Teacher Preparation Notes for
Who took Jerell's iPod? – An Organic Compound Mystery

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This activity reinforces student understanding of different types of organic compounds and several aspects of the scientific method. Before you begin this activity, your students should be familiar with the basic chemical structures and general properties of carbohydrates, lipids, proteins and nucleic acids.

In the first class period, students learn how to test for different types of organic compounds, primarily by using chemical indicators (pages 1-4 of the Student Handout). In the second class period each student group will test one or two types of food or a sample of the evidence to figure out who took Jerell's iPod (pages 5-6). Review and discussion questions are provided on pages 7-8 of the Student Handout.

If you have limited laboratory time, only pages 2-3 and 5 of the Student Handout need to be completed in the laboratory. The other pages of the Student Handout can be assigned as homework and/or discussed in the classroom before and after the laboratory periods.

If you would like to challenge your students and engage them more actively in the scientific process, you can use the second laboratory day for a student-designed investigation. Each group of students will develop their own plan to identify the thief by testing Jerell's evidence and the types of food that were eaten by the coworkers for the different types of organic compounds. For this investigation activity, you can use the last page of these Teacher Preparation Notes to replace pages 5-6 of the Student Handout. You may want to have a class discussion of the strengths and weaknesses of the plans developed by the different student groups and then either encourage the student groups to use insights from this discussion to improve their plans or develop a class plan for the various student groups to cooperate in carrying out the needed tests.

An alternative hands-on activity, A Scientific Investigation – What types of food contain starch and protein? (available at http://serendipstudio.org/sci_edu/waldron/#starch), uses some of the same experimental procedures, but is aligned with the Next Generation Science Standards. In this activity, students first learn about the structure and functions of starch and protein and the role of glucose in the synthesis of starch and amino acids. Then, students learn about scientific investigation by carrying out key components of the scientific method, including developing experimental methods, generating hypotheses, designing and carrying out experiments to test these hypotheses and, if appropriate, using experimental results to revise the hypotheses. Students design and carry out two experiments which test whether starch and protein are found in some or all foods derived from animals or plants or both.

Teaching Points

- Plants and animals contain mainly water and organic compounds (molecules made by living organisms such as plants or animals).
- Most of the organic compounds found in living organisms are lipids, carbohydrates, proteins, or nucleic acids.
    - Examples and functions of each of these types of organic compound are reviewed.
- Most of the food we eat comes from plants and animals so food contains these types of organic compounds.
    - Different types of food have different proportions of the different types of organic compounds.
- An indicator is a substance that changes color in the presence of a particular type of compound.
    - Indicators can be used to determine what types of organic compounds are in a sample.
- Many large organic compounds are made of multiple repeats of smaller building block compounds (i.e. many large organic compounds are polymers made up of monomers).
- Aspects of scientific method are reviewed, including:
    - significance of negative controls
    - comparing results with predictions
    - using evidence to draw conclusions

[1] These Teacher Preparation Notes and the related Student Handout are available at http://serendipstudio.org/sci_edu/waldron/#organic

Equipment and Supplies

- Biuret reagent for protein testing (approximately 6 ml per student lab group; Biuret reagent should be fresh since old Biuret reagent is less sensitive as a protein indicator)[2]
- Iodine-Potassium Iodide Solution for starch testing (approximately 1.5 ml per student lab group)
- Visually readable glucose test strips (5 per student lab group for the first day and 1 or 2 per student lab group for the second day depending on whether you have each student lab group test one or two samples; to find a source I suggest a Google search for "urinalysis glucose test strips" or http://www.carolina.com/other-diagnostic-instruments/urinary-glucose-test-strip-vial-of-100/695960.pr . You may need to modify steps 3-4 on page 3 of the Student Handout, depending on the specific type of glucose test strip. For one type of test strip we have found it necessary to rinse the strip before reading the color. Each student group will need access to a copy of the color code for the glucose test strips for step 3 on page 5 of the Student Handout.)
- Containers for testing food such as test tubes, specimen jars, small plastic or Styrofoam cups, etc. (10 per student lab group for the first day or half this amount if you want the students to wash the containers between the carbohydrate and protein tests; white containers or transparent containers placed on a white background make it easier to see the color change of the indicator solutions) (If you are using test tubes that are too tall to easily dip glucose test strips, you will also need one forceps per group.)
- Stirrers, such as plastic knives (10 per student lab group; an alternative is to have the students shake the containers)
- Masking tape for labeling testing containers
- Gloves (1 or 2 per student for each day)
- Brown paper bag for lipid testing (1 per student lab group; half for each day)

Samples for testing (Save the labels with nutrition information from all the food packages. These will be useful for discussing any discrepancies between predictions and observed results.)

