

# Trouble in the Kitchen: A Problem-Based Activity in Human Biology

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## ***Abstract***

In Ontario, the secondary school science curriculum advocates the use of laboratory activities to reinforce specific scientific concepts and promotes the development of skills in scientific investigation and communication. Students in biology courses are often expected to identify unknown substances using standard tests, but rarely are these tests integrated into a problem-based learning situation. This activity provides an opportunity for students to demonstrate critical thinking and deductive reasoning skills, while also demonstrating procedural aptitude. To be successful, students must conduct a series of controlled experiments and, by analyzing the results, solve the dilemma of which food to serve to which hospital patient.

## ***Introduction***

It has been suggested that there is a positive correlation between conceptual and procedural knowledge (Hiebert & Lefevre, 1986; Johnson & Siegler, 1998). These are often evaluated independently, and rarely in a framework that permits the assessment of applied knowledge. Consequently, there is a need for approaches that encourage students to combine both types of knowledge to solve problems. In the study of digestion, biology students are often expected to investigate the effect of parameters such as temperature and pH on enzyme activity, or to set up controlled experiments. Further, in earlier science courses, they are taught the basic food groups such as carbohydrates, fats, and proteins. In addition, procedures for determining the presence of the monomers that make up these groups may be introduced. Such procedures include the standard test for a simple sugar, for starch (a polymer of glucose), for amino acids (the basic units for proteins), and for lipids. However, rarely are they asked to combine this knowledge to solve a problem.

This activity overview describes a situational problem that requires students to conduct a series of controlled experiments, providing an opportunity for them to show their critical thinking and deductive reasoning abilities while demonstrating procedural knowledge. Teachers are invited to implement it in a way appropriate to their particular context.

## ***Scenario***

Christmas is nearly ruined when Marge has to spend the day at Springfield General Hospital to remove the faucet her son has stuck to his forehead. Dr. Hibert, brandishing a bone saw, frightens Bart who runs away. Finally, ending up in the kitchen, Bart finds trays of prepared meals in containers labelled with patients' names. With a mischievous grin, he removes the labels.

You are a dietician at Springfield General Hospital responsible for preparing the special supplements for a group of patients who require specific nutrients to speed up their recovery. The supplements are administered as a power shake. Having prepared and labelled the supplements for each patient, you are called to help search for a boy with a faucet stuck to his head. When you return you find the labels are missing. Each shake was individually prepared for patients with specific disorders, and if they get the wrong one, it could have dire consequences. You do not have

time to prepare fresh portions, but you do have time to conduct some simple tests to determine which major nutrients are present. You must then provide each person with his or her correct power shake and explain your reasoning.

### ***Pre-Activity***

Remind students of the test reagents used to detect the presence of the three basic food groups: carbohydrates, fats, and proteins. In addition, the test for glucose--a simple carbohydrate--and starch--a polymer of glucose-- is addressed, but the expected positive test results for each of these macromolecules is not given. This is to ensure that positive and negative controls are used. In order to complete the necessary tests, reference should be made to appropriate safety measures, such as the use of safety glasses and care in the use of the Bunsen burner or hotplate when setting up a water bath.

### ***Patient List and Medical History***

Mr Cranky has a sweet tooth, but is also diabetic. His insulin treatments were interrupted because of a recent urinary tract infection and he now shows signs of hyperglycaemia that can lead to death. Since he is unable to produce insulin, his meal must be free of simple sugars. The absence of insulin triggers the use of fats and fatty acids as an energy source and this leads to an increase in ketone body formation in the blood. Fats should therefore be avoided in the supplement.

Ms Yellowstone has infective jaundice, which she caught while on safari. She is now anorexic due to excessive vomiting, and experiences stomach pain. Her skin and eyes have a yellow colour. She is in the early stages of the disease and becomes ill if food containing fats are included.

Custodian Willie suffered severe third degree burns to 80% of his body during a fire in the school kitchen. He has had several skin grafts and, in order to speed up the healing process, he needs a diet rich in amino acids.

A young singer, Brittany S., suffers from chronic renal failure, where her kidneys are progressively and irreversibly damaged. As the condition advances, there is a build-up of urea and uric acid as waste products of metabolism. Many of her symptoms are due to urea accumulation, which results from protein breakdown. Protein in her diet may result in hiccups, muscle spasms, and increasing drowsiness, which precedes terminal coma and death.

Cleo Rhinestart was an obese man who enjoyed feasting on high carbohydrate foods, until he began to show sensitivity to particular foods such as gluten, found in wheat and rye. Cleo Rhinestart also suffers from swollen and painful lower joints and is to be tested for the presence of excess uric acid, which can cause gout. For the last 48 hours, he has been on a fat free diet and now requires a high fat diet in order for the x-ray test to be completed.

