

The Role of Eggs in the Diet: Update

Prepared for the American Council on Science and Health

by Kathleen Meister, M.A.

Project Coordinator
Ruth Kava, Ph.D., R.D.
Director of Nutrition

President
Elizabeth M. Whelan, Sc.D., M.P.H.

Art Director
Yelena Ponirovskaya

August 2002



AMERICAN COUNCIL ON SCIENCE AND HEALTH
1995 Broadway, 2nd Floor, New York, NY 10023-5860
Tel. (212) 362-7044 • Fax (212) 362-4919
URL: <http://www.acsh.org> • E-mail: acsh@acsh.org

THE AMERICAN COUNCIL ON SCIENCE AND HEALTH (ACSH) APPRECIATES
THE CONTRIBUTIONS OF THE REVIEWERS NAMED BELOW.

John B. Allred, Ph.D.
The Ohio State University

Manfred Kroger, Ph.D.
Pennsylvania State University

Dean O. Cliver, Ph.D.
University of California, Davis

Dale R. Romsos, Ph.D.
Michigan State University

Nancy Cotugna, Dr. P.H., R.D., C.D.N.
University of Delaware

Gilbert L. Ross, M.D.
ACSH

F. J. Francis, Ph.D.
University of Massachusetts

Herbert P. Sarett, Ph.D.
Sarasota, Florida

David M. Klurfeld, Ph.D.
Wayne State University

Elizabeth M. Whelan, Sc.D., M.P.H., M.S.
ACSH

ACSH accepts unrestricted grants on the condition that it is solely responsible for the conduct of its research and the dissemination of its work to the public. The organization does not perform proprietary research, nor does it accept support from individual corporations for specific research projects. All contributions to ACSH—a publicly funded organization under Section 501(c)(3) of the Internal Revenue Code—are tax deductible.

Individual copies of this report are available at a cost of \$5.00. Reduced prices for 10 or more copies are available upon request.

Copyright © by American Council on Science and Health, Inc.
This book may not be reproduced in whole or in part, by mimeograph or any other means, without permission.

Table of Contents

Executive Summary	5
Introduction	7
Eggs and Cholesterol	7
<i>New Research Findings</i>	8
<i>Is an Egg a Day OK?</i>	10
Nutritional Value of Eggs	11
<i>The Concept of Nutrient Density</i>	12
Eggs: A Functional Food?	14
“Designer” Eggs	15
Other Desirable Properties of Eggs	16
Eggs in the Diet: A Balanced View	17
Eggs and Food Allergies	18
Handling Eggs Safely	18
Summary	22
References	23
Suggestions for Further Reading	27

Table

Table 1. What’s In An Egg?	13
----------------------------------	----

Executive Summary

- A substantial body of scientific research shows that dietary cholesterol has only a small effect on blood cholesterol and that the consumption of eggs — up to an intake of one egg per day — has no detectable effect on heart disease risk in healthy people. Experts no longer consider it necessary for healthy people to limit their intake of egg yolks to a specified number per week.
- Consuming an average of one egg per day is acceptable for many people but not for everyone. Although specific recommendations for strict limitations on egg intake have been dropped, the American Heart Association still recommends that the intake of dietary cholesterol be limited to an average of no more than 300 mg/day. An egg a day fits within this limitation only if the individual's overall diet is otherwise low in cholesterol.
- Eggs are highly nutritious. They are an excellent source of high-quality protein, and they provide significant amounts of several vitamins and minerals. Recent research indicates that egg eaters are more likely than non-egg eaters to have diets that provide adequate amounts of essential nutrients.
- Eggs have other desirable properties in addition to their nutritional value. They are inexpensive, convenient, easy to prepare, and easy to chew, and they play important roles in a wide variety of recipes.
- Eggs contain certain components that may have health benefits that go beyond basic nutrition. Research on these “functional” components is in its early stages, however, and no health benefits have been conclusively demonstrated.
- It is possible to modify some aspects of the nutritional composition

The Role of Eggs in the Diet: Update

of eggs by feeding the hens special diets. Modified “designer” eggs containing increased amounts of omega-3 fatty acids and vitamin E are now on the market. Whether these modified eggs have special health benefits has not been established.

- Allergies to eggs are uncommon. However, those individuals who do have an egg allergy must avoid eggs and egg-containing products completely.
- Eggs need to be handled and prepared with care to ensure their microbiological safety. They should always be stored under refrigeration and cooked thoroughly. Recent coordinated efforts to improve food safety in the U.S. appear to have resulted in a decrease in foodborne illnesses, including the type associated with *Salmonella* in eggs. Despite this improvement, however, all authorities recommend that people should continue to refrain from consuming raw or undercooked eggs.

Introduction

Views on the role of eggs in the diet have varied drastically over the years. Traditionally, eggs were thought of as an excellent, low-cost source of nutrients, and people were encouraged to eat them daily. In the early 1970s, however, recommendations were made to limit the use of eggs because of their cholesterol content. People began to think of an egg as merely cholesterol in a shell, and articles with headlines such as “Do I Dare To Eat an Egg?” appeared frequently in the news media.

More recently, views on the role of eggs in the diet have changed again. As scientific understanding of the role of dietary factors in heart disease has increased, advice to restrict egg intake has been modified. New headlines indicating that the egg is “Better than It’s Cracked Up To Be” have replaced the old anti-egg messages. Some consumers have been pleased to learn that they need not strictly limit their use of a favorite food. Others, however, have been understandably confused by the shifting dietary advice.

This special report by the American Council on Science and Health (ACSH) assesses the scientific evidence on the role of eggs in the diet, with an emphasis on new research conducted since ACSH last reported on this topic in 1996. The report also discusses other issues pertaining to eggs, including their potential role as a functional food, the invention of “designer eggs,” the facts about egg allergy, and new developments pertaining to the microbiological safety of eggs.

Eggs and Cholesterol

If it weren’t for cholesterol, eggs would not be controversial. After all, as will be discussed in detail later in this report, eggs are tasty, nutritious, easy to prepare, useful in recipes, safe to eat when prepared correctly, and remarkably inexpensive. There would be no reason for anyone to object to the use of such a food — if it weren’t for cholesterol.

Eggs are the largest single source of cholesterol among the foods commonly eaten in the U.S. A large egg contains about 215 milligrams (mg) of cholesterol — more than two-thirds of the Daily Value* of 300 mg. More specifically, the yolk of an egg contains the cholesterol; the white contains none.

* Daily Values are the quantities established by the U.S. government as appropriate for daily consumption. The values you see on the Nutrition Facts labels on food products are percentages of Daily Values.

