



Gender	Age (years)	Activity Level		
		Sedentary	Moderately Active	Active
Female	4–8	1,200	1,400–1,600	1,400–1,800
	9–13	1,600	1,600–2,000	1,800–2,200
	14–18	1,800	2,000	2,400
	19–30	2,000	2,000–2,200	2,400
	31–50	1,800	2,000	2,200
	51+	1,600	1,800	2,000–2,200
Male	4–8	1,400	1,400–1,600	1,600–2,000
	9–13	1,800	1,800–2,200	2,000–2,600
	14–18	2,200	2,400–2,800	2,800–3,200
	19–30	2,400	2,600–2,800	3,000
	31–50	2,200	2,400–2,600	2,800–3,000
	51+	2,000	2,200–2,400	2,400–2,800

Table 1. Calorie needs by gender, age, and activity level



This exercise machine, called an ergometer, was used in the laboratory of Wilbur Olin Atwater to measure the amount of calories released by exercising.

But how calories are produced and used—that is, our metabolism—varies from person to person and is mostly affected by how much a person exercises, the amount of fat and muscle in his or her body, and the person's basal metabolic rate—the rate at which a person's body uses energy while at rest.

The basal metabolic rate is responsible for up to 70% of the calories used by our bodies, so it can play a role in a person's tendency to gain weight. For example, a person with a low basal metabolic rate will not use as much energy as a person with a high metabolic rate for the same amount of food.

To a certain extent, the basal metabolic rate is inherited, but it also depends on the amount of muscle and fat present; people with more muscle and less fat generally have a higher basal metabolic rate. Also, people can change their basal metabolic rate by exercising or practicing a sport, which, in the long run, increases the basal metabolic rates of

the heart, lungs, kidneys, liver, and the brain. Some outdoor activities can burn a substantial amount of calories (Table 2).

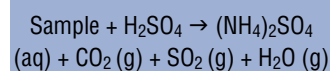
## Proteins in food

In addition to calories, the nutrition label also displays the amount of the three main nutrients: proteins, fat, and carbohydrates. Proteins are found in meat, beans, milk, and nuts. Fat is present in vegetable oil, dairy products, and fish. Carbohydrates are found in fruits, vegetables, and cereals.

So how are these nutrients measured? Let's look at proteins first: The standard method for determining the amount of protein in food is called the Kjeldahl (pronounced: Kel-daal) method. Measuring the protein content of food is similar to measuring its nitrogen content because nitrogen in food is contained mostly in proteins.

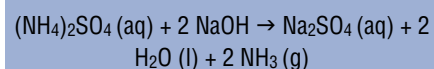
**The Kjeldahl method** consists of three steps (summarized in Fig. 1):

1. A sample of food is heated in boiling sulfuric acid ( $\text{H}_2\text{SO}_4$ ), which leads to ammonium sulfate  $[(\text{NH}_4)_2\text{SO}_4]$ , among other products:

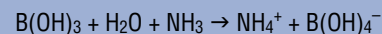


Ammonium sulfate is made of ammonium ions ( $\text{NH}_4^+$ ) and sulfate ions ( $\text{SO}_4^{2-}$ ). The ammonium ions contain the nitrogen that was initially present in the sample.

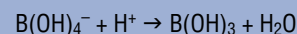
2. The ammonium ions are then converted into ammonia gas ( $\text{NH}_3$ ) by adding sodium hydroxide ( $\text{NaOH}$ ) to the solution of ammonium sulfate:



3. The ammonia gas goes inside a condenser and ends up in a flask that contains a solution of boric acid. The ammonia is neutralized by the boric acid, as follows:



When all the ammonia has reacted with the boric acid, the amount of borate ions  $[\text{B}(\text{OH})_4^-]$  is determined by titration with a strong acid:



The amount of acid needed corresponds to the amount of ammonia that was present. The amount of ammonia is the same as the amount of nitrogen initially present in the sample, which is then used to determine the amount of protein present in the sample.

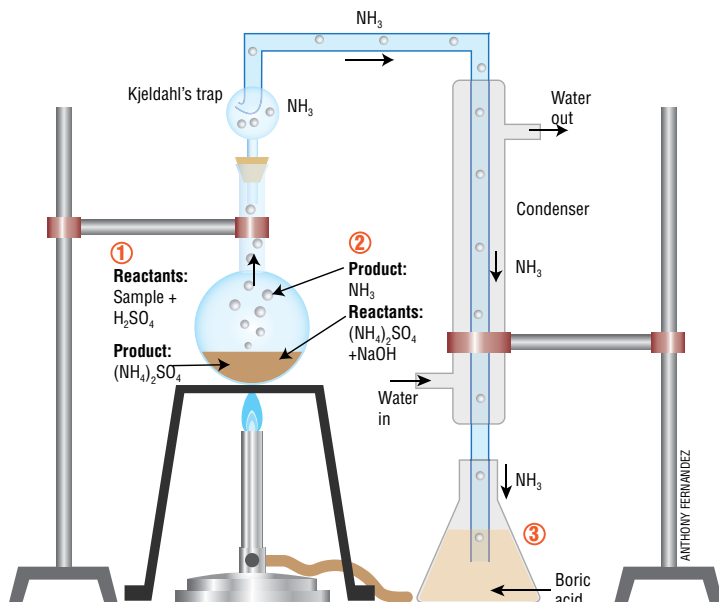
How much protein do we need every day? The Institute of Medicine recommends that adults consume a minimum of 0.36 grams of protein for every pound of body weight per day. That's about 58 grams for a 160-pound adult.