Baby Herman, normally a very quiet child, has become irritable and has a ravenous appetite but gains no weight. After some tests, the results suggest that he is unable to produce the pancreatic enzymes amylase, lipase, and trypsin. Digestion is impaired and absorption cannot occur, and this explains the increase in appetite. Although the appropriate enzymes can be added to his food, his diet has to be modified to reduce the amount of fat, as digestion and absorption of proteins and carbohydrates are reduced in the presence of fats in the intestine. The doctor has prescribed a fat free diet.

Students might be asked to research additional information about these diseases, symptoms, and dietary requirements, using websites such as Diabetes (2005) and Celiac Sprue Association (2005).

### ***Teacher Preparatory Materials***

Sources of protein include albumin, gelatine, or skim milk powder. Where fat is required, a small amount of lard is rubbed into Borax powder, giving a powdery texture. This reduces the likelihood of direct observation of the fat by students.

Diet A contains equal parts of protein, starch, and glucose, Diet B contains equal parts of fat/borax mixture, Diet C contains equal parts of glucose and protein, Diet D contains protein, Diet E contains equal parts protein and starch, Diet F contains equal parts of glucose, starch, and fat, and this information is summarized in Table 1.

Table 1  
*Constituency of Each Diet*

Diet	Contents			
	Glucose	Starch	Fat	Protein
A	+	+		+
B			+	
C	+			+
D				+
E		+		+
F	+	+	+	

### ***Expected Results***

Diet A is for Baby Herman, because it lacks fat but contains the other foods. His prescribed diet should be fat free, but contain carbohydrates and proteins. The addition of the enzymes permits the digestion of the food supplements, and absorption occurs more readily in the absence of fats.

Diet B is for Cleo Rhinestart, because it lacks starch due to his obesity and sensitivity to gluten, which is found in starch. He also requires a high fat diet.

Diet C is for Ms Yellowstone, because it lacks fats and starch. The sugar provides the energy requirements and the protein replaces lost of nutrients due to vomiting

Diet D is for Custodian Willie, who requires a protein diet for tissue repair and healing. Although glucose and fats are needed, amino acids are the highest priority for tissue repair.

Diet E is for Mr Cranky. His diabetic condition means that simple sugar should be excluded. To reduce ketone build-up as a consequence of fat utilization, fats should be avoided.

Diet F is for Brittany S. She suffers from renal failure, which results in urea and uric acid waste build-up. These wastes are a result of deamination of proteins; hence a diet excluding proteins is necessary.

### ***Conclusion***

School science traditionally involves the use of prescribed lab activities that, while attempting to combine theory with practice, often fall short. The development and use of situational problems,

like the one described here, challenges students to combine conceptual knowledge with procedural knowledge and collaborative skills to solve a problem associated with digestion in humans. The problem-based nature of this activity also encourages students to work cooperatively and collaboratively while using basic laboratory skills. In addition, it facilitates the application of logical and sequential thinking and enhances the development of deductive reasoning skills.

### **References**

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## **Critical Incident**

### ***An Invitation***

Readers are invited to send, to the Editor at [editor@ScienceEducationReview.com](mailto:editor@ScienceEducationReview.com) , a summary of a critical incident in which you have been involved. A critical incident is an event, or situation, that marks a significant turning point, or change, for a teacher. The majority of critical incidents are not dramatic or obvious, but are rendered critical through the analysis of the teacher (see Volume 3, p. 13 for further detail). You might describe the educational context and the incident (please use pseudonyms), analyse the incident (e.g., provide reasons to explain your observations), and reflect on the impact the incident made on your views about the learning and teaching process. Upon request, authors may remain anonymous.

We have undoubtedly all done things about which we were very pleased, and perhaps done other things about which we did not feel so pleased, and we all need to remain reflexive of our practice. While teachers will view an incident through the lenses of their own professional experiences, and may therefore explain it differently, this does not detract from the potential benefits to be gained from our willingness to share our experiences and thus better inform the practice of other teachers.

### ***The History of Understanding***

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Once when I was in the optical laboratory, I asked one of my second-year students to describe the reason why a beam of light is refracted when traveling from air into glass. She answered that refraction occurs because light corpuscles are attracted by glass corpuscles. I was much surprised, and inquired where she had learned this explanation. She had brought a well-known course in optics. I asked her to find the required passage and read it aloud for the benefit of other students in the laboratory. She found it and began reading: "Isaac Newton considered that refraction of light is due to the attraction acting between light corpuscles and glass corpuscles," and added that she learned this without any doubt because Newton is always right. This accident taught me a remarkable lesson. It is always useful to discuss and compare the ancient and contemporary interpretations of physical phenomena in order to convey the idea that it took a lot of time and effort to come to modern thinking, and that any great scientist can have his or her own misfortunes