



**“The Protein Myth: Getting the Right Balance”**

*April/May 2018*

<http://www.acs.org/chemmatters>

**Teacher’s Guide**



**Teacher's Guide for**

***“The Protein Myth:
Getting the Right Balance”***

**April/May 2018**

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# Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Energy** | While discussing heat measurement as calories or Joules in a lesson on specific heat capacity, students apply this to the measurement of the energy contained in foods expressed as Calories. The discussion of the difference between calories (c) and food calories (C) in the article supports this lesson.  |
| **Thermochemistry** | The chemical potential energy content of food expressed as the kilocalorie (C) being converted to the kinetic energy used in the body can be used as one example while studying the heat changes of chemical reactions. |
| **Biochemistry** | Metabolic reactions of energy transfer involve the biomolecules of proteins, carbohydrates, and fats. Metabolism converts excess digestible food from any source, including protein, into fat. Students can keep this in mind as they examine their diet, possibly in a unit on food chemistry. |
| **Protein synthesis** | Proteins are polymers of long chains of amino acids. The illustration “How Your Body Uses Amino Acids as Building Blocks” in this article can help students visualize the primary, secondary, and tertiary structure of proteins while studying these biomolecules. |
| **Essential amino acids** | Not all plant proteins contain the same amino acids. From the list of essential amino acids in the article, students learn about the specific amino acids that must come from their diet. This is useful during a unit on food chemistry or protein synthesis. |

# Teaching Strategies and Tools

## Standards

* Links to **Common Core Standards for Reading**:
	+ **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
	+ **ELA-Literacy.RST.9-10.5**: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
	+ **ELA-Literacy.RST.11-12.1**:Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
	+ **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
	+ **ELA-Literacy.WHST.9-10.2F**: Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
	+ **ELA-Literacy.WHST.11-12.1E**: Provide a concluding statement or section that follows from or supports the argument presented.

## Vocabulary

**Vocabulary** and **concepts** that are reinforced in the April/May 2018 issue:

Food Chemistry

Structural Formulas

Chemical Reactions

Reaction Rates

Oxidation & Reduction

Distillation

Environmental chemistry

* Some of the articles in this issue provide information to help students consider their impact on the environment.
* Consider asking students to read “Open for Discussion: Weighing in on calories” to learn about calories in food prior to reading the article “The Protein Myth: Getting the Right Balance.”
* Students may find the infographic on page 19, “As a Matter of Fact: The Aroma of the Seaside” interesting after reading the article “Toxic Shorelines: The Science of Algal Blooms.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles.
* You might also ask them how information in the articles might affect their choices regarding food or water use. Also, ask them if they have questions about some of the issues discussed in the articles.

# Reading Supports for Students

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are provided to help students as they prepare to read and in locating and analyzing information from the article.

The borders on these pages distinguish them from the rest of the pages in this Teacher’s Guide—they have been formatted for ease of photocopying for student use.

* **Anticipation Guide (p. 8):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

***NEW!!!***

Instead of using the Anticipation Guide, consider these ideas to engage your students in reading.

**The Protein Myth: Getting the Right Balance**

* Before reading, ask students to write 2-3 things they know about proteins, and one question they have about proteins.
* As they read the article, they can compare what they knew (or thought they knew) to the information in the article as they also search for answer(s) to their question.
* **Graphic Organizer (p. 9):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (p. 10-11):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Sites for Additional Information” section of the Teacher’s Guide provides sources for additional information that might help you answer these questions.

““The Protein Myth: Getting the Right Balance,” *ChemMatters*, April/May 2018

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Anticipation Guide

“A Close-up Look at the Quality of Indoor Air” (*ChemMatters*, April/May 2016 Issue)

**Directions:**  ***Before reading the article*,** in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Proteins are macronutrients needed to survive.
 |
|  |  | 1. Fats, proteins, and carbohydrates all provide the same number of calories per gram.
 |
|  |  | 1. According to the National Academy of Medicine, at least 50% of the calories we consume each day should come from protein.
 |
|  |  | 1. Teen athletes may need more protein than others.
 |
|  |  | 1. If you eat too much protein, it can be stored as fat.
 |
|  |  | 1. Avocado and nuts are healthy sources of fat.
 |
|  |  | 1. Both plant and animal proteins contain all 20 amino acids we need.
 |
|  |  | 1. Extra protein builds muscle.
 |
|  |  | 1. Egg whites and lean chicken are heart-healthy sources of protein.
 |
|  |  | 1. Nutrition experts claim that eating a variety of foods is healthier than using supplements.
 |