## Fat content of food

The standard method for measuring fat content is called the **Soxhlet extraction**. In this method, food is ground up and continuously

Exercise	Calories per hour
Walking (3 mph)	280+
Tennis	350+
Bicycling (moderate)	450+
Swimming (active)	500+
Hiking	500+
Power walking	600+
Running	700+

Table 2. Calorie-burning chart for various activities



**Figure 1.** Schematic representation of the apparatus used to estimate the amount of proteins in food by using the Kjeldahl method.

washed with an organic solvent, dissolving only the fat. Although the Soxhlet extraction method has been used for more than 100 years, it is slow and complicated. It can take 6 hours or longer to remove all of the fat.

A new method uses a technique, called nuclear magnetic resonance, to measure fat. Here is how it works: The sample is placed in a strong magnetic field and is bombarded with a pulse of radio frequency. This causes

the magnetic moments of the hydrogen nuclei to flip. After the pulse ends, the magnetic moments of the nuclei oscillate, but the magnetic moments of nuclei in fat oscillate at a slightly different frequency than the magnetic moments of nuclei in other substances. So the signal generated by nuclei in fat can be separated from the signals generated by nuclei in other substances present in the sample, and the amount of fat can be determined.

How much fat should we consume?

Experts agree that 30% of our daily calories should come from fat. If you consume 2,000 Calories in a day, that means no more than 600 Calories should come from fat. One way to consume 600 Calories from fat is to eat foods that have a total of 67 grams of fat (fat=9 calories per gram, see p. 6).

## Carbohydrate content of food

The amount of total carbohydrates in food has traditionally been calculated rather than measured. Other components of food—such as protein, fat, and water—are measured and added together. This sum is subtracted from the total, and the difference is assumed to be the amount of total carbohydrates.

One problem with calculating the amount of total carbohydrates is that it does not distinguish between carbohydrates used by our bodies to produce energy—such as sugars—and carbohy-

drates that we cannot digest and are, therefore, excreted, such as fiber.

About half of the calories that you consume should come from carbohydrates. This means that if you consume 2,000 Calories per day, 1,000 Calories should be from carbohydrates. Because each gram of carbohydrate has 4 kilocalories, you would need no more than 250 grams of carbohydrates per day.

## Staying healthy

Knowing about calories, proteins, fats, and carbohydrates can help people make informed decisions about the foods they buy and eat, especially if they are overweight or obese. According to the U.S. Centers for Disease Control and Prevention, the percentage of obese U.S. children ages 6 to 11 increased from 7% in 1980 to nearly 20% in 2008, and the percentage of obese U.S. adolescents ages 12 to 19 increased from 5% to 18% during the same period.

The average American diet is high in fat and sugar, so many teenagers consume too much sugar, mainly in the form of sugar-sweetened drinks, such as soft drinks, sports drinks, and energy drinks, along with high-fat foods such as chips, fries, and burgers.

By looking at the nutrition label on food products, you may gain a better understanding of what you are eating and what to include in your diet. *CM*

### SELECTED REFERENCES

- How to Understand and Use the Nutrition Facts Label, U.S. Food and Drug Administration: <http://www.fda.gov/Food/ResourcesForYou/Consumers/NFLPM/ucm274593.htm> [accessed Oct 2012].
- Food and Fitness, TeensHealth: [http://kidshealth.org/teen/food\\_fitness/](http://kidshealth.org/teen/food_fitness/) [accessed Oct 2012].
- McArdle, W. D.; Katch, F.; Katch, V. L. Exercise and Sports Nutrition, 4th ed., Lippincott Williams & Wilkins: Baltimore, 2013.
- Fast Food Facts: <http://www.foodfacts.info/> [accessed Oct 2012].

**Michael Tinnensand** is a science writer and education consultant who lives in Portland, Ore. His latest *ChemMatters* article, "Graphene: The Next Wonder Material?" appeared in the October 2012 issue.



Check out the video podcasts on nutrition labels at: [www.acs.org/chemmatters](http://www.acs.org/chemmatters)



When eating out, watch portion sizes and choose meals that contain a balance of proteins, fruits and vegetables, and whole grains. A garden salad provides fiber, vitamins, and minerals without a lot of calories or fat.