Day 1: (approximately 1.5 ml of each per student lab group)

- Vegetable oil
- Glucose (may also be sold as Dextrose, can be found online, in the pharmacy often times in tablet form, or sometimes, in a cake decorating supply store (e.g. Joann's))
- Corn starch or potato starch (both can be found in the baking needs aisle in a grocery store)
- Powdered egg whites (can be found in the baking needs aisle) or unsweetened gelatin (you will need to change the Student Handout tables on pages 1 and 2 and caution the students to use only one quarter milliliter of gelatin to avoid having it gel)
- Water

Day 2: (approximately 3 ml of each per class)

- Hard pretzels
- Peanut butter
- Jelly (You may want to make sure this tests positive for glucose; we have had success with strawberry jelly and grape jelly or most jellies sweetened with high fructose corn syrup should test positive for glucose.)
- Fat-free or low-fat vanilla or plain yogurt (You will want to check the ingredients list to make sure that you have a brand that does not have added starch (e.g. Dannon or Stonyfield) and a type that is not artificially sweetened.)
- Beans (canned beans that have been mashed into a paste; e.g. canned white beans)
- Glucose, starch, protein (powdered egg whites), oil and water to prepare the evidence samples

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[2] To dispose of significant amounts of Biuret solution, "Place in a vessel containing water, neutralize slowly with diluted hydrochloric acid, discharge into sewer with sufficient water. Dispose of in accordance with federal, state and local regulations or contact and approved licensed disposal agency." It appears that the tiny amounts of Biuret solution added to each sample can safely be disposed of by placing the tested samples in the regular trash. Additional safety information is available at http://www.carolina.com/text/teacherresources/MSDS/biuretreagen.pdf and http://www.carolina.com/text/teacherresources/MSDS/iodinepotiod.pdf.

Preparation of Evidence Samples for Day 2

- These directions are based on the assumption that your test results will reflect the following nutritional information, given in percent by weight (data from www.nutritiondata.com)

Food	Sugars*	Starch (some data missing)	Total carbohydrates	Protein	Fat
Pretzels	3%	71%	79%	10%	3%
Peanut butter – smooth	9%	5%	20%	25%	50%
Jellies	51%		70%	0%	0%
Low-fat vanilla yogurt[+]	14%	0%	14%	5%	1%
White beans (canned)	0%		21%	7%	0%
Kidney beans (canned)	2%	9%	16%	5%	1%
Burritos with beans and cheese	1%	5%	32%	7%	6%
White bread	4%	41%	51%	8%	3%

*The proportion of sugars which is free glucose varies for different types of foods. For example, free glucose is about half of the total sugar in grapes and plums, about a quarter in apples and peaches, 5-50% in different types of corn syrup, and none in table sugar.

[+]These figures apply to brands like Dannon and Stonyfield which do not add starch.

- You will need to prepare dry and liquid evidence in separate containers because, unfortunately, we have only had success in carrying out the tests when the dry and liquid evidence are tested separately. For the dry evidence you will use the glucose, starch and protein (powdered egg whites) that were also used on Day 1, as shown in the table below. For the liquid evidence you will use either oil or water, as shown. For example, if you decide that Jose will be the thief for your first laboratory class, you will prepare the evidence samples for Jose's bean burrito with cheese by mixing starch and protein in one sample jar labeled Dry Evidence A and putting oil in another sample jar labeled Liquid Evidence A.

Worker in break room	**Lunch**	**Dry Evidence**	**Glucose**	**Starch**	**Protein**	**Liquid Evidence**	**Lipid**
Jose	Bean burrito with cheese	A	-	+	+	A	+ (oil)
Ashley	Fat-free yogurt	B	+	-	+	B	- (water)
Bruce	Peanut butter and jelly sandwich	C	+	+	+	C	+ (oil)
Kiara	Pretzels	D	-	+	+	D	- (water)

- Results of the organic compound tests on day 2 may vary, and we encourage you to test your particular food samples with your indicators before presenting this lab to your students. If one of the food samples does not give the expected results, you may want to avoid picking certain coworkers as the thief in order to minimize student confusion.