## Graphic Organizer

““The Protein Myth: Getting the Right Balance,” *ChemMatters*, April/May 2018

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to describe proteins.

|  |  |
| --- | --- |
| What are they?Proteins | Why do we need them?  |
| How should we choose whichproteins to eat? | What necessary foods are NOT proteins? |

* Complete this graphic organizer to describe the best sources of protein.

|  |  |
| --- | --- |
| **Recommended Protein Sources** | **Advantages** |
|  |  |
|  |  |
| For vegetarians:  |  |

**Summary:** On the back of this paper, write one new thing you learned about protein and a healthy diet that you would like to share with a friend who is concerned about his or her health.

## Student Reading Comprehension Questions

““The Protein Myth: Getting the Right Balance,” *ChemMatters*, April/May 2018

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

**Directions**: Use the article to answer the questions below.

* 1. Sarah and Anthony both increase what dietary component in their respective diets?
	2. What are macronutrients?
	3. What is a possible problem with Sarah and Anthony’s high protein diets?
	4. Compare the calorie content of the macronutrients—fat, proteins, and carbohydrates.
	5. What is the difference between “calorie” and “Calorie”? Which one is used to represent the energy content of the food we eat?
	6. What is an adequate daily amount of protein for teens?

**Student Reading Comprehension Questions, cont.**

““The Protein Myth: Getting the Right Balance,” *ChemMatters*, April/May 2018

* 1. Why do you need protein in your diet?
	2. What are some of the functions of proteins in the body?
	3. The body does not make all 20 of the amino acids it needs. List the nine amino acids that can only be acquired through diet.
	4. (a) Explain the difference between complete and incomplete protein sources, and (b) give examples of each.
	5. How can eating too much protein weaken bones?
	6. Describe how your body uses amino acids to produce proteins.

## Answers to Student Reading Comprehension Questions

1. **Sarah and Anthony both increase what dietary component in their respective diets?**

*Sarah and Anthony both increase their intake of protein in their respective diets.*

1. **What are macronutrients?**

*“Macronutrients are compounds that humans (and many other animals) need in their diets to meet their nutritional needs and provide the energy, or calories, they need to survive.”*

1. **What is a possible problem with Sarah and Anthony’s high protein diets?**

*Sarah and Anthony’s high-protein diets rely primarily on protein for their caloric needs, instead of food from several of the food groups that are a part of a balanced diet, so they may be missing out on the vitamins, minerals, and other nutrients needed to stay healthy.*

1. **Compare the calorie content of the macronutrients—fat, proteins, and carbohydrates.**

*Of the macronutrients fat, protein, and carbohydrates, fat contains nine food calories per gram while carbohydrates and proteins each contain four food calories per gram.*

1. **(a) What is the difference between “calorie” and “Calorie”?** **(b) Which one is used to represent the energy content of the food we eat?**
	1. *When lower case “c” is used in calorie, it represents a unit of measure that is defined as the amount of heat energy required to raise the temperature of one gram of water by one degree Celsius. When the upper case “C” is used, as in “Calorie”, it represents 1000 calories or a kcal. [Students may also find this information in this same issue of* ChemMatters *(April/May 2018) in the “Open for Discussion” article, entitled “weighing in on calories”, page 4.]*
	2. *The kcal or “Calorie” is used to express the energy content of food.*
2. **What is an adequate daily amount of protein (a) for teenage boys and (b) for teenage girls?**

*An adequate daily amount of protein for*

* 1. *teenage boys is 52 grams, while*
	2. *for teenage girls, it is 46 grams.*
1. **Why do you need protein in your diet?**

*Protein is important in the diet because it provides the 20 amino acids that the body uses to build new proteins in our body that keep us alive.*

1. **What are some of the functions of proteins in the body?**

*Proteins make up most of the physical structure of the body such as skin, hair, muscles, and organs. They also act as enzymes that catalyze reactions, enable the nerves to communicate, and help protect you from getting sick.*

1. **The body does not make all 20 of the amino acids it needs. List the nine amino acids that can only be acquired through diet.**

