

Purpose

Students will explore the presence of biological macromolecules in food using a laboratory experiment and deductive reasoning.

Student Guide

The student guide is provided during the instruction as well as at the beginning of the virtual experiment and the in-laboratory (“wet”) experiment, both of which follow the same lab procedure. Be sure either to provide copies to students or enable them to print the guides themselves when they reach the instruction phase of the lab lesson.

Background Information

We find four types of macromolecules in all organisms. While this lab does not include nucleic acids, it does include proteins, lipids, and carbohydrates (carbohydrates are further categorized as simple or complex). These macromolecules are common ingredients in the foods we eat and more commonly called nutrients. These simple chemical tests shown below help us to identify their presence.

Macromolecule	Indicator Test	Resulting Color	Control Treatment in this Lab
protein	Biuret reagent	pink/purple	liquid gelatin
lipid (oils, waxes, and fats)	Sudan red	floating red layer	Vegetable oil
complex carbohydrate (polysaccharides)	Lugol's solution	blue/black	polysaccharide solution
simple carbohydrate (monosaccharides)	Benedict's Solution	red	monosaccharide solution

By observing the color change when the reagents are added to a positive control and by observing the lack of color change when the reagents are added to water (which has no nutrients despite its integral role in life), students will be able to determine whether each macromolecule is present in their mystery food samples.

Teacher Guide

While such tests will not provide conclusive identification of the mystery food samples, this process of testing has applicability in a broad range of scientific endeavors, including forensic investigation. When unknown materials are found, it is their response to known reagents and our ability to compare those responses to controls that allows scientists eventually to make positive, certain identification.

Preparation / Alternatives

Below are recommendations for preparing the five treatments:

- **Monosaccharide Solution:** Corn syrup, commercially available in grocery stores, is a ready-made solution of simple carbohydrates. Some syrup, such as the high-fructose corn syrup commonly used in soft drinks, will have more fructose, and other syrups will have more glucose, but the syrup may be a quick, accessible alternative to preparing a glucose solution. Dilute to a 10% by volume solution.
- **Polysaccharide Mixture:** Prepare a polysaccharide mixture by slowly stirring up to 120mL of corn starch into 1000mL of tap water to create a mixture. If shaken or otherwise agitated, the mixture should not be lumpy and should stay in suspension long enough to test.
- **Lipid:** You can use common vegetable oil.
- **Protein:** Prepare a liquid gelatin mixture for the lab. Do *not* follow the package instructions; you can add as little as 15 mL of powdered gelatin to 1000 mL of warm water. If the mixture is too runny, you can always add small quantities of the gelatin until you achieve the desired consistency.
- **Water:** Use regular, room temperature tap water.

Also, for the wet lab, you may use any of the four mixtures as the mystery food. However, giving all students the same mystery food sample may help to avoid confusion and better allow for a whole-class discussion about the procedure, tests, and results.

Monitoring the Lab Procedure

- Ensure that safety procedures are followed at all times. In particular, make sure students have gloves to use while working with the Sudan red solution.
- Students moving themselves and objects to and away from the boiling water baths should be closely supervised.

Teacher Guide

- Consider modeling all tests before instructing students to continue. This will be especially useful when the students test the vegetable oil. Water and oil, if spilled on the classroom or laboratory floor, make for a hazardous situation.
- To expedite the lab, teams of 4 students might divide the different tests and then share their results. This would increase the students' opportunities to test a wider variety of known and unknown foodstuffs.
- Remind students at the beginning of the laboratory to never eat in a science lab. During the laboratory, circulate to ensure that students treat the mystery sample as a chemical and not a food.

Teacher Guide

Data

While students perform the procedure, they should record their data in the format that best shows their findings. The data table format used in the lab lesson is sufficient for this purpose. Sample data shown below matches the result of the virtual experiment. Student data may vary, particularly depending on what mystery food sample you choose for students, but generally, students should record colors similar to those shown and the explain any deviations in their reports.

Step 2: Protein Test (Biuret Solution)

	Gelatin (Positive Control)	Water (Negative Control)	Mystery Food Sample
Color	<i>Pink/Purple</i>	<i>Blue</i>	<i>Blue</i>
Conclusion	<i>The color of the liquid in the test tube was <u>not</u> pink/purple, so the mystery food sample has tested negative for protein. The food was likely <u>not</u> Zack's tofu, contrary to the hypothesis.</i>		

Step 3: Lipid Test (Sudan Red Solution)

	Vegetable Oil (Positive Control)	Water (Negative Control)	Mystery Food Sample
Color	<i>Red</i>	<i>Clear</i>	<i>Red</i>
Conclusion	<i>The color of the liquid in the test tube <u>was</u> red, so the mystery food sample has tested positive for lipids. There is a chance that the food was Nicole's salad dressing.</i>		

Teacher Guide

Step 4: Polysaccharide Test (Lugol's Solution)

	Polysaccharide Mixture (Positive Control)	Water (Negative Control)	Mystery Food Sample
Color	Blue/Black	Brown	Brown
Conclusion	The color of the liquid in the test tube was <u>not</u> blue/black, so the mystery food sample has tested negative for polysaccharides.		

Step 5: Monosaccharide Test (Benedict's Solution)

	Monosaccharide Solution (Positive Control)	Water (Negative Control)	Mystery Food Sample
Color Before Heat	Clear	Clear	Clear
Color After Heat	Orange/Red	Blue	Blue
Conclusion	The color of the liquid in the test tube was <u>not</u> orange/red, so the mystery food sample has tested negative for monosaccharides.		

Teacher Guide

Analysis

When students write their lab reports, they should provide a written explanation of their results and how the dependent variable was affected by the independent variable.

Sample Analysis: *The mystery food sample contains a lipid because it was red in contact with the Sudan red, an indicator of lipids. However, when the mystery food sample was tested with Benedict's solution, Lugol's solution, and Biuret reagent, it demonstrated no color changes. Therefore, the mystery food sample contains only a lipid among the four macromolecules tested.*

Conclusion

When students write their lab reports, they should restate the hypothesis and explain whether it was supported by the data. They may also revise the hypothesis and state what they would do differently next time. They should also identify any additional questions that arose from conducting the experiment.

Sample Conclusion: *The hypothesis was "If the mystery food tests positive for protein and negative for other macromolecules, then Zack is guilty, because his tofu is high in protein." This hypothesis was not supported because the Biuret reagent did not give a positive test. Moreover, The mystery food sample did react with the Sudan red reagent, indicating a lipid is present. Tests like these indicating the presence of a macromolecule can be used in crimes scene investigations to identify the presence of certain substances. For example, since blood contains protein, the Biuret reagent could be used to test for the presence of blood.*

Extension Activities

Here are some variations that may lead to an increased understanding of nutrients, and how their identification is applied.

- Students can compare their data against a table of known nutrients in different foods to narrow their search for the specific mystery foods they had.
- After the completion of the lab, students can be provided with named samples of food for testing. When students positively match their results to the known, they can confidently claim to have identified their mystery foods.
- For fats not in a watery mixture (such as those in solids like baked or fried goods), students can explore the grease-spot method.

Teacher Guide

- Use the nutritional information on the package to identify the nutrients (proteins, lipids, and simple and complex carbohydrates) present in foods. Use the tests described in this lab and compare results to the information on the packaging. Note that in some cases, test results may appear negative or inconclusive based on the low concentration or percentage composition of some nutrients.