Unlike many other foods that are high in cholesterol, such as fatty meats and full-fat dairy products, eggs are relatively low in saturated fat and calories. A single “large” egg (the size most commonly sold in the U.S.) provides only 75 calories and 1.5 grams (8% of the Daily Value) of saturated fat. It supplies 71% of the Daily Value of cholesterol, however. Eggs account for about 33% of the cholesterol in the American diet but only 1.7% of the saturated fat.¹

High levels of cholesterol in the bloodstream, especially low-density lipoprotein (LDL) cholesterol, are associated with increased risks of atherosclerosis and its consequences, including heart attacks and strokes. Health authorities, including the U.S. government² and the American Heart Association,^{3,4} have advised all Americans (except those under the age of 2 years) to adopt dietary habits designed to keep blood cholesterol down. For people who already have high cholesterol levels, therapy designed to lower cholesterol levels can substantially reduce the risk of heart attacks.*

Cholesterol in the diet is not the principal factor affecting the level of cholesterol in the bloodstream, however. As ACSH pointed out in our previous report on eggs in 1996, extensive scientific research indicates that the type and amount of fat in the diet are more important in determining blood cholesterol levels than the amount of cholesterol in the diet. The main dietary determinant of blood levels of LDL cholesterol is saturated fat intake.³

Cholesterol in the bloodstream comes from two sources: some is synthesized by the body, and some comes from food. In most instances, when dietary cholesterol intake increases, the body compensates by decreasing its cholesterol production. Conversely, when cholesterol intake decreases, synthesis increases. The existence of this compensatory mechanism is the reason why changes in dietary cholesterol intake have only a limited effect on blood cholesterol levels.

New Research Findings

New scientific studies completed since 1996 have confirmed and strengthened the conclusions that dietary cholesterol has only a small effect on blood cholesterol and that little if any relationship exists between egg consumption and heart disease risk.

Two different research groups have conducted meta-analyses (combined statistical analyses) of data from various studies in which volunteers had been given different amounts of cholesterol as part of a closely

* For more on this subject, see the ACSH report “Chemoprevention of Coronary Heart Disease.”

controlled diet.^{5,6} One analysis indicated that a 100 mg change in dietary cholesterol intake would cause blood cholesterol to change by about 2.5 mg/dL,⁵ on average, and the other indicated that the change would be 2.2 mg/dL.⁶ This is quite a small response to a proportionally large change in cholesterol intake; since the mean daily cholesterol intake in the U.S. is 273 mg/day,⁷ a 100 mg increase or decrease is more than a one-third change. In contrast, it has been estimated that a 30% decrease in saturated fat intake would reduce blood cholesterol by 9.6 mg/dL.⁵

Individuals differ in their blood cholesterol responses to dietary cholesterol. Some show very little response to a change in cholesterol intake, while others have a more substantial response. It has been estimated that between 15 and 25% of the population is relatively sensitive to cholesterol.⁸ The difference in blood cholesterol response between these individuals and others is almost threefold. The degree of response to dietary cholesterol predicted by the meta-analyses described above applies to groups of people, not individuals. Although a typical individual might respond to a 100 mg change in dietary cholesterol with a 2 or 3 mg/dL change in blood cholesterol, a few sensitive individuals might show a change of 4 mg/dL, while other, less sensitive individuals might show a change of only about 1 mg/dL.⁸

Several recent studies have assessed the relationship between intake of eggs and/or dietary cholesterol and blood cholesterol levels or heart disease risk in free-living groups of people. In a study of more than 20,000 male smokers in Finland, no association was found between dietary cholesterol intake and the risk of death from heart disease over a six-year period.⁹ This study is of special interest because the cholesterol intakes of the study participants were higher than those usually seen in U.S. studies. An analysis of data from a major U.S. national nutrition survey showed no relationship between dietary cholesterol intake and blood cholesterol level and actually found lower blood cholesterol levels in people who ate eggs frequently than in those who did not.⁷

In two studies conducted by researchers from the Harvard School of Public Health, one involving eight years of follow-up of a group of more than 37,000 U.S. men and the other involving 14 years of follow-up of a group of more than 80,000 U.S. women,¹⁰ no association was found between egg consumption, up to a level of one egg per day, and the risk of coronary heart disease in the study populations as a whole. Egg consumption did seem to be associated with increased heart disease risk in people with diabetes, however. The researchers were not able to reach any conclusions about egg intakes above one egg per day because

very few of their study subjects ate that many eggs. The Harvard findings are consistent with the findings of two earlier studies in the U.S. that specifically examined egg (rather than cholesterol) intake. Neither of those studies found an association between egg intake and the risk of coronary heart disease.^{11,12}

Why was there no relationship between egg intake and heart disease risk in these studies, even though it is well known that dietary cholesterol can have an effect on blood cholesterol levels? One possibility is that components of eggs other than cholesterol might have beneficial effects on heart disease risk that counterbalance the small adverse effect of the eggs' cholesterol content. Possible candidates for such an effect include antioxidants, folic acid and other B vitamins, and unsaturated fats.¹⁰

A second possibility is that eating eggs may indeed raise blood cholesterol slightly but that this effect can't be detected in free-living populations because people who don't eat eggs choose other foods that raise their cholesterol levels even more. As will be discussed later in this report, egg eaters are, in general, breakfast eaters. People who choose to eat breakfast may have better diets overall than those who skip breakfast and make up for it by eating poorly chosen snacks during the day.

A third possibility is that the effect of egg eating on heart disease risk is not detectable simply because the effect of dietary cholesterol on blood cholesterol is small — perhaps too small to produce an effect on heart disease risk that can be detected in a population.

The most recent (2000) version of the American Heart Association (AHA) dietary guidelines for healthy people no longer includes a specific limitation on the number of eggs or egg yolks that a person may consume in a week.³ The AHA does continue to recommend limiting cholesterol intake to no more than 300 mg/day. However, the technical document that presents the recommendations acknowledges that “there is no precise basis for selecting a target level for dietary cholesterol intake for all individuals”.³

Is an Egg a Day OK?

After the AHA changed its dietary guidelines, many people wondered whether it would now be OK to eat an egg every day. The answer is that an egg a day is acceptable for some people, but it is not acceptable for everyone. Although there is no longer a specific limit on the number of eggs that can be included in a heart-healthy diet, the recom-

mendation to limit dietary cholesterol to 300 mg/day still stands. An egg contains more than two-thirds of the recommended daily cholesterol limit. Therefore, an egg a day can fit into a heart-healthy diet only if that diet is low in other sources of cholesterol. If an individual is already getting large amounts of cholesterol (and saturated fat) from other sources, such as fatty meats or full-fat dairy products, adding an egg a day to the diet is not acceptable. An egg a day may also not be acceptable for individuals who are being treated for high blood cholesterol levels. The therapeutic diets usually prescribed for such patients (including those who are also on cholesterol-lowering drug therapy) limit daily cholesterol intake to less than 200 mg, and it is difficult to plan such a diet without strictly limiting the use of eggs.

Some people have raised concerns about allowing increased egg consumption on the grounds that eggs are often served with bacon or sausage, which are high in saturated fat. But condemning eggs for the company that they kept in old-fashioned breakfasts makes no more sense than condemning bread because people might put butter on it. Certainly, the traditional eggs-and-bacon or eggs-and-sausage breakfast is too high in saturated fat for routine consumption, but there is no need to serve eggs in these particular ways. Many other ways of serving eggs — such as a vegetable omelet or a main-dish salad that includes hard-boiled eggs — can fit easily into a heart-healthy diet.

