A Scientific Investigation – What types of food contain starch or protein?[1]

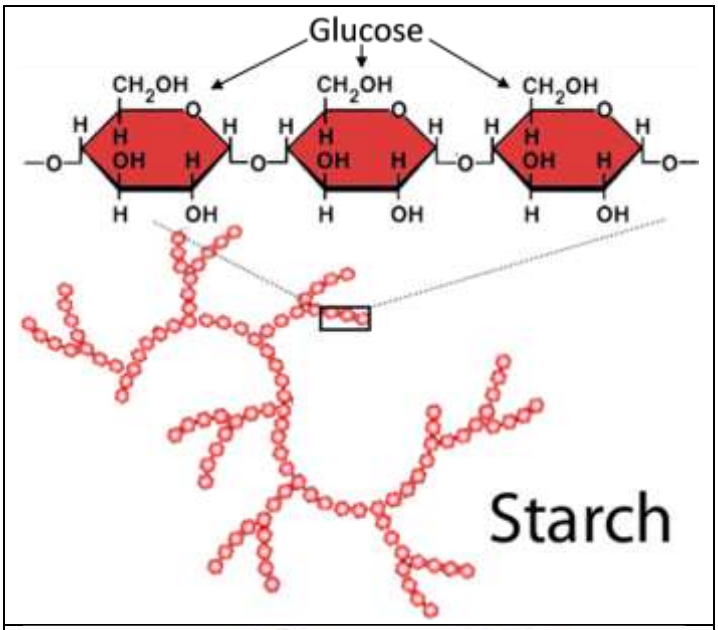
1a. List some foods that you think contain starch. Label each food with A if the food comes from animals, P if the food comes from plants, or A & P if the food comes from animals and plants.

1b. Propose a hypothesis about which types of food contain starch (all or some foods that come from animals and/or plants).

1c. List some foods that you think contain protein. Label each food with A, P, or A & P.

1d. Propose a hypothesis about which types of food contain protein.

A **starch** molecule is a polymer of glucose molecules (see figure). A **polymer** is a large molecule made up of many repeated subunits, called **monomers**.

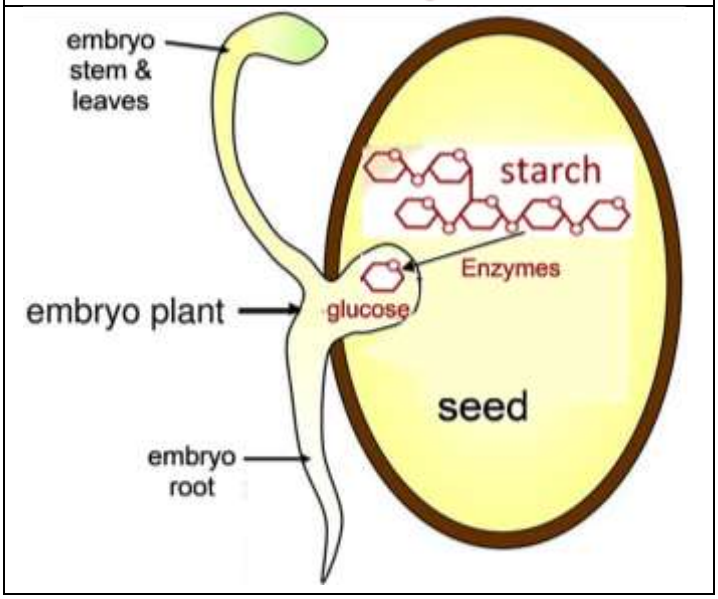


2a. The monomer in starch is_____.

2b. Which three types of atoms are found in starch?

The function of starch molecules is to store the sugar, glucose, for later use. For example, some plants put starch in their seeds. When a seed sprouts, enzymes break down the starch in the seed to individual glucose molecules which are used by the embryo plant.