*The nine amino acids that can only be acquired through diet are:*

*1) histidine 2) leucine 3) tryptophan*

*4) valine 5) threonine 6) lysine*

*7) methionine 8) isoleucine 9) phenylalanine*

1. **(a) Explain the difference between complete and incomplete protein sources, and (b) give examples of each.**
	1. *A complete protein source is one that contains all of the essential amino acids needed by the body. An incomplete protein source only contains some of the essential amino acids.*
	2. *Animal proteins from eggs, milk, cheese, and meat are complete protein sources. Most plant sources lack some of the essential amino acids. Nuts, legumes, grains, fruits, and vegetables are incomplete protein sources that must be eaten in the correct combination to supply all nine essential amino acids.*
2. **How can eating too much protein weaken bones?**

*Eating too much protein can weaken the bones because, when protein is metabolized by the body, acid byproducts are released, which can lower blood pH and cause calcium to leach from the bones.*

1. **Describe how your body uses amino acids to produce proteins.**

*Individual amino acids join into a long strand called a peptide which, when increased in length, winds around itself to become a protein.*

# Possible Student Misconceptions

1. **“Since muscle is made of protein, if I want to build muscle I need to eat more protein.”** *Eating extra protein alone will not build muscle. To build muscle you need to do weight training. It is important to consume enough calories to fuel your weight training and extra exercise, but that can be done with normal or slightly increased amounts of protein and extra carbohydrates.* *Carbohydrates and fats can be stored in your muscles and used for energy during high-intensity workouts. Since your body cannot store protein, it is important to eat some protein after a workout to help the body build more muscle. Any extra protein that you eat above what your body can use is simply broken down and excreted by the kidneys. This is one reason that a high-protein diet can stress your kidneys. On the other hand, if you do not eat enough calories to fuel your exercise, then your body will break down muscle. Eating more protein without exercising will only cause you to gain weight in the form of fat.*
2. **“Protein is only in meat and animal products.”** *There are many plant sources of protein, too. Soy is a complete protein and is available as beans (edamame), soy milk, or as bean curd (Tofu). Quinoa is another plant product that is a complete protein. Other plant foods that are good sources of proteins, though not necessarily complete, are beans, peas, grains such as rice and oats, nuts, corn, avocados, spinach, broccoli, Brussels sprouts, and pumpkin seeds.*
3. **“Carbohydrates are bad for you.”** *Some diets encourage you to reduce the amount of carbohydrates in your diet to the extent that you may think carbohydrates are bad for you but, in the right amount, they are good for you. In fact, carbohydrates are the main source of fuel for the body where they are converted to the glucose required for all cells. The brain needs glucose, more than any other organ, to function properly. When you limit carbohydrates, you deprive your body of a main source of fuel and many essential nutrients that you need to stay healthy. Without enough carbohydrates, the body will use fat and protein for energy.*
4. **“All the essential amino acids must be eaten together during the meal in order to consume complete proteins from vegetable sources.”** *It used to be thought that each vegetarian meal needed to contain all nine essential amino acids in order to count as eating a complete protein. This myth can be traced to 1971 with the publishing of a book that advocated a vegetarian diet—“*Diet for a Small Planet”*. The author proposed pairing different vegetables based on their amino acid content, in order to ensure all nine essential amino acids would be consumed, eliminating the need for meat-based products. After multiple studies, it has been found that, if a variety of vegetables are consumed through the course of the day, they do not all have to be consumed in the same meal in order to supply the daily requirement for the essential amino acids. (*[*https://www.forksoverknives.com/the-myth-of-complementary-protein/#gs.QwfV3zk*](https://www.forksoverknives.com/the-myth-of-complementary-protein/#gs.QwfV3zk)*).*
5. **“Protein is protein. There isn’t any difference between the protein in a supplement and the protein in a normal diet.”** *Proteins are all different, based on their amino acid content. Some proteins contain all 20 of the amino acids the body uses to build its specific proteins, while some only contain a few amino acids. A person eating a varied diet will consume all the necessary amino acids. The amino acids that are present in protein supplements depend on the source of the protein used to make the supplement and how it is prepared. Whey protein is used for lots of protein supplements. It is the liquid portion of milk and contains 18 amino acids. It is particularly rich in the amino acid leucine. Leucine is the amino acid that is the gatekeeper to the muscle-building process. Twenty grams of whey protein contains 1.8 grams of leucine, which is the amount needed to initiate muscle growth. Proteins are compared based on the amount of leucine they contain. According to Alan Flanagan in “5 Common Myths About Protein”,*

To get 1.8 grams of leucine from lean beef, you’d need to eat 113 grams, which would include a total of 30 grams of protein. If you prefer brown rice protein, you’d have to eat about 48 grams of it to get your leucine quota. In short, the limit of how much protein you could or should eat has more to do with how much of that protein it takes to get 1.8 grams of leucine, not how much actual protein you eat.”