Another frequently raised objection to eggs is the fact that the customary serving size is two eggs rather than one, and the cholesterol content of two eggs is over the 300 mg limit. It is not necessary, however, for people to keep their cholesterol intake under 300 mg/day every single day. Instead, this is an average to be achieved over a period of several days. Having a two-egg meal on one day is fine, as long as it is balanced out by a meal low in dietary cholesterol (such as a breakfast consisting of cereal, nonfat milk, and fruit) on another day, so that cholesterol intake stays under an average of 300 mg/day over a several-day period.

Nutritional Value of Eggs

Eggs are highly nutritious foods. One large egg provides about six grams of protein; about half of this protein is in the egg white. Egg white is considered an ideal protein — the one by which all others are measured — because it contains all the essential amino acids in proper proportion for human nutrition. Of the total fat in eggs, more than half

is the unsaturated variety. Eggs are a significant source of iron, riboflavin, folate and vitamins B12, D, and E. The iron in egg yolks, like the iron in meat, is highly bioavailable; egg yolks may therefore be valuable in the diets of individuals who may need more iron, such as infants.¹³ An egg's contribution of vitamin D is noteworthy because the egg is one of the very few foods that supply this nutrient. About the only nutrient not found in an egg is vitamin C.

Eggs are one of the best sources of a nutritionally important substance called choline; the other top sources are milk, liver, and peanuts.¹⁴ The human body manufactures its own choline, but it may not always be able to make enough of it to fully meet the body's needs. Therefore, dietary sources of choline may be necessary. Choline is also being investigated for possible beneficial effects on cognitive function.¹⁵ The National Academy of Sciences, which establishes the recommendations for nutrient intake in the U.S., says that 550 mg/day and 425 mg/day are adequate intakes of choline for men and women, respectively.¹⁴ Since a large egg contains 280 mg of choline, it meets more than half of the day's need.

Most of the nutrients in eggs are found in the yolk. The yolk contains all of the fat-soluble vitamins (A, D, and E) and most of the other vitamins and minerals. Protein is found in both the white and the yolk, however.

In the Food Guide Pyramid, eggs are part of the group of protein-rich foods, officially known as the "Meat, Poultry, Fish, Dry Beans, Eggs, and Nuts Group." The Pyramid calls for two to three servings from this group every day, for a total of five to seven ounces of meat or its equivalent. One egg can be substituted for one ounce of meat. One egg therefore counts as one-third to one-half of a meat group serving.

The Concept of Nutrient Density

When nutritionists compare the nutritional contributions of different foods, they often use a concept called "nutrient density." A nutrient-dense food is one that provides a relatively high proportion of a person's daily need of essential nutrients while supplying only a small proportion of the daily need for calories. For good nutrition, most of a person's daily food intake should consist of foods of high nutrient density.

Eggs are nutrient-dense foods. Although they are not an unusually rich source of any one nutrient, they provide substantial amounts of a wide variety of nutrients. Table 1 shows the amounts of various nutrients in an egg. One large egg, which represents less than 4% of the total daily calorie intake of a person who consumes 2000 calories per day,

Table 1. What's In An Egg?

Nutrient or Other Component	Quantity in One "Large" Egg*	Percent of Daily Value
Calories	75	
Total fat	5 g	7
Saturated fat	1.5 g	8
Cholesterol	213 mg	71
Protein	6.25 g	10
Vitamin A	317 IU	6
Vitamin D	24 IU	6
Vitamin E	0.7 mg	3
Vitamin B ₁₂	0.5 mcg	8
Vitamin B ₆	0.07 mg	4
Folate	23 mcg	6
Thiamin	0.031 mg	2
Riboflavin	0.254 mg	15
Phosphorus	89 mg	8
Zinc	0.5 mg	4
Iron	0.72 mg	4
Choline	280 mg	
Lutein	150–250 mcg	
Zeaxanthin	200 mcg	

* Large eggs are the size most commonly sold in the U.S. Eggs of larger or smaller sizes contain proportionally greater or lesser amounts of nutrients.

provides 4% or more of the Daily Value for several nutrients, including protein; riboflavin; vitamins A, B₆, and B₁₂; folate; iron; phosphorus; and zinc. Because the percentage of the Daily Value for many nutrients provided by an egg is greater than the proportion of total calorie intake that the egg represents, the egg more than pulls its weight nutritionally.

Data from NHANES III show that intakes of many nutrients are higher among egg eaters than among people who don't eat eggs, and that egg eaters are less likely to have diets that are inadequate in various nutrients.⁷ As might be expected, egg eaters have higher intakes of nutrients found in eggs, such as vitamins A and B₁₂. But they also have higher intakes of vitamin C — even though eggs don't have any vitamin C in them. How can this finding be explained? The most likely possibility is that egg eating is an indicator of a generally healthful eating pattern that includes breakfast. The vitamin C probably comes from orange juice or some other fruit that is consumed along with eggs at breakfast. In general, breakfast eaters have more nutritious overall diets than breakfast skippers do.¹⁶⁻¹⁸ This seems to be true both for those who eat eggs at breakfast and for those who choose other foods.

Eggs: A Functional Food?

Foods that may have health benefits beyond the traditional nutrients that they contain are often called “functional foods.” The concept of functional foods has become popular in recent years, first in Japan and later in other countries, including the U.S.* When people think of functional foods, they often think of plant foods, many of which may contain beneficial components called “phytochemicals.” It's also possible, though, to find potentially beneficial substances in foods of animal origin. Such substances can be called “zoochemicals.” Research on functional foods and phytochemicals/zoochemicals is in an early stage of development. Few foods or food components have actually been proven to have special health benefits. Many, however, are under investigation.

Eggs can be considered potential “functional foods” because they contain components that may have benefits that go beyond basic nutrition, such as the carotenoids lutein and zeaxanthin, which may help to protect against age-related eye diseases, including cataracts and macular degeneration.^{15,19} The lutein and zeaxanthin in eggs may be particularly

* For more on this subject, see the ACSH report “Facts about ‘Functional Foods.’”

valuable because they are highly bioavailable.²⁰ It is important to note, however, that research on these egg components is still preliminary. Much more will need to be learned before scientists will be able to reach definitive conclusions about their roles in the diet.

“Designer” Eggs

In addition to the functional food trend, eggs are also part of another notable trend in 21st century food production: the creation of specialty

Is It Safe to Eat Easter Eggs?

Is it safe to eat hard-cooked Easter eggs? In theory, it can be, if the eggs are handled correctly. Realistically speaking, however, this is so hard to do that it’s probably not worth the effort.

Two different problems make it difficult to keep Easter eggs safe.

First, although the shell on a hard-cooked egg may appear to be impermeable, it is not. Bacteria can easily get in from the outside. Hard-cooked eggs are more vulnerable than raw eggs to contamination because the cooking process removes the thin protective layer of mineral oil that most egg producers spray on raw eggs.