- We recommend that for each laboratory class you teach, you pick a different one of the coworkers as the thief and prepare evidence for the lunch of that particular coworker.

Safety precautions

Students should at least wear gloves while performing tests for carbohydrate and proteins; goggles are also recommended. You may also want to keep the Biuret reagent and iodine solution at your desk and have students come to pick it up when they need it.

Advice for Organizing the Laboratory Work

- On day 1, we recommend that each student group test all five substances for all four types of organic compounds.
- To solve the mystery on day 2, students will need to test which types of organic compounds are present in the types of foods listed in the tables on page 5 of the Student Handout and which types of organic

compounds are present in the evidence that Jerrell found. Students will use these data and the questions on page 6 to see which coworker's lunch had the types of organic compounds found in Jerrell's evidence.

- There are five types of food to be tested and separate dry and liquid parts of the evidence, so if you have seven groups of students in a class, you can assign one of these seven samples to each group. If possible, we recommend that you assign each type of food or evidence to two student groups in order to compare their results and assess the reliability of the results. The results from all of the student groups will be combined to complete the table in question 4 on page 5 of the Student Handout.

Information and Suggestions for Discussing the Questions in the Student Handout

Page 1, question 1

- Include distinctions between different types of carbohydrates -- monosaccharides (e.g. glucose), disaccharides (e.g. sucrose), polysaccharides (e.g. starch, glycogen, cellulose).
- Encourage students to give multiple characteristics, e.g.:
  - Sugars are sweet; sugars provide energy for cellular processes.
  - Starch comes from plants, e.g. from grains and potatoes; starch serves as an energy store.
  - Lipids feel greasy because nonpolar molecules slip past each other (and your fingers) more easily than polar groups. Lipids (commonly known as fats) provide energy for cellular processes and serve as an energy store.
  - Protein is abundant in muscle which is what most meat and fish foods are. Proteins have many diverse functions, including muscle contraction, enzymes, structural proteins (e.g. collagen), transport proteins (e.g. hemoglobin), hormones (e.g. insulin), receptor molecules, antibodies.

Page 1, question 2

- Concentrated sources of specific types of organic compounds are storage parts of plants or animals, e.g. vegetable oil from seeds, starch from corn seeds, and protein from egg whites (all of these provide nutrients for a developing embryo).

Page 2

- Questions 4 and 6 provide the opportunity to discuss the importance of negative controls for verifying the specificity of a test as well as the correct procedures for hypothesis testing.

Page 3

- For Instruction 4, you may want to ask your students: "Why do drugstores sell glucose test strips? What are they used for?" (See information available at http://www.livestrong.com/article/65971-diabetes-test-strips-work/ for an explanation of different types of glucose test strips.)

Page 4

- In discussing question 1, it may be useful to compare results from different student groups and use the food labels as well as the following nutritional information.

Nutritional Information -- percent by weight (data from www.nutritiondata.com)

Food	Sugars	Starch (some data missing)	Total carbohydrates	Protein	Fat
Cornstarch	0%		91%	0%	0%
Vegetable oil (corn oil)	0%	0%	0%	1%	81%
Dried egg whites	5%		8%	81%	0%
Gelatin, unsweetened	0%	0%	0%	86%	0%

- Question 3 is designed to reinforce student understanding that our food contains organic compounds made by other organisms for their own needs. We use these organic compounds to provide energy and to make the molecules in our bodies. This question will also help to prepare students to answer question 1 on page 5 of the Student Handout.
- To help your students understand the relationship between organic molecules, food and energy, you can use the following minds-on discussion/worksheet activities:
  - How Do Biological Organisms Use Energy? (available at http://serendipstudio.org/exchange/bioactivities/energy)

This activity is designed to help students understand the basic principles of how biological organisms use energy, with a focus on the roles of ATP and cellular respiration.

- Food, Energy and Body Weight (available at http://serendipstudio.org/exchange/bioactivities/foodenergy) This activity helps students to understand the relationships between food molecules as a source of energy, cellular respiration, physical activity, and changes in body weight.