*(*[*https://www.bodybuilding.com/content/5-common-myths-about-protein.html*](https://www.bodybuilding.com/content/5-common-myths-about-protein.html)*)*

1. **“Eating fat is bad for you.”** *Actually, not eating fat is bad for you. You cannot live without some fats. Fat is one of the three macronutrients and is as important as protein and carbohydrates. The following are some of the important functions of fats in the body:*
* *Fats provide the essential fatty acids (similar to the essential amino acids).*
* *Cell membranes are made from lipids (remember the phospholipid bilayer you learned about in biology class?).*
* *The structural backbone of hormones is the fat, cholesterol.*
* *Many of the brain’s structural components are fat.*
* *The outer covering of nerve cells, the myelin sheath, is composed of fat.*
* *Some components of the immune system are fat based.*
* *Fat-soluble vitamins are stored in fat until the body needs them.*
* *Fats are a great source of energizing fuel.*
* *Fats make you feel full so you eat less food.*
* *Fats keep the skin soft.*

*So, you see, fats have many important functions and it would be unhealthy to eliminate them from your diet. That being said, there are different types of fats, some of which are better than others for your health. Saturated fats are comprised of single-bonded hydrocarbon chains. They are called “saturated” because all four bonding sites of every carbon atom in the chain is bonded to one other element. Examples of saturated fats are animal fats, butter, and cheese. Unsaturated fats are made up of hydrocarbon chains where there is at least one double/triple bond in the carbon chain. These fats are typically liquid at room temperature, like olive oil, safflower oil, corn oil, and nut oils. The third type of fat—and the one you want to avoid eating—is* trans *fat. These are primarily industrially-produced fats that are made by hydrogenation (adding hydrogen to the double- or triple-bonded carbon atoms in the hydrocarbon chain) of an unsaturated fat, to make it a solid at room temperature. These can be found in some margarines and in many processed foods.*

*In choosing the fats for your diet, choose unsaturated fats first, some saturated fats second, and avoid processed fats like trans fats.*

*(*[*https://www.health.harvard.edu/staying-healthy/the-truth-about-fats-bad-and-good*](https://www.health.harvard.edu/staying-healthy/the-truth-about-fats-bad-and-good)*)*