Second, hard-cooked eggs are perishable. Like all other perishable foods, they should never be left at room temperature for more than two hours.

If you plan to eat your Easter eggs, you need to take the following precautions:

- Everyone who handles the eggs must wash their hands thoroughly, in hot soapy water, before cooking, dyeing, decorating, hiding, or hunting for them.
- Use only food-grade dyes and nontoxic art materials and make sure that all of the equipment that you use (e.g., paintbrushes, containers, drying racks) is clean enough for food use.
- Hide eggs only in clean, sanitary places where they will not be exposed to dirt, pets, insects, or household chemicals. (Rule of thumb: If you would be willing to hide an *unwrapped* chocolate bunny in a particular location, feel free to hide an egg there, too.)
- Don’t leave the eggs at room temperature for more than two hours, total, while dyeing, drying, decorating, hiding, and hunting for them.

“designer foods.” The term “designer foods” usually refers to foods that have been modified through biotechnology to enhance their quality or nutritional value. In the case of eggs, though, a somewhat less sophisticated technique has been used to modify their content — namely, feeding the hens different types of food. Through special feeding practices, it has been possible to produce eggs that contain substantially increased amounts of omega-3 polyunsaturated fatty acids (the beneficial fatty acids found in salmon and other fatty fish) and vitamin E.²¹ Some eggs of this type are now on the market. It has been demonstrated that consumption of these eggs can increase DHA (one of the omega-3 fatty acids) levels in the bloodstream;¹³ however, whether this change results in health benefits remains to be established.

Other Desirable Properties of Eggs

In addition to their nutritive value and possible benefits as a functional or designer food, eggs have numerous other desirable properties.

Eggs have several important physical and chemical properties that help make recipes work. They thicken custards, puddings, and sauces; emulsify and stabilize mixtures such as mayonnaise and salad dressings; coat or glaze breads and cookies; bind ingredients together in dishes such as meat loaf and lasagna; clarify soups; retard crystallization in boiled candies and frostings; and leaven some types of baked goods such as soufflés and sponge cakes. Eggs are used for these purposes both in home-prepared recipes and in processed foods.

Eggs are also a convenient food. They can be prepared easily, in a variety of ways. Eggs are easy to use, even for people who live alone. They come in handy, single-serving packages. They keep well on a shelf in the refrigerator for about three weeks, and therefore an individual or couple can easily use up the dozen eggs in a carton before they spoil. Because most egg recipes involve short cooking times, eggs are convenient for the person with little time to prepare meals.

Eggs are easy to chew — an important advantage for elderly people or others who may have difficulty chewing meats or other high-protein foods because of dental problems.

Eggs are economical, especially when compared to other high-protein foods. Although prices vary, a dozen large eggs — the basis for six main-dish servings — can often be purchased for less than \$1.50, much less than the cost of a similar number of servings of most kinds of meat, poultry, or fish. Moreover, eggs are quicker and easier to prepare than

some of the other inexpensive high-protein foods, such as dry beans and stewing meats. For people who are looking for convenient ways to balance their food budgets as well as their diets, serving eggs occasionally instead of meat, poultry, or fish may be helpful.

Eggs in the Diet: A Balanced View

A person's entire diet, not any single component, is what is crucial for good nutrition. There are bad diets, but there is no such thing as a bad food (unless the food is spoiled or contaminated). Moderate amounts of any food can be incorporated into a balanced, nutritious diet. Unfortunately, people often misunderstand this principle; they misconstrue advice to moderate the intake of some foods as advice to eliminate them. In the case of nutritious foods, such as eggs, complete avoidance may do more harm than good.

Excessive consumption of eggs — like excessive consumption of any food — is unwise. For most people, however, the avoidance of eggs is also undesirable and unnecessary. It limits variety in the diet and keeps people from taking advantage of the benefits of eggs, including their high nutrient density, low cost, convenience, and usefulness in recipes. Excessively strong advice to minimize the use of eggs may be especially detrimental to people with limited incomes, who need low-cost protein-rich foods, and to elderly people, for whom the high nutritional value, low cost, ease of preparation, and ease of chewing of eggs are all important advantages. Although people with high cholesterol levels who are sensitive to dietary cholesterol intake may need to strictly limit their consumption of egg yolks, most other people need not be concerned about their moderate intake of eggs.

All of the research on eggs published since ACSH last reported on this subject in 1996 has confirmed and strengthened the conclusion that eggs can have a place in a healthful diet and can make an important contribution to good nutrition. The current dietary recommendations of the American Heart Association call for limits on saturated fat and cholesterol intake (with the stronger emphasis on saturated fat) but do not specifically restrict the number of eggs consumed per week. This advice is consistent with both recent scientific findings and the results of earlier research.

Eggs and Food Allergies

Food allergies are among the most misunderstood health problems. People often think that allergies to foods or food ingredients are common but relatively mild. In fact, exactly the opposite is true. Only about 1.5% of adults and up to 6% of young children have true food allergies,²² but for those who do have them, food allergies can be a serious, even life-threatening problem. Allergic reactions to foods account for an estimated 30,000 emergency room visits and 150–200 deaths each year in the U.S.²³

Allergies to nearly 175 foods have been reported.²⁴ However, eight foods or food groups — peanuts, shellfish, milk, eggs, fish, tree nuts (almonds, walnuts, hazelnuts, etc.), soy, and wheat — account for 90% of all food allergies.²³

For people with food allergies, strict avoidance of the offending food is an essential part of treatment. In the case of egg allergy, avoidance is particularly challenging. Because eggs are so useful in recipes, they are present in many mixed dishes and processed foods, including some where their presence is not obvious (such as marshmallows, batters used to coat fried foods, and some brands of yogurt).²⁴ Planning an egg-free diet can be difficult because careful label reading is required and because it can be hard to find breads and other grain products that do not contain any ingredients derived from eggs.

ACSH recommends that people who suspect that they or their children may be allergic to a food see a physician for a proper diagnosis and that anyone who is diagnosed with a true allergy to eggs or any other food consult a registered dietitian for help in planning a safe and nutritious diet. Helpful information on how to cope with food allergies in various settings (e.g., school, camp, travel) can also be obtained from the Food Allergy and Anaphylaxis Network, which can be reached online at <http://www.foodallergy.org>.

Handling Eggs Safely

One of the basic principles of food safety is that raw foods of animal origin must be cooked thoroughly. In their raw state, these foods may contain harmful bacteria; proper cooking kills the bacteria and makes the food safe to eat.

Prior to the early 1980s, eggs seemed to be an exception to this rule. At that time, eggs with clean shells with no cracks (not even hair-

line cracks) were thought to be sterile (free from microorganisms) on the inside, and therefore they were considered safe to eat even when raw. However, in the 1980s, it became evident that some intact shell eggs are contaminated with *Salmonella* bacteria.^{25,26} This is believed to be a relatively new problem; apparently, sometime in the late 1970s, strains of *Salmonella* developed the ability to colonize the ovaries of healthy hens and contaminate eggs from the inside before the eggs are laid. The bacteria don't make the hens sick and don't spoil the eggs, but

What's So Special About . . .