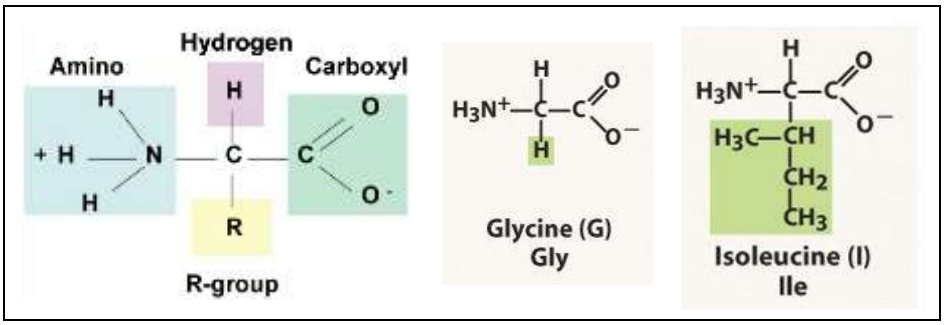
- The embryo plant uses some of the glucose molecules to synthesize other organic molecules for the growing embryo plant.
- The embryo plant uses other glucose molecules to supply energy for the activities of life.



3. Why do some plants put starch in their seeds?

[1] By Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, © 2024. This Student Handout and Teacher Preparation Notes with suggestions for implementation and background biology are available at https://serendipstudio.org/sci_edu/waldron/#starch.

Proteins are polymers of **amino acids**. This figure shows the basic structure of an amino acid and two examples of the 21 different types of amino acids in human proteins.



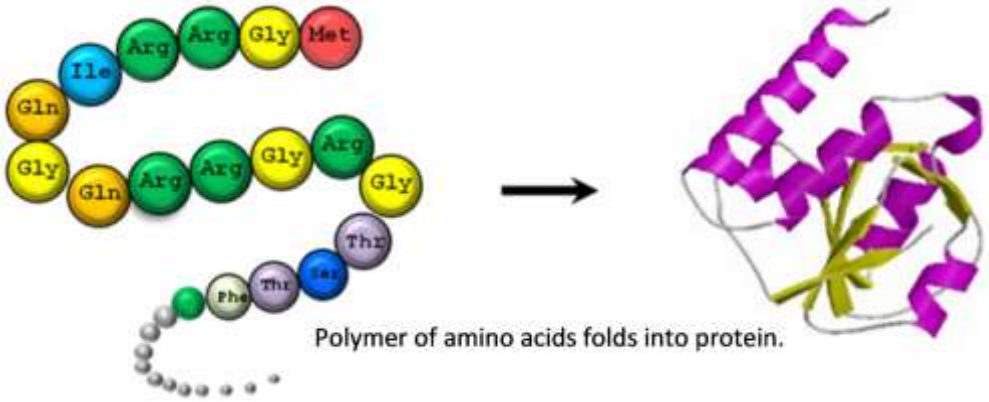
4a. Each amino acid has a central carbon atom linked to:

- a nitrogen-containing _____ group
- a hydrogen atom
- a carboxyl group which acts as an acid
- an R group which varies in different amino acids

4b. In the above figure, circle the part of each amino acid that is the same in all types of amino acids.

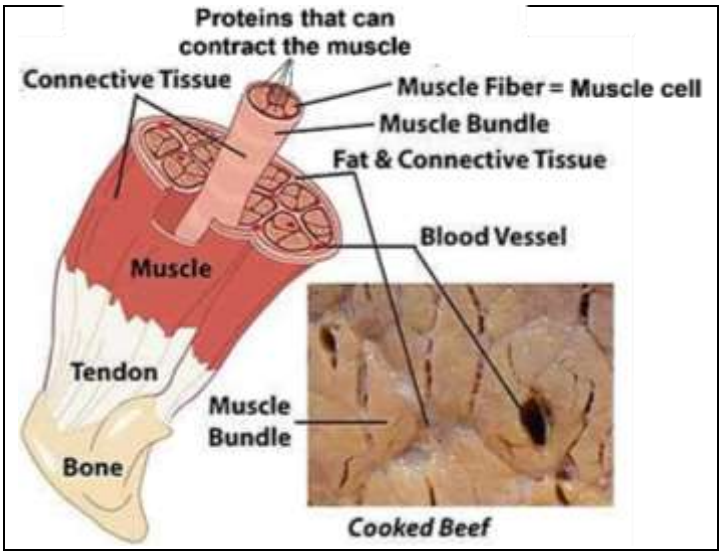
4c. Which type of atom is present in each amino acid, but not in glucose?