# Anticipating Student Questions

1. **“What are the Atkins and Paleo diets?”** *The Atkins and Paleo diets are both diets that restrict carbohydrates while allowing more protein and fat to take its place. They are both referred to as ketogenic diets. When the body has to break down fat for its energy, the liver will convert fat into fatty acids and ketone bodies. In some situations, the cells will use the ketone in place of glucose. Excess ketone is excreted in the urine.
The Atkins diet was founded by Dr. Atkins, a cardiologist. It restricts carbohydrate intake, while not restricting protein or fat. Protein and fat use more calories to process, so he claimed that eating these foods help burn more calories. The limited amount of carbohydrate eaten should be non-processed, so he recommends fresh vegetables instead of bread, pasta, and chips.
The Paleo diet is very similar, in that processed foods are not allowed. It is based on a diet similar to a caveman. It promotes the mantra, “If a caveman didn’t eat it, then neither should you.” In the Paleo diet, all grains are eliminated, as well as corn. It is a gluten- and lectin-free diet, both of which are high in wheat, rye, and barley. Sugar is forbidden, as are all processed foods. On this diet, you can eat meats, fish, nuts, leafy greens, regional vegetables, and seeds. Usually, milk and milk products are not eaten with this diet, but some variations will allow these to be added back in slowly after they have been eliminated for a while. Some people prone to food allergies may be prescribed a paleo diet.*
2. **“Are there other macronutrients besides proteins, fats, and carbohydrates?”** *Proteins, fats, and carbohydrates are the nutrients our bodies need in the greatest amounts for our energy. Their energy content is measured in calories, and some sources will only list these three as macronutrients. However, our bodies also need water and fiber in large quantities to function properly, so many sources consider these macronutrients as well.*
3. **“If there are *macro*nutrients, there must be *micro*nutrients, too. What are they, and what do they do for us?”** *The micronutrients are the vitamins and minerals that we need only in minute amounts in our diets. They do not provide energy, but they enable many chemical reactions that occur in the body to help regulate cell function. Iron, for example, is complexed with proteins to form the larger molecule hemoglobin.
Vitamins are organic (carbon-containing) compounds that can be changed by heat, oxygen, light, and chemical processes. Therefore, a food’s vitamin content may change depending on how the food is altered before you eat it. The water-soluble vitamins are vitamins B1, B2, B6, B12, C, niacin, and folic acid. When excess amounts of these vitamins are consumed, they are excreted in the urine, so they need to be consumed daily. The water-insoluble, or fat-soluble, vitamins can be stored in the fatty tissues of the body when in excess. Because they can be stored, fat-soluble vitamins can become toxic if taken in large quantities. The fat-soluble vitamins are Vitamins A, D, E, and K.
Minerals are inorganic substances that are found in the soil or water and are absorbed by plants which are then eaten by animals and humans. Minerals exist in their simplest chemical form as ionized elements and are not destroyed by heat or light. The mineral content of plants varies with the soil content and the maturation of the plant. The major minerals are calcium, potassium, sodium, chloride, phosphorus, sulfur and magnesium. The body requires more than 100 milligrams of these per day. The minerals that are required in quantities less than 100 milligrams a day are referred to as “trace minerals”. The trace minerals are iron, copper, zinc, cobalt, chromium, selenium, iodine, manganese, molybdenum, and fluoride. (*[*http://www.innerbody.com/nutrition/micronutrients#major-minerals*](http://www.innerbody.com/nutrition/micronutrients#major-minerals)*)*
4. **“What exactly could happen to me if I eat too much protein?”** *(1) If you eat more protein than your body can use, some would be converted and stored as fat, and the excess nitrogen would be excreted by the kidneys. (2) When proteins are broken down into fatty acids and ketones, the buildup of ketones will give you bad breath and an unpleasant body odor. (3) Some people experience bowel problems, either in the form of constipation or diarrhea, often times due to the lack of fiber in the diet. (4) When the protein is broken down, the nitrogen products must be flushed from the body and, often, water that is needed elsewhere is used for this, causing you to become dehydrated. (5) If your protein source is red meat, then there is an increased risk you may develop heart disease and/or cancer. This increased risk is not seen in persons whose primary source of protein, even in excess, is from plants.*
5. **“What are some of the vegetable combinations that provide complete proteins?”** *Some examples of vegetable combinations that together provide all nine essential amino acids are rice and beans, lentils and barley, peanut butter with whole wheat bread, and beans and cornbread.*
6. **“How does eating too much red meat cause disease?”** The mechanisms at work that lead *people who eat a lot of red meat to develop heart disease or cancer* are *not completely understood, but scientists have made some suggestions for the causes. Red meat is high in saturated fats, which raise blood cholesterol. The excess cholesterol can build up in the arteries and restrict blood flow to the heart, causing heart disease. There is a strong correlation between a diet that includes a lot of red meat and heart disease. There is also a significant correlation between diets high in saturated fats and an increased risk of colon cancer and breast cancer. There is not as strong a correlation between eating red meat and cancer, but several research studies have shown an increased risk for colorectal cancer in persons who have a diet rich in red meat and processed meats like bacon, ham, sausage, and hot dogs. When meat is grilled at high temperatures heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs) are formed in the meat. Eating these compounds increases the risk of cancer. Well-done meat contains more of these compounds than meat that is not cooked as long. So, if you love grilled meat, you may try grilling it at a lower temperature, avoid allowing any juice to fall on the coals, and avoid overcooking it. (*[*https://www.webmd.com/food-recipes/features/the-truth-about-red-meat#1*](https://www.webmd.com/food-recipes/features/the-truth-about-red-meat#1)*)*
7. **“What happens to proteins in the body?** *In the body, the digestion of proteins begins in the stomach. Hydrochloric acid in the stomach maintains a pH of 1.5–3.5, which denatures the protein, while the enzyme pepsin cuts the denatured protein into smaller polypeptides and individual amino acids. In the small intestine the pancreas secretes bicarbonate, to neutralize the acid, and more digestive enzymes, to break down the polypeptides into individual amino acids. The amino acids are transported across the intestinal mucosa to the liver and cells throughout the body, to create new proteins, or to be converted into fats or acetyl Co A needed for the Krebs cycle. When there are excess amino acids, they undergo decomposition, which results in hydrocarbons and ammonium ions. A high concentration of nitrogen is toxic. The body’s urea cycle uses to ammonium ions to make urea, which can then be excreted from the body. (*[*https://opentextbc.ca/anatomyandphysiology/chapter/24-4-protein-metabolism/*](https://opentextbc.ca/anatomyandphysiology/chapter/24-4-protein-metabolism/)*)*
8. **“How do they make protein powder? What else is in it?”** *There are a variety of different protein powders on the market, and their preparation and content depend on the source. Whey protein is one of the most popular and least expensive. It is made from the liquid portion of milk. There are three types of whey powder—concentrate, isolate, and hydrolysate. Protein concentrates have some fats and carbohydrates and may contain 30% to 90% protein. Whey protein isolates have the lactose and fat removed and are at least 90% protein. Whey hydrolysate has been partially digested and is more easily absorbed. This is the form that is used in baby formulas. Casein is the solid protein in milk when the whey is removed. Both casein and whey have the same protein profile (same amino acids) and both are sold as protein powders. Whey is absorbed quickly by the body, while casein takes longer to digest. It is best to use casein powder before going to bed. Egg protein is rich in vitamins and minerals and as a powder is slightly more expensive than whey and casein protein. Soy protein powders are also an economical source of complete protein. Protein powders prepared from hemp seeds are among the most vegan-friendly of the complete protein powders. Since hemp is only harvested in mass quantities in select countries because of its association with cannabis, it is the most expensive of all the protein powders.* ([*https://www.medicalnewstoday.com/articles/263371.php*](https://www.medicalnewstoday.com/articles/263371.php)*) (*[*https://greatist.com/fitness/protein-supplement-nutrition-guide*](https://greatist.com/fitness/protein-supplement-nutrition-guide)*)*