Fertile eggs? Fertile eggs are eggs that can be incubated and developed into chicks. They are not more nutritious than other types of eggs, and they do not have a lower cholesterol content. Fertile eggs have no special advantages over other eggs. They have two disadvantages, however: They don't keep as well as unfertilized eggs, and they cost more.

Organic eggs? Organic eggs are eggs produced by hens fed "organic" feeds; (i.e., grains grown without pesticides or commercial fertilizers) and raised without medications. Organic eggs have the same nutrient content as other eggs, but they are more expensive because of their higher production costs.

Free-range eggs? True free-range eggs are produced by hens raised outdoors or with daily access to the outdoors. This type of production is possible only on a seasonal basis in most parts of the U.S. The term "free-range" is sometimes used more loosely (and erroneously) to refer to eggs produced by hens raised indoors on an open floor rather than in cages. Free-range production (real or otherwise) does not affect the nutritional value or cholesterol level of eggs. It does increase their price, however.

Brown eggs versus white eggs? The breed of the hen determines the color of the egg's shell. Since most U.S. consumers prefer white eggs, most producers raise White Leghorn hens, which produce eggs with a white shell. Consumers in New England prefer brown-shelled eggs, so most producers there raise breeds such as the Rhode Island Red that produce brown shells. Shell color has nothing to do with egg quality, flavor, or nutritional value. The price of brown eggs is usually a bit higher than the price of white eggs because the brown-shell-producing breeds are larger birds with bigger appetites for feed.

they can make people sick if a contaminated egg is not cooked adequately before it is eaten. The risk is increased if the egg is allowed to sit at room temperature because bacteria multiply quickly in a warm environment.

Like other animal products, eggs are safe to eat if handled and cooked correctly. However, as is also true for other foods, improperly handled or inadequately cooked eggs have sometimes been implicated in foodborne illness.

Salmonella bacteria can cause an intestinal infection. Typical symptoms include diarrhea, abdominal pain, fever and vomiting. The symptoms usually begin 12 to 36 hours after a contaminated food is eaten. In healthy adults, *Salmonella* food poisoning is usually not serious, and most patients recover within a few days. The disease can be much more severe or even fatal, however, in young children, elderly people, pregnant women (the risk is to the fetus), or people with impaired immune systems.²⁷

It has been estimated that about 1 in 20,000 eggs sold in the U.S. is contaminated with *Salmonella*.²⁸ That sounds like a very small proportion, and it is. But on a national basis, it represents a substantial problem. According to the U.S. Department of Agriculture, about 2.3 million contaminated eggs are produced in the U.S. each year²⁹ (the total production of eggs is about 47 billion!). The vast majority of the contaminated eggs are handled and cooked properly, and they don't cause any health problems. But there are exceptions. The USDA estimates that 100,000 to 150,000 cases of foodborne illness are caused each year by *Salmonella* in shell eggs.²⁹

As part of an overall federal government effort to improve food safety, the President's Council on Food Safety announced an Egg Safety Action Plan in 1999. The overall goals of this plan are a 50% reduction in egg-associated *Salmonella* illnesses by 2005 and the elimination of these illnesses by 2010.³⁰ Part of this plan involves steps taken on farms and at egg packing and processing plants to reduce *Salmonella* contamination. For example, efforts are being made to identify and remove infected flocks from the egg supply and to increase quality assurance and sanitation measures.²⁷ However, since these steps are unlikely to completely eliminate *Salmonella*, it is also important to ensure that retailers, food service establishments, and consumers handle eggs properly, so that even if an egg contains *Salmonella*, it won't make anyone sick. This means storing eggs under refrigeration at all times and cooking them thoroughly.

As part of the overall plan, the Food and Drug Administration (FDA) issued a new regulation in November 2000, effective in September 2001, requiring that all packages of shell eggs (except those treated to destroy *Salmonella* by pasteurization or some other process) carry the following label statement:³¹

SAFE HANDLING INSTRUCTIONS: To prevent illness from bacteria: keep eggs refrigerated, cook eggs until yolks are firm, and cook foods containing eggs thoroughly.

This label statement is similar to those required on packages of raw meat and poultry.

The same regulation that established the labeling requirement also requires that eggs be kept under refrigeration at 45°F or lower at retail establishments such as supermarkets and restaurants. The FDA had intended to take some additional steps in the egg safety action plan in 2001 but had to postpone them until 2002 in order to devote its attention to emergency situations.³²

To protect themselves against *Salmonella* in eggs, consumers should take the following precautions:

- Don't eat raw eggs or foods that contain raw eggs. If a recipe contains eggs, don't taste the uncooked food (for example, if there are eggs in a cake batter or cookie dough, don't lick the spoon).
- Don't buy dirty, cracked, or outdated eggs.
- Cook eggs until both the yolk and the white are firm.
- Cook casseroles and other dishes containing eggs to 160°F.
- If a recipe calls for eggs that are raw or undercooked when the dish is served (as some recipes for homemade ice cream, Caesar salad dressing, homemade mayonnaise, eggnog, hollandaise sauce, and various other dishes do), use pasteurized eggs or a pasteurized egg product instead of regular shell eggs or choose a different recipe. Many newer cookbooks include cooked-egg versions of recipes traditionally made with raw eggs.
- Take the same precautions with eggs that you should take with other perishable foods, including the following:
 - ◆ Store perishables in the refrigerator.
 - ◆ Don't allow drippings from raw animal products to contaminate other foods.
 - ◆ Keep everything clean while handling, preparing, and serving foods.

The Role of Eggs in the Diet: Update

- ◆ Use a food thermometer to determine whether foods such as casseroles are cooked adequately.
- ◆ Serve perishable foods promptly after cooking.
- ◆ When serving perishable foods buffet-style, keep cold foods cold and hot foods hot.
- ◆ When carrying perishable food away from home, use ice or cold packs to keep it cold.
- ◆ Refrigerate leftovers and use or discard them within 3–4 days.

Recent disease surveillance data collected by the federal government's Centers for Disease Control and Prevention show that the number of reported cases of most of the major types of foodborne illness declined between 1996 and 2001; cases of the type of *Salmonella* infection associated with contaminated eggs decreased 22%.³³ Thus, the increased efforts that have been made to enhance food safety over the past few years appear to be having an effect. However, there is room for further improvement.

Summary

Eggs are a major source of dietary cholesterol, but they are not high in saturated fat or calories. They can easily be included in a diet that meets current dietary guidelines for the prevention of heart disease. There is no longer any specific limit on the number of eggs or egg yolks that can be eaten each week, but the recommendation to limit dietary cholesterol intake to an average of 300 mg/day still stands.