Page 7, question 1
If your students are familiar with the terms polymer and monomer, you will probably want to replace "building block" with "monomer".
To reinforce student understanding of polymers, you may also want to add the following question:
For each of the following, indicate whether it is a polymer (P) or not a polymer (N).
___ DNA
___ fat
___ glucose
___ glycogen [if you have discussed this molecule]
___ protein
___ starch
___ steroid hormone [if you have discussed this type of molecule]
___ sucrose
(Hint: Only four of the above are polymers.)

Page 8, questions 3 and 4
These questions address an important issue which is ignored in the rest of the Student Handout, namely that test results are not simply "positive" or "negative", but rather reflect quantitative differences in the amount of each type of organic compound.

A food may test positive for glucose but not have enough glucose to taste sweet, or the sweet flavor may be masked, e.g. by a sour flavor. Sweet foods may have little glucose, but significant amounts of other sugars (or artificial sweeteners that bind to taste receptors for sugars).

When there is a small amount of a type of molecule (e.g. fat in pretzels) the tests used in this activity may not be sensitive enough to read positive. The results of the protein test for pretzels may be somewhat ambiguous, but if a little bit of pretzel is crushed into fine crumbs and you wait a while for the color change, you can see the purple color indicating the protein in pretzels. This provides a good opportunity to discuss how scientific results are sometimes ambiguous. To clarify any ambiguity scientists try to improve their methodology and then repeat the experiment.

Related Activities

- A Scientific Investigation – What types of food contain starch and protein? (available at http://serendipstudio.org/sci_edu/waldron/#starch)
  In this activity, students first learn about the structure and functions of starch and protein and the role of glucose in the synthesis of starch and amino acids. Then, students learn about scientific investigation by carrying out key components of the scientific method, including developing experimental methods, generating hypotheses, designing and carrying out experiments to test these hypotheses and, if appropriate, using experimental results to revise the hypotheses. Students design and carry out two experiments which test whether starch and protein are found in some or all foods derived from animals or plants or both. (NGSS)

- Macromolecules Jeopardy (available at http://serendipstudio.org/exchange/bioactivities/macromolecules)
  This game reviews introductory chemistry, including organic compounds and chemical reactions.

- Enzymes Help Us Digest Food (available at http://serendipstudio.org/sci_edu/waldron/#enzymes)
  Students learn about enzyme function, enzyme specificity and the molecular basis of lactose intolerance through experiments with the enzyme lactase and analysis and discussion questions. Students engage in the scientific practices of designing and carrying out experiments and interpreting data. (NGSS)

- Understanding the Functions of Proteins and DNA (available at http://serendipstudio.org/exchange/bioactivities/proteins)
  This overview provides a sequence of learning activities to help students understand that proteins and DNA are not just abstract concepts in biology textbooks, but rather crucial components of our bodies that affect functions and characteristics that students are familiar with. Students learn about how proteins contribute to the digestion of food and to characteristics such as albinism, sickle cell anemia and hemophilia. Then, students learn about the relationship between the genetic information in DNA and the different versions of these proteins. The discussion, web-based, and hands-on learning activities presented are appropriate for an introductory unit on biological molecules or as an introduction to a unit on molecular biology.

The next page provides a page to substitute for pages 5-6 of the Student Handout if you want to use the second laboratory day for a student-designed investigation (see page 1 of these Teacher Notes).

Part II – Solving the Mystery – Who took Jerell's iPod?

The following table lists the co-workers in the break room and the type of lunch they were eating while Jerell was studying.

Worker in break room	Lunch/Snack
Jose	Bean burrito with cheese
Ashley	Fat-Free Yogurt
Bruce	Peanut butter and jelly sandwich
Kiara	Pretzel

The samples you will have available to test for different types of organic compounds are the liquid and dry parts of the evidence that Jerrell found and five types of foods (pretzel, peanut butter, jelly, fat-free yogurt, and beans).

Design a plan to get the information you need to figure out who took Jerell's iPod by using the tests for different types of organic compounds.

Advice: You will need to test the dry and liquid parts of Jerell's evidence separately since the tests for organic compounds will not work if you combine the dry and liquid parts of the evidence. To test the pretzel, crush a little bit into fine crumbs. To test the beans, mash them into a paste. Do not add water when you test the beans, yogurt or liquid part of Jerell's evidence.

Write down your plan, and create a data table or tables that you will use to figure out who took Jerell's iPod. Check these with your teacher before you begin testing your samples.

After you have tested your samples, use your findings to figure out who took Jerell's iPod.