# Activities

**Labs and demos**

**“Food Calorimetry: How to Measure Calories in Food”:** Students learn how to use a soda-can calorimeter to determine the calorie content of a variety of foods. The procedure includes pictures that illustrate several steps, so students will know exactly how to set up their calorimeter. ([https://www.carolina.com/teacher-resources/Interactive/food-calorimetry+/tr23949.tr](https://www.carolina.com/teacher-resources/Interactive/food-calorimetry%2B/tr23949.tr)) Another source for this activity can be found here: <https://www.flinnsci.com/api/library/Download/f9560a5fc7ef4a6b8f4598fea30626eb>.

**“Presence of Protein in Food (Qualitative Analysis)” (30 min):** This, the 4th experiment in a set of six experiments in “Food Science Experiments to Support the Teaching of Science and Technology” uses Biuret reagent to test for the presence of protein in a variety of different foods. When food samples are tested, the difference in color between deep purple and lighter pink shows students the qualitative difference between a high-protein concentration and a protein source consisting primarily of short-chain polypeptides.

(<http://www.nzifst.org.nz/careers/secondaryresources.asp>)

“**Denaturing Proteins”:** In this short laboratory experiment, students explore how heat, acids and bases, organic compounds, and heavy metals denature proteins. In six different test tubes, students test the effect of adding heat, salt, acid, base, alcohol, or a heavy metal salt to a sample of egg white. (<http://www.math.unl.edu/~jump/Center1/Labs/DenaturingProteins.pdf>)

**Simulations**

“**Eating and Exercise” (PhET):** Students can calculate their body mass index (BMI) and enter their activities and diet to determine if they are heart healthy. The app graphs the projected weight change over time, based on the diet and exercise activities the student chooses. (<https://phet.colorado.edu/en/simulation/legacy/eating-and-exercise>)

**Calorimetry experiments:** This simulation provides students the opportunity to conduct a variety of virtual calorimetry experiments, where they can manipulate the variables of mass, temperature, and type of substance (liquid, solid, solution), and observe how changing the variable affects the amount of heat exchanged in a constant-pressure calorimeter. (<http://dbpoc.com/pearson/chemsims/gold/calorgold5/Calor.php>)

**Proteins and their synthesis:** The “Protein & DNA” simulation at the *Molecular Workbench* Web site, which contains maneuverable molecular models, would be useful during a unit on protein structure and composition; the first six lessons pertain to proteins as polymers of amino acids and how the shape of the protein is determined by the amino acids and their sequence. The Web site index can be found here: <http://mw.concord.org/modeler/>; search for “Proteins and DNA” among the icons. You will need to download the Molecular Workbench software and Java software to use the simulation. (Molecular Workbench is a worthwhile site that has many biology, chemistry, and physics simulations, somewhat similar to PhET.)

