy of Friedlinde Krotscheck



ostasis happens at all levels – between cells and between organs – and that homeostasis (balance) is necessary for a healthy body.

#### 4) Introducing the *Science in School* article

Even if the variation in metabolic energy expenditure were taken into account, not all the students would have an energy balance of close to 0; instead, some of them clearly consume more (or less) energy than they expend. Why? The discussion should lead to the concept of satiety: the feeling of having eaten enough.

Introduce a second diagram (below, right) from Wynne & Bloom (2007) – but without labels<sup>w1</sup>. Describe the research reported in the article and explain the signalling involved in appetite, eating and satiety. In particular, the role of the L cell can be researched and discussed, drawing on the students' knowledge of cell functions within our organ systems.

The students should label the diagram accordingly.

Since the students are now familiar with the concept of BMI and the definition of obesity, get them to discuss in small groups the problems of obesity and the necessity for help, with the aid of Worksheet 3<sup>w1</sup>.

Ask the students to imagine they were obese and answer the following questions:

1. Which one of the disadvantages associated with obesity (see Worksheet 3) would you like to address first?
2. How would you do it?
3. Would you ask for help? If so, from whom?
4. Make a list of small steps to reach your goal.
5. How do the disadvantages of obesity relate to each other? What could these disadvantages lead to?
6. Do you think that obesity is something that could happen to you? Explain.

The discussion should lead the

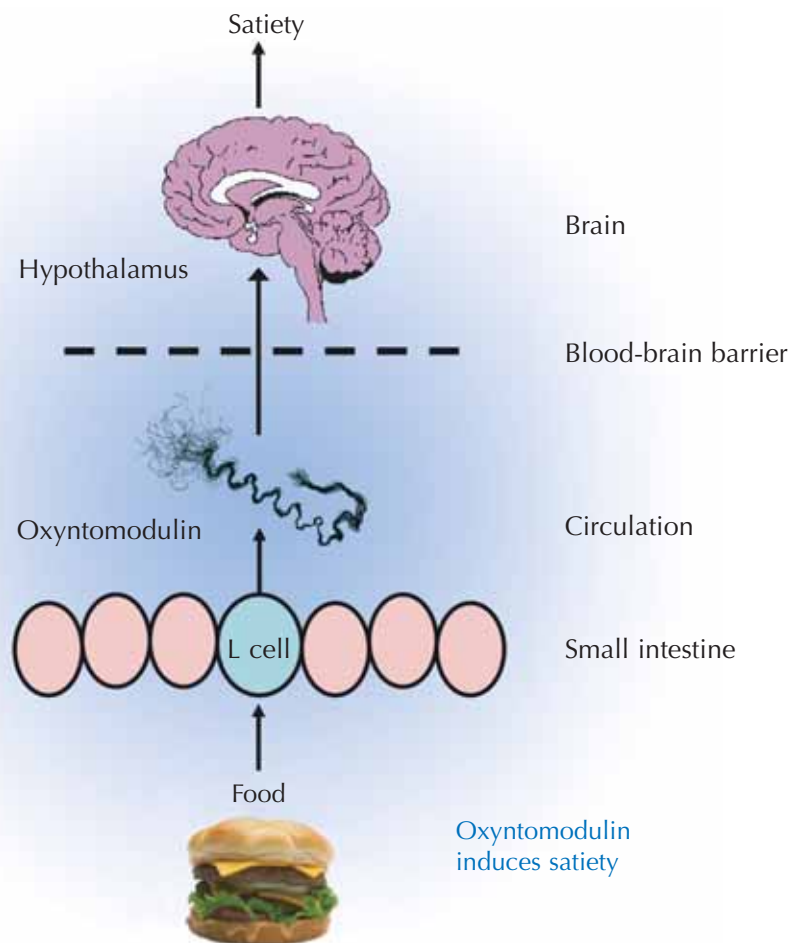


Image courtesy of Katie Wynne

Image courtesy of Friedlinde Krotscheck



Image courtesy of egal / iStockphoto



students to the conclusion that obesity is a sign of disturbed homeostasis, when some individuals do not recognise satiety because their L cells may not function properly. Treatment with oxyntomodulin has the potential to cause weight loss by correcting the body's energy balance, enabling a healthy weight to be maintained.