Eggs are a highly nutritious food. They are an excellent source of high-quality protein and are far less expensive than most other animal-protein foods. Eggs also provide significant amounts of several vitamins and minerals. Recent research indicates that egg eaters are more likely than non-egg eaters to have diets that provide adequate amounts of essential nutrients. This seems to be partly due to the nutritional contribution of the eggs themselves and partly due to the fact that the inclusion of eggs in the diet is a marker for a desirable eating pattern that includes breakfast.

Like many other foods — both those of plant origin and those of animal origin — eggs contain components that may have beneficial health effects beyond their basic nutritional value. Research on these “functional” components is in progress.

It is possible to modify some aspects of the nutritional composition

of eggs by feeding the hens special diets. Modified “designer” eggs containing increased amounts of omega-3 fatty acids and vitamin E are now on the market. It has not yet been determined whether these eggs have special health benefits.

Allergies to eggs are uncommon. However, those individuals who do have an egg allergy must avoid eggs completely. Because eggs are a common ingredient in both home-prepared and processed foods, planning an egg-free diet is difficult.

As with all perishable foods, eggs need to be handled and prepared with care to ensure their microbiological safety. Although only a very small proportion of the eggs on the market contain potentially harmful bacteria, consumers should be careful to always store eggs under refrigeration and cook eggs thoroughly. Recent coordinated efforts to improve food safety in the U.S. appear to have resulted in a decrease in food-borne illnesses, including the type associated with the bacteria that can contaminate eggs.

References

1. Applegate E, Introduction: Nutritional and functional roles of eggs in the diet, *J Am Coll Nutr* 2000;19:495S-498S.
2. U.S. Departments of Agriculture and Health and Human Services, *Nutrition and Your Health: Dietary Guidelines for Americans* (booklet), 5th ed., 2000, available online at <http://www.usda.gov/cnpp/DietGd.pdf>
3. American Heart Association, AHA dietary guidelines. Revision 2000: A statement for healthcare professionals from the nutrition committee of the American Heart Association, *Circulation* 2000;102:2296–2311.
4. American Heart Association, *An Eating Plan for Healthy Americans* (booklet), Dallas, AHA, 2000, available online at http://www.americanheart.org/downloadable/heart/4102_EatPlan2000.pdf
5. Clarke R, Frost C, Collins R, Appleby P, Peto R, Dietary lipids and blood cholesterol: Quantitative meta-analysis of metabolic ward studies, *BMJ* 1997;314:112–117.

The Role of Eggs in the Diet: Update

6. Howell WH, McNamara DJ, Tosca MA, Smith BT, Gaines JA, Plasma lipid and lipoprotein responses to dietary fat and cholesterol: a meta-analysis, *Am J Clin Nutr* 1997;65:1747–1764.
7. Song WO, Kerver JM, Nutritional contributions of eggs to American diets, *J Am Coll Nutr* 2000;19:556S–562S.
8. McNamara D, The impact of egg limitations on coronary heart disease risk: Do the numbers add up? *J Am Coll Nutr* 2000;19:540S–548S.
9. Pietinen P, Ascherio A, Korhonen P, Hartman AM, Willett WC, Albanes D, Virtamo J, Intake of fatty acids and risk of coronary heart disease in a cohort of Finnish men. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study, *Am J Epidemiol* 1997;145:876–877.
10. Hu FB, Stampfer MJ, Rimm Eb, Manson JE, Ascherio A, Colditz GA, Rosner BA, Spiegelman D, Speizer FE, Sacks FM, Hennekens CH, Willett WC, A prospective study of egg consumption and risk of cardiovascular disease in men and women, *JAMA* 1999;281:1387–1394.
11. Dawber TR, Nickerson RJ, Brand FN, Pool J, Eggs, serum cholesterol, and coronary heart disease, *Am J Clin Nutr* 1982;36:617–625.
12. Fraser GE, Diet and coronary heart disease: beyond dietary fats and low-density-lipoprotein cholesterol, *Am J Clin Nutr* 1994;59:1117–1123.
13. Makrides M, Hawkes JS, Newmann MA, Gibson RA, Nutritional effect of including egg yolk in the weaning diet of breast-fed and formula-fed infants: a randomized controlled trial, *Am J Clin Nutr* 2002;75:1084–1092.
14. National Academy of Sciences, Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline, National Academy Press, Washington, D.C., 2000.

15. Hasler CM, The changing face of functional foods, *J Am Coll Nutr* 2000;19:499S–506S.
16. Morgan KJ, Zabik ME, Stampely GL, The role of breakfast in diet adequacy of the U.S. adult population, *J Am Coll Nutr* 1986;5:551–563.
17. Hammond GK, Chapman GE, The nutritional role of breakfast in the diets of college students, *J Can Diet Assoc* 1994;55:69–74.
18. Nicklas TA, Bao W, Webber LS, Berenson GS, Breakfast consumption affects adequacy of total daily intake in children, *J Am Diet Assoc* 1993;93:886–891.
19. Moeller MS, Jacques PF, Blumberg JB, The potential role of dietary xanthophylls in cataract and age-related macular degeneration, *J Am Coll Nutr* 2000;19:522S–527S.
20. Handelman GJ, Nightingale ZD, Lichtenstein AH, Schaefer EJ, Blumberg JB, Lutein and zeaxanthin concentrations in plasma after dietary supplementation with egg yolk, *Am J Clin Nutr* 1999;70:247–251.
21. Watson, RR, ed., *Eggs and Health Promotion*, Iowa State Press, Ames, IA, 2002.
22. Formanek R Jr, Food allergies: when food becomes the enemy, *FDA Consumer*, July/August 2001, available online at http://www.fda.gov/fdac/features/2001/401_food.html
23. Food Allergy & Anaphylaxis Network, Food Allergy Basics, 2001, available online at <http://www.foodallergy.org/faaw/FoodAllergyBasics.pdf>
24. Egg Nutrition Center, *Understanding Food Allergies* (booklet), 2000, available online at <http://www.enc-online.org/foodalrgy.pdf>
25. Blumenthal D. *Salmonella enteritidis*: from the chicken to the egg, *FDA Consumer*, April 1990, Available online at <http://www.fda.gov/bbs/topics/CONSUMER/CON00072.html>

The Role of Eggs in the Diet: Update

26. St. Louis ME, Morse DL, Potter ME, DeMelfi TM, Guzewich JJ, The emergence of grade A eggs as a major source of *Salmonella enteritidis* infections: new implications for the control of salmonellosis. *JAMA* 1988;259:103–107.
27. Centers for Disease Control and Prevention, *Salmonella enteritidis* (disease information fact sheet), 2001, available online at http://www.cdc.gov/ncidod/dbmd/diseaseinfo/salment_g.htm
28. Kurtzweil, P. Safer eggs: Laying the groundwork, *FDA Consumer*, Sept/Oct 1998, Available online at <http://vm.cfsan.fda.gov/~dms/fdaceggs.html>
29. Crutchfield SR, Roberts T, Food safety efforts accelerate in the 1990s, *FoodReview* 2000;23:44–49. Available on the USDA web site at <http://www.ers.usda.gov/publications/foodreview/septdec00/FRsept00h.pdf>
30. Buckner R, U.S. egg safety action plan, *Food Testing & Analysis*, April/May 2000, available online at <http://www.cfsan.fda.gov/~acrobat/fs-eggs3.pdf>
31. HHS (Department of Health and Human Services), FDA finalizes safe handling labels and refrigeration requirements for marketing shell eggs, press release, November 30, 2000, available online at <http://www.cfsan.fda.gov/~lrd/hhseggs2.html>
32. Anonymous, Headless FDA begins 2002 with broad agenda, *Food Chemical News*, January 7, 2002.
33. Centers for Disease Control and Prevention, Preliminary FoodNet data on the incidence of foodborne illnesses — selected sites, United States, 2001, *Morbidity and Mortality Weekly Report*, 2002;51:325–329.