After amino acids have been joined together in a specific sequence, some of the amino acids are attracted to each other, so the polymer folds into the complex shape of a protein. The specific sequence of amino acids in the protein determines the structure and function of the protein.

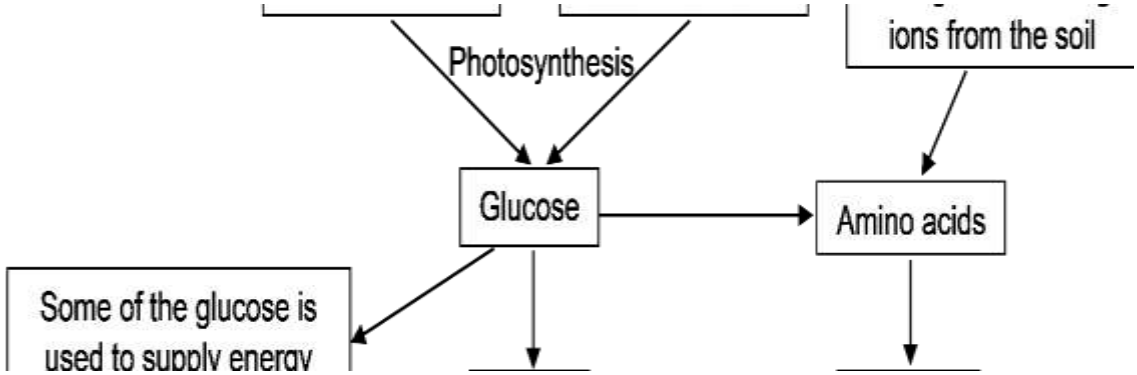


Proteins have many functions. For example, some proteins are enzymes, which speed up chemical reactions. Other proteins contribute to structure or movement (e.g., muscle contraction).

5. Meat is made up mainly of muscle cells from farm animals. Muscle cells have lots of protein. What is the main function of the proteins in muscle cells?



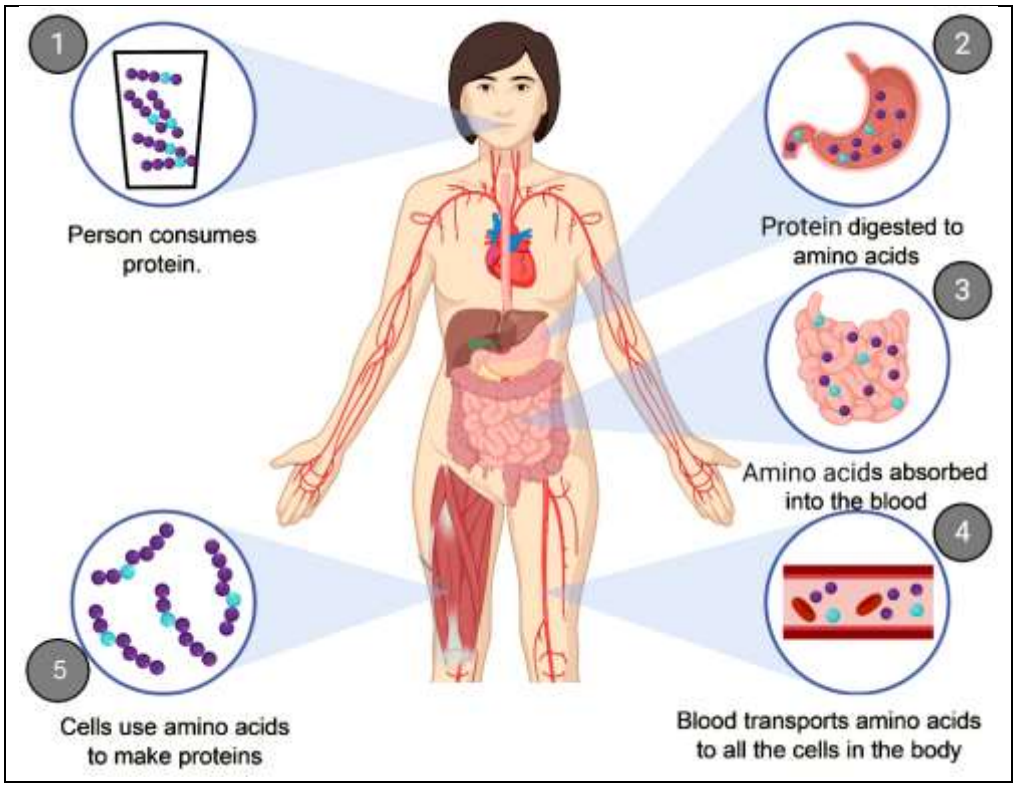
The flowchart indicates how plant cells make starch and proteins. To begin, plant cells use photosynthesis to make glucose molecules. To make a starch molecule, plant cells join glucose molecules together. To make amino acids, plant cells combine carbon-containing molecules derived from glucose with nitrogen-containing ions from the soil. Then, specific amino acids are joined together in the correct sequence to make a specific protein.