### 5) Outlook of the treatment

Before oxyntomodulin can be used widely to treat obesity, further study is necessary. From Wynne & Bloom (2007), use the box about clinical

drug trials (right) to show that before drugs are licensed, they go through many stages of testing to identify and minimise side effects.

The following questions may arise or could be posed:

1. What effect does injected oxyntomodulin have on the receptors in the brain?
2. What effect did oxyntomodulin have on the volunteers in the study, other than triggering satiety?
3. Could the injected hormone disturb the production of oxyntomodulin by the body (substrate-induced inhibition)? State a hypothesis.

### Concluding the topic

Ask the students to write a short essay – either a creative story or a factual discussion – about the possible impact of using oxyntomodulin to treat obesity.

Finally, the students could discuss whether this type of research should be funded at all. Why? Why not? With my students, this led to a lively debate, including the point that many more people starve to death around the world than die of obesity-related problems.

By the end of the unit, the students should have understood that our organ systems depend on and influence each other, and that if one parameter is changed there will be a chain of changes elsewhere in the system. This is true of any disturbance of body homeostasis, whether overeating, starvation or even drug abuse.

### References

Evans RM, Friedman JM (2004) Howard Hughes Medical Institute holiday lectures: *The Science of Fat*.

In these lectures for secondary school, leading scientists discuss how the body regulates weight by carefully controlling the storage and burning of fat – and how a better understanding of these complex metabolic systems could lead



## Clinical drug trials

New drugs must go through a series of trials, known as phases, in order to test whether they are effective and safe.

**PHASE I:** Early trial in a small number of usually healthy volunteers to establish a safe dose and look for potential side-effects.

**PHASE II:** Larger group trial of volunteers (up to 100) with the illness to be treated, to establish short-term effectiveness and safety. Both studies described in this article were early Phase II trials.

**PHASE III:** Large group drug trial of volunteers (up to several thousand) with the illness, over an extended period of a year or more to compare the treatment with an existing therapy or a placebo.

**PHASE IV:** Drug trial usually performed after a treatment has been licensed, to establish the effectiveness of the treatment when it is used more widely and to investigate long-term risks and benefits.

	Phase			
	I	II	III	IV
Number	124	259	169	55

**Table 3:** Potential obesity drugs entering each phase of clinical trials in 1994-2007. Although many potential drugs are investigated, few reach the market: only two are currently licensed in the USA.

BACKGROUND

researchers to treatments that curb obesity and improve public health.

Lecture 1: Deconstructing obesity, by Jeffrey M Friedman, MD, PhD

Lecture 2: Understanding fat: syndrome x and beyond, by Ronald M Evans, PhD

Lecture 3: Balancing the fat equation, by Ronald M Evans, PhD

Lecture 4: Exploring obesity: from the depths of the brain to the far Pacific, by Jeffrey M Friedman, MD, PhD

These and all other lectures in the Howard Hughes Medical Institute holiday lecture series can be viewed online or ordered free on DVD. The transcripts of the lectures are available to download. See [www.hhmi.org/biointeractive/obesity](http://www.hhmi.org/biointeractive/obesity)

To learn more about some of the Howard Hughes Medical Institute holiday lectures, see the following reviews:

Hadjimarcou M (2006) Review of *Learning from Patients: the Science of Medicine*. *Science in School* 2: 83.

[www.scienceinschool.org/2006/issue2/patients](http://www.scienceinschool.org/2006/issue2/patients)

Hadjimarcou M (2007) Review of *Clockwork Genes: Discoveries in Biological Time and Evolution: Constant Change and Common Threads*. *Science in School* 7: 66-67.

[www.scienceinschool.org/2007/issue7/clockwork](http://www.scienceinschool.org/2007/issue7/clockwork)

Hadjimarcou M (2009) Review of *Potent Biology: Stem Cells, Cloning, and Regeneration*. *Science in School* 11: 92.