Suggestions for Further Reading:

Planning a Heart-Healthy Diet

U.S. Departments of Agriculture and Health and Human Services, *Nutrition and Your Health: Dietary Guidelines for Americans* (booklet), 5th ed., 2000, available online at <http://www.usda.gov/cnpp/DietGd.pdf>

American Heart Association, *An Eating Plan for Healthy Americans* (booklet), AHA, 2000, available online at http://www.americanheart.org/downloadable/heart/4102_EatPlan2000.pdf

Functional Foods

American Council on Science and Health, *Facts about “Functional Foods”*, 2002, available online at <http://www.acsh.org/publications/booklets/funfood2002.pdf>

American Dietetic Association, Position of the American Dietetic Association: Functional Foods. *J Am Diet Assoc* 1999;99:1278–1285. Available online at <http://www.eatright.com/adap1099.html>

Allergies to Eggs and Other Foods

Egg Nutrition Center, *Understanding Food Allergies* (booklet), 2000, available online at <http://www.enc-online.org/foodalrgy.pdf>

The Food Allergy & Anaphylaxis Network, <http://www.foodallergy.org>

Handling Eggs and Other Foods Safely

Food and Drug Administration, *Playing It Safe with Eggs: What Consumers Need to Know* (brochure), available online at <http://www.cfsan.fda.gov/~acrobat/fs-eggs.pdf>

Food Safety and Inspection Service, U.S. Department of Agriculture, *Focus on Shell Eggs*, available online at <http://www.fsis.usda.gov/OA/pubs/shelleggs.htm>

Elizabeth M. Whelan, Sc.D., M.P.H.
President

ACSH BOARD OF DIRECTORS

Fredric M. Steinberg, M.D.
Chairman of the Board, ACSH
Hertfordshire, England

Terry L. Anderson, Ph.D., M.S.
Political Economy Research Center

Elissa P. Benedek, M.D.
University of Michigan

Norman E. Borlaug, Ph.D.
Texas A&M University

Michael B. Bracken, Ph.D., M.P.H.
Yale University School of Medicine

Christine M. Bruhn, Ph.D.
University of California

Taiwo K. Danmola, C.P.A.
Arthur Andersen IIP

Thomas R. DeGregori, Ph.D.
University of Houston

Henry I. Miller, M.D.
Hoover Institution

A. Alan Moghissi, Ph.D.
Institute for Regulatory Science

John H. Moore, Ph.D., M.B.A.
Grove City College

Albert G. Nickel
Lyons lavy Nickel swift, inc.

Kenneth M. Prager, M.D.
Columbia College of Physicians and Surgeons

Stephen S. Sternberg, M.D.
Memorial Sloan-Kettering Cancer Center

Mark C. Taylor, M.D.
Physicians for a Smoke-Free Canada

Lorraine Thelian
Ketchum Public Relations

Kimberly M. Thompson, Sc.D.
Harvard School of Public Health

Elizabeth M. Whelan, Sc.D., M.P.H.
American Council on Science and Health

Robert J. White, M.D., Ph.D.
Case Western Reserve University

ACSH BOARD OF SCIENTIFIC AND POLICY ADVISORS

Ernest L. Abel, Ph.D.
C.S. Mott Center

Alwynelle S. Ahl, Ph.D., D.V.M.
Tuskegee University, AL

Julie A. Albrecht, Ph.D.
University of Nebraska, Lincoln

James E. Alcock, Ph.D.
Glendon College, York University

Thomas S. Allems, M.D., M.P.H.
San Francisco, CA

Richard G. Allison, Ph.D.
American Society for Nutritional Sciences (FASBN)

John B. Allred, Ph.D.
Ohio State University

Philip R. Alper, M.D.
University of California, San Francisco

Karl E. Anderson, M.D.
University of Texas, Medical Branch

Dennis T. Avery
Hudson Institute

Robert S. Baratz, D.D.S., Ph.D., M.D.
International Medical Consultation Services

Nigel M. Bark, M.D.
Albert Einstein College of Medicine

Stephen Barrett, M.D.
Allentown, PA

Thomas G. Baumgartner, Pharm.D., M.Ed.
University of Florida

Barry L. Beyerstein, Ph.D.
Simon Fraser University

Blaine L. Blad, Ph.D.
Kanosh, UT

Hinrich L. Bohn, Ph.D.
University of Arizona

Ben Bolch, Ph.D.
Rhodes College

Joseph F. Borzelleca, Ph.D.
Medical College of Virginia

Michael K. Botts, Esq.
Ames, IA

George A. Bray, M.D.
Pennington Biomedical Research Center

Ronald W. Brecher, Ph.D., C.Chem., DABT
GlobalTox International Consultants, Inc.