6a. How does photosynthesis contribute to the production of proteins in plants?

6b. How do plant roots contribute to the production of proteins in plants?

This figure shows how human cells get the amino acids they need to make proteins. We need to eat foods that contain the essential amino acids that our cells cannot make. Our cells can convert these essential amino acids to the other needed amino acids.



7. Milk contains a lot of protein. How do babies use the proteins in their mother's milk?

How can we test for starch and protein?

In this section, you will evaluate whether either of two indicator solutions can be used to test for starch. An indicator solution is a good test for starch if it changes color in the presence of starch, but does not change color in the presence of other molecules such as sugars, proteins or lipids.

The supplies you will have available to test the indicator solutions are:

- Indicator Solution 1
- Indicator Solution 2
- Containers for testing
- Marker and masking tape for labeling the containers
- Stirrers
- Gloves
- Samples you can use for testing the indicator solutions:
  - Corn starch
  - Egg whites (high in protein)
  - Gelatin (protein from bones, skin, etc. of farm animals)
  - Potato starch
  - Sucrose = table sugar
  - Vegetable oil

8. You will also evaluate whether either of the indicator solutions can be used to test for proteins. Complete this table.

An indicator solution that is a good test for protein will change color when added to these samples from the above list:	An indicator solution that is a good test for protein will *not* change color when added to these samples from the above list:

9a. Which of the available samples should be tested to evaluate whether either indicator solution is a good test for starch? Explain your reasoning.

9b. Which samples should be tested to evaluate whether either indicator solution is a good test for protein? Explain your reasoning.

Before you begin your tests, read the Cautions and the Instructions and answer question 10.

Cautions:

- **Do *not add both* indicator solutions to the same sample; use each indicator solution on a different sample in a separate container.**
- ***Be careful* when handling indicator solution 1; it can stain hands and clothing**.
- **Indicator solution 2 contains sodium hydroxide, a strong base. Be very careful *not to splash or spill any* on yourself or your clothes. If you splash any of this indicator solution on yourself, immediately wash it off with water and then ask your teacher for help**.
- **Wear *gloves* to protect yourself.**

Instructions:

A. For either type of starch or for sucrose, dissolve about 0.3 g in about 2 mL of water.
For gelatin, dissolve about 0.1 g in about 2 mL of water.
For egg whites, use about 0.8 g as your sample for each indicator solution.
For oil, use about 1 mL as your sample for each indicator solution.

B. To use indicator solution 1, add up to 5 drops to the sample and stir.
To use indicator solution 2, add up to 20 drops to the sample and stir. With indicator solution 2, the color change may take up to a minute.

10a. Two student groups tested the same indicator-sample combination. One group observed a color change, but the other group did not. Give at least one possible reason why these two groups got different results for the same indicator-sample combination.

10b. What is the advantage of having replicate tests (i.e. having two different groups test the same indicator with the same sample)?

To be confident of your class results, you will need to carry out each test carefully and have replicate tests. A large number of tests will be required to evaluate whether either of the indicator solutions can be used to test for starch or for protein. Your teacher will assign specific tests to each student group.