[www.scienceinschool.org/2009/issue11/potentbiology](http://www.scienceinschool.org/2009/issue11/potentbiology)

Wynne K, Bloom S (2007)

Oxyntomodulin: a new therapy for obesity? *Science in School* 6: 25-29.

[www.scienceinschool.org/2007/issue6/oxyntomodulin](http://www.scienceinschool.org/2007/issue6/oxyntomodulin)

### Web references

w1 – The necessary tables and worksheets for this activity can be downloaded from the *Science in School* website:

[www.scienceinschool.org/2010/issue16/obesity#resources](http://www.scienceinschool.org/2010/issue16/obesity#resources)

w2 – Body mass index can be calculated using online tools such as:

[www.nhlbisupport.com/bmi/bmi-m.htm](http://www.nhlbisupport.com/bmi/bmi-m.htm) and

[www.bmi-calculator.net](http://www.bmi-calculator.net) (in either metric or imperial measures).

w3 – To calculate their energy intake in kJ, the students might find the search function on the Nutrition Data website helpful. See:

[www.nutritiondata.com](http://www.nutritiondata.com)

To calculate their energy expenditure in kJ, they could use the information on Answers.com:

[www.answers.com/topic/average-energy-expenditure-of-various-activities-and-sports](http://www.answers.com/topic/average-energy-expenditure-of-various-activities-and-sports)

w4 – To calculate their own basal metabolic rates, the students could use the following website:

[www.bmi-calculator.net](http://www.bmi-calculator.net)



w5 – A useful slideshow presentation about basal metabolic rates is available here:

[www.slideshare.net/Meggib/energy-expenditure-presentation-703878](http://www.slideshare.net/Meggib/energy-expenditure-presentation-703878)

w6 – To learn more about the European Molecular Biology Laboratory (EMBL), see:

[www.embl.org](http://www.embl.org)

For more information about the European Learning Laboratory for the Life Sciences, EMBL's science-education facility to bring secondary-school teachers in contact with EMBL's scientific environment, see: [www.embl.org/ells](http://www.embl.org/ells)

w7 – Science on Stage is a network of local, national and international events for teachers. National Science on Stage events culminate in a European teaching festival every two years, the next one being in Copenhagen, Denmark, from 16-19 April 2011.

To learn more about Science on Stage and find your national contact, see the Science on Stage Europe website:

[www.science-on-stage.eu](http://www.science-on-stage.eu)

To find out more about Science on

Stage Austria, see:

[www.scienceonstage.at](http://www.scienceonstage.at)

To read about the Science on Stage Austria national event in February 2010, see:

Hayes E (2010) Science on Stage: gathering momentum. *Science in School* 15: 2-3.

[www.scienceinschool.org/2010/issue15/sons](http://www.scienceinschool.org/2010/issue15/sons)

## Resources

To learn more about clinical trials, see:

Garner S, Thomas R (2010) Evaluating a medical treatment. *Science in School* 16: 54-59.

[www.scienceinschool.org/2010/issue16/clinical](http://www.scienceinschool.org/2010/issue16/clinical)

To browse all medicine-related articles in *Science in School*, see:

[www.scienceinschool.org/medicine](http://www.scienceinschool.org/medicine)

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Friedlinde Krotscheck has taught for a total of 25 years. After qualifying as a teacher, she taught both biology and sports at secondary schools in Hamburg and Heidelberg, Germany.

In 1988, she and her family moved to Texas, USA, where she taught science for six years, and organised the annual science and mathematics day at the school. After summer courses on biotechnology and gene technology, she became a biotechnology ambassador, teaching the subjects to US high-school teachers.

Returning to her old school in Heidelberg (the Internationale Gesamtschule) in 1995, Friedlinde became involved with the education activities at the European Molecular Biology Laboratory<sup>w6</sup>, visiting the laboratory with her students and taking part in teacher-training courses. These emphasised the importance of 'real' science in science teaching – planning and doing experiments and understanding the process of scientific discovery.

Since moving to Austria after her retirement in 2008, Friedlinde has continued to review articles and resources for *Science in School*, and to chair Science on Stage Austria<sup>w7</sup>.