**Media**

**“How Does Protein Build Muscle?” video (3:40):**  This video describes how muscles grow in response to exercise, and it reviews the protein requirements for muscle growth in athletes and non-athletes. Protein powders are depicted as one way to increase protein intake. (<https://www.youtube.com/watch?v=L5-tKciXEG8>)

**“7 Warning Signs Your Body Needs More Protein that You Shouldn't Really Ignore” video (3:22):** This short video helps students know if they are protein deficient, by going over seven symptoms of protein deficiency. It also reviews the average daily requirement for protein and gives examples of several foods rich in protein. (<https://www.youtube.com/watch?v=0s0WXiSd3dQ>)

**Lessons and lesson plans**

**Isolation and testing of milk proteins:** “Unit 3: Proteins” from *Food Chemistry Experiments* contains background information about proteins for students and teachers. In the laboratory activity, students isolate milk proteins by three different methods, test them for protein using a biuret test, and complete an accompanying worksheet. (<https://naitc-api.usu.edu/media/uploads/2017/06/16/experiments_foodscience.pdf>)

**“Protein: Complete and Incomplete”:** This lesson plan contains background information concerning complete and incomplete proteins and provides five options for the presentation of the lesson. Students can take notes and complete a study guide, examine a variety of foods and record their protein content in “Protein Hunt”, record their daily intake of protein by keeping and analyzing a food diary, and/or taste and prepare foods, like tofu, with high protein content. (<https://www.uen.org/lessonplan/view/1269> )

**Projects and extension activities**

**Graph protein content, experiment with fat content, or make tofu burgers:** In “Unit 2 - Lipids and Proteins”—of the *Food Science Curriculum*—students analyze the nutritional components in a variety of meat sources listed on a nutritional information chart and prepare a bar graph of the information. In a lab activity, students measure the amount of fat in a variety of meat sources, while a cooking activity introduces students to tofu as an alternative source of protein, by having them make tofu burgers. (<https://www.isbe.net/Documents/fcs_guide.pdf>)

# References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles
published from the magazine’s inception in October 1983 through April 2013; all available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [**http://ww.acs.org/chemmatters**](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get the past 30 Years of *ChemMatters* on DVD!” (the icon on the right of the screen)**

**Selected articles and the complete set of
Teacher’s Guides for all issues from the past three
years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**

***30* Years of *ChemMatters !***

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In “Hold the Meat”, author Nolte writes about how to get protein in your meals while on a vegetarian diet. After presenting the need for proteins and their chemical composition, she discusses the most popular protein-containing meat substitutes on the market. (Nolte, B. Hold the Meat. *ChemMatters*. 2011, *29* (4), pp 9–11)

The Teacher’s Guide for the December 2011 *ChemMatters* Nolte article above provides additional information on protein function, structure, and synthesis. Several classroom activities are described, including a lab for the separation of an amino acid mixture by paper chromatography.

“Sports Supplements: Helpful or Harmful?” contains a discussion about the use of whey protein powder as a dietary supplement to build muscle. The supplements creatine and L-arginine are also discussed. (DeAntonis, K. Sports Supplements: Helpful or Harmful? *ChemMatters*. 2013, *31* (3), pp 12–14)

The Teacher’s Guide for the October 2013 *ChemMatters* DeAntonis article above contains extensive information about whey protein used as a dietary supplement, as well as information about the lack of regulation of dietary supplements. It presents extensive information that discourages the use of these supplements by teenagers.

# Web Sites for Additional Information

**Dietary requirements for protein**

The USDA site ChooseMyPlate.gov contains several tables giving the recommended dietary allowance for protein based on age and gender. This is an excellent source for information about foods and their nutritional content, including vegetarian choices. (<https://www.choosemyplate.gov/protein-foods>)

In “How Much Protein Do You Really Need to Eat?”, Sheela Prakash, a food editor and registered dietician, explains how to calculate your daily protein requirements based on factors specific to your lifestyle. (<https://www.thekitchn.com/how-much-protein-do-you-really-need-243520>)