11. Record the results of your group's tests in this table. Report your results to your teacher.

Sample	Indicator Solution 1 or 2?	Color of Indicator Solution		
		Before added to sample	After added to sample	Change? Yes or no

12. Use the data from all of the student groups to complete this table.

Sample	Did indicator solution 1 change color?		Did indicator solution 2 change color?	
	Replicate 1	Replicate 2	Replicate 1	Replicate 2
Corn Starch				
Potato starch				
Egg whites				
Gelatin				
Sucrose				
Vegetable oil				

If any of the replicate tests yielded different results, your class will need an additional, very careful replicate test to resolve the disagreement.

13a. Based on the results in question 12, is either indicator solution a good test for <u>starch</u>?

If yes, which one?

13b. Briefly summarize the evidence that supports your conclusion.

14a. Based on the results in question 12, is either indicator solution a good test for <u>protein</u>?

If yes, which one?

14b. Briefly summarize the evidence that supports your conclusion.

15. What additional evidence would allow you to be more certain of your conclusions?

You have tested the indicator solutions on samples of food that have high concentrations of starch or protein. If a food contains only a tiny amount of starch or protein, this will not cause a noticeable change in the color of the indicator solution. Therefore, in this activity, "What types of food contain starch?" is shorthand for "What types of food contain enough starch to cause a noticeable color change in indicator solution 1?"

16. In this activity, "What types of food contain protein?" is shorthand for "What types of food _____?"

What types of food contain starch? What types of food contain protein?

In this part of the activity, you will evaluate whether starch or protein is contained in:

- all foods derived from animals
- all foods derived from plants
- all foods derived from animals or plants
- some foods derived from animals
- some foods derived from plants
- some foods derived from animals or plants

17. Begin by summarizing the results from question 12 in this table.

Foods derived from animals	Did this food have starch?	Did this food have protein?		Foods derived from plants	Did this food have starch?	Did this food have protein?

18a. Write a hypothesis about which types of food contain starch (all or some foods from animals and/or plants).

18b. Write a hypothesis about which types of food contain protein.

Your hypotheses may differ from some of your classmates' hypotheses. Your class will be given the foods listed in the table below to test these different hypotheses.

19. Complete the second through fourth columns in this table to predict the expected results if your hypotheses are correct. If your hypotheses do not predict a specific result, put a ?.

Food (with instructions to prepare sample for testing)	**Does this food come from plants or animals?**	**Based on your hypotheses, do you expect this food to contain:**		**After the testing is complete, use the class data to indicate whether the food contains:**	
		starch?	**protein?**	**starch?**	**protein?**
Beans (mash 2 beans into a paste with ~1 mL water)					
Almond paste (mix ~0.6 g with ~0.5 mL of water)					
Marmalade (mix ~1.5 g with ~0.5 mL water)					
Butter (~1 g)					
Yogurt (~1 g)					

To evaluate your hypotheses (question 18), you will need to test your predictions (question 19). Many tests will be needed, so your teacher will assign specific tests to each student group.

20. To guide your testing, use:

- the cautions and instruction B on page 5
- the instructions in the first column of the table in question 19.

Record your data in this table, and report the results to your teacher.

Sample	**Based on your results, does this food contain**	
	starch?	**protein?**

21. Record the class data in the last two columns of the table in question 19.

22a. Is your hypothesis about which types of food contain <u>starch</u> (question 18a) supported by the new data in question 19? yes ___ no ___

22b. Explain how the evidence does or does not support your hypothesis.

22c. If your hypothesis was not supported, use all of the relevant data in questions 17 and 19 to write a new hypothesis about which types of food contain starch.

23a. Is your hypothesis about which types of food contain <u>protein</u> (question 18b) supported by the new data in question 19? yes ___ no ___

23b. Explain how the evidence does or does not support your hypothesis.

23c. If your hypothesis was not supported, use all of the relevant data in questions 17 and 19 to write a new hypothesis about which types of food contain protein.

24. Indicate any limitations of the evidence and any uncertainty in your conclusions. What additional evidence would be useful to evaluate your hypotheses?