 The above link is one of the 11 segments of *Protein 101*, which attempts to educate about dietary protein. Some of the topics presented are the amount of protein needed if you’re working out, ways for vegetarians to fulfill their protein requirements, and common myths surrounding protein, as well as multiple examples of different foods and their protein content. (<https://www.thekitchn.com/search?q=Protein+101>)

**Whey protein**

This site answers these questions: What is whey protein? Do whey supplements work? Are whey supplements safe? The article cites several studies, including one done on Marines during basic training, to provide evidence for its claims about whey supplements. (<https://www.livescience.com/45120-whey-protein-supplements.html>)

The article “What are the Benefits and Risks of Whey Protein?” not only discusses the benefits, side effects, and potential risks of using whey protein supplements, but it also describes three different types of whey protein supplements. (<https://www.medicalnewstoday.com/articles/263371.php>)

**Protein powders and protein bars**

This site compares the difference in protein uptake from liquid protein shakes vs solid protein bars. One study comparing solid protein bars to liquid protein shakes found that the participants consuming the liquid protein registered higher levels of amino acids in their bloodstream 30 minutes and four hours after consumption. (<https://www.livestrong.com/article/462471-protein-bar-vs-powder/>)

**Protein synthesis**

A brief outline of how proteins are chemically synthesized in the lab can be found here: <http://resources.schoolscience.co.uk/unilever/16-18/proteins/Protch4pg1.html>.

This site is an animation that shows how every protein molecule of an organism is synthesized by that organism in a prescribed process, using DNA, mRNA, and amino acids. This activity helps students understand how proteins are made in the human body. (<https://www.wisc-online.com/learn/natural-science/life-science/ap1302/protein-synthesis>)

**Essential amino acids**

The article “Which Amino Acids are Contained in Milk and Eggs?” presents information about the nine essential amino acids, four non-essential amino acids, and the eight semi-essential amino acids, and which ones are contained in milk and eggs. While milk and eggs are considered complete proteins, they do not contain all the amino acids the body uses to make protein. (<http://healthyeating.sfgate.com/amino-acids-contained-milk-eggs-3992.html>)

Some sources will include arginine in the list of essential amino acids because it is required in the diet for young children, but it is not needed in the adult diet. This site shows the structural formulas for the 10 essential amino acids.

(<http://hyperphysics.phy-astr.gsu.edu/hbase/Organic/essam.html>)

**Plant sources of protein**

“The 20 Highest Protein Veggies (And Other Plant-based Foods) You Can Eat” not only lists 20 plant-based foods with high protein content, it also gives recipes for dishes using some of them. (<https://www.prevention.com/eatclean/high-protein-vegetables-and-plant-based-food>)

“26 Delicious Vegan Sources of Protein” discusses the myth of protein combining and ways to “rethink” protein, before going through a pictorial list of 26 vegan-friendly foods with high protein content. Some recipe links are provided with most of the foods. (<http://www.onegreenplanet.org/vegan-food/vegan-sources-of-protein/>)

**Macronutrients & micronutrients**

This article discusses micronutrients, dividing them into specific categories of
water-soluble and water-insoluble vitamins, and major and trace minerals. It discusses the recommended intake, the food sources containing the nutrient, and the effects on the body of getting too much or too little of the nutrient. (<http://www.innerbody.com/nutrition/micronutrients>)

A brief description of the macronutrients and micronutrients that are part of the food pyramid’s essential nutrients can be found here: <http://www.fao.org/elearning/Course/NFSLBC/en/story_content/external_files/Essential_Nutrients.pdf>.

**Health problems caused by eating too much protein**

The article “Are There Risks Associated with Eating Too Much Protein?” reviews some of these risks and mentions the sources of protein that prove the most problematic. (<https://www.healthline.com/health/too-much-protein>)

“The Truth about Red Meat” citesseveral research studies concerning the risk factors from eating too much red meat. Heart disease and cancer are not the only diseases that studies show to have a correlation with a diet rich in red meat.

(<https://www.webmd.com/food-recipes/features/the-truth-about-red-meat#1>)

# About the Guide

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Articles from past issues of *ChemMatters* and related Teacher’s Guides can be accessed from a DVD that is available from the American Chemical Society for $42. The DVD contains the entire 30-year publication of *ChemMatters* issues, from February 1983 to April 2013, along with all the related Teacher’s Guides since they were first created with the February 1990 issue of *ChemMatters*.

The DVD also includes “Article”, “Title”, and “Keyword” indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.