Robert L. Brent, M.D., Ph.D.
Alfred I. duPont Hospital for Children

Allan Brett, M.D.
University of South Carolina

Gale A. Buchanan, Ph.D.
University of Georgia

George M. Burditt, J.D.
Bell, Boyd & Lloyd LLC

Edward E. Burns, Ph.D.
Texas A&M University

Francis F. Busta, Ph.D.
University of Minnesota

Elwood F. Caldwell, Ph.D., M.B.A.
University of Minnesota

Zerle L. Carpenter, Ph.D.
Texas A&M University System

C. Jelleff Carr, Ph.D.
Columbia, MD

Robert G. Cassens, Ph.D.
University of Wisconsin, Madison

Erocle L. Cavallieri, D.Sc.
University of Nebraska Medical Center

Russell N. A. Cecil, M.D., Ph.D.
Mohawk Valley Orthopedics, NY

James J. Cerda, M.D.
University of Florida

Morris E. Chafetz, M.D.
Health Education Foundation

Bruce M. Chassy, Ph.D.
University of Illinois, Urbana-Champaign

Dale J. Chodos, M.D.
Kalamazoo, MI

Martha A. Churchill, Esq.
Milan, MI

Emil William Chynn, M.D.
Manhattan Eye, Ear & Throat Hospital

Dean O. Cliver, Ph.D.
University of California, Davis

F. M. Clydesdale, Ph.D.
University of Massachusetts

Donald G. Cochran, Ph.D.
Virginia Polytechnic Institute and State University

W. Ronnie Coffman, Ph.D.
Cornell University

Bernard L. Cohen, D.Sc.
University of Pittsburgh

John J. Cochrissen, Esq.
Public Health Policy Advisory Board

Neville Colman, M.D., Ph.D.
St. Luke's Roosevelt Hospital Center

Gerald F. Combs, Jr., Ph.D.
Cornell University

Michael D. Corbett, Ph.D.
Omaha, NE

Morton Corn, Ph.D.
John Hopkins University

Nancy Cotugno, Dr.Ph., R.D., C.D.N.
University of Delaware

Roger A. Coulombe, Jr., Ph.D.
Utah State University

H. Russell Cross, Ph.D.
Future Beef Operations, L.L.C.

Charles R. Curtis, Ph.D.
Ohio State University

Ilene R. Danse, M.D.
Boinas, CA

Ernst M. Davis, Ph.D.
University of Texas, Houston

Harry G. Day, Sc.D.
Indiana University

Robert M. Devlin, Ph.D.
University of Massachusetts

Seymour Diamond, M.D.
Diamond Headache Clinic

Donald C. Dickson, M.S.E.E.
Gilbert, AZ

John Diebold
The Diebold Institute for Public Policy Studies

Ralph Dittman, M.D., M.P.H.
Houston, TX

John E. Dodes, D.D.S.
National Council Against Health Fraud

Sir Richard Doll, M.D., D.Sc., D.M.
University of Oxford

John Doull, M.D., Ph.D.
University of Kansas

Theron W. Downes, Ph.D.
Michigan State University

Adam Drewnowski, Ph.D.
University of Washington

Michael A. Dubick, Ph.D.
U.S. Army Institute of Surgical Research

Greg Dubord, M.D., M.P.H.
RAM Institute

Edward R. Duffie, Jr., M.D.
Savannah, GA

David F. Duncan, Dr.Ph.
Brown University

James R. Dunn, Ph.D.
Averill Park, NY

Robert L. DuPont, M.D.
Institute for Behavior and Health, Inc.

Henry A. Dymsha, Ph.D.
University of Rhode Island

Michael W. Easley, D.D.S., M.P.H.
State University of New York, Buffalo

J. Gordon Edwards, Ph.D.
San Jose State University

George E. Ehrlich, M.D., F.A.C.P., M.A.C.R., FRCP (Edin)
Philadelphia, PA

Michael P. Elston, M.D., M.S.
Rapid City Regional Hospital

William N. Elwood, Ph.D.
University of Miami School of Medicine

James E. Enstrom, Ph.D., M.P.H.
University of California, Los Angeles

Stephen K. Epstein, M.D., M.P.P., FACEP
Beth Israel Deaconess Medical Center

Myron E. Essex, D.V.M., Ph.D.
Harvard School of Public Health

Terry D. Etherton, Ph.D.
Pennsylvania State University

William Evans, Ph.D.
Georgia State University

Daniel F. Farkas, Ph.D., M.S., P.E.
Oregon State University

Richard S. Fawcett, Ph.D.
Huey, IA

John B. Fenger, M.D.
Phoenix, AZ

Owen R. Fennema, Ph.D.
University of Wisconsin, Madison

Frederick L. Ferris, III, M.D.
National Eye Institute

David N. Ferro, Ph.D.
University of Massachusetts

Madelon L. Finkel, Ph.D.
Cornell University Medical College

Jack C. Fisher, M.D.
University of California, San Diego

Kenneth D. Fisher, Ph.D.
Washington, DC

Leonard T. Flynn, Ph.D., M.B.A.
Morganville, NJ

William H. Foege, M.D., M.P.H.
Emory University

Ralph W. Fogleman, D.V.M.
Upper Black Eddy, PA

Christopher H. Foreman, Jr., Ph.D.
University of Maryland

E. M. Foster, Ph.D.
University of Wisconsin, Madison

F. J. Francis, Ph.D.
University of Massachusetts

Glenn W. Froning, Ph.D.
University of Nebraska, Lincoln

Vincent A. Fulginitti, M.D.
University of Colorado

Arthur Furst, Ph.D., Sc.D.
University of San Francisco

Robert S. Gable, Ed.D., Ph.D., J.D.
Claremont Graduate University

Shayne C. Gad, Ph.D., D.A.B.T., A.T.S.
GAD Consulting Services

William G. Gaines, Jr., M.D., M.P.H.
Scott & White Clinic

Charles O. Gallina, Ph.D.
Professional Nuclear Associates

Raymond Gambino, M.D.
Quest Diagnostics, Inc.

Randy R. Gaugler, Ph.D.
Rutgers University

LaNelle E. Geddes, Ph.D., R.N.
Purdue University

J. Bernard L. Gee, M.D.
Yale University School of Medicine

K. H. Ginzle, M.D.
University of Arkansas for Medical Sciences

William Paul Clezen, M.D.
Baylor College of Medicine

Jay A. Gold, M.D., J.D., M.P.H.
Medical College of Wisconsin

Roger E. Gold, Ph.D.
Texas A&M University

Renée M. Goodrich, Ph.D.
University of Florida

Frederick K. Goodwin, M.D.
The George Washington University Medical Center

Timothy N. Gorski, M.D., F.A.C.O.G.
Arlington, TX

Ronald E. Gots, M.D., Ph.D.
International Center for Toxicology and Medicine

Michael Gough, Ph.D.
Bethesda, MD

Henry G. Grabowski, Ph.D.
Duke University

James Ian Gray, Ph.D.
Michigan State University

William W. Greaves, M.D., M.S.P.H.
Medical College of Wisconsin

Kenneth Green, D.Env.
Research Public Policy Institute

Laura C. Green, Ph.D., D.A.B.T.
Cambridge Environmental, Inc.

Saul Green, Ph.D.
Zol Consultants

Richard A. Greenberg, Ph.D.
Hinsdale, IL

Sander Greenland, Dr.P.H., M.S., M.A.
UCLA School of Public Health

Gordon W. Gribble, Ph.D.
Dartmouth College

William Grierson, Ph.D.
University of Florida

Lester Grinspoon, M.D.
Harvard Medical School

- F. Peter Guengerich, Ph.D.
Vanderbilt University School of Medicine
- Caryl J. Guth, M.D.
Hillsborough, CA
- Philip S. Guzelian, M.D.
University of Colorado
- Alfred E. Harper, Ph.D.
University of Wisconsin, Madison
- Clare M. Hasler, Ph.D.
University of Illinois at Urbana-Champaign
- Robert D. Havener, M.P.A.
Sacramento, CA
- Virgil W. Hays, Ph.D.
University of Kentucky
- Cheryl G. Heaton, Dr.Ph.
Columbia University, School of Public Health
- Clark W. Heath, Jr., M.D.
American Cancer Society
- Dwight B. Heath, Ph.D.
Brown University
- Robert Heimer, Ph.D.
Yale School of Public Health
- Zane R. Helsel, Ph.D.
Rutgers University, Cook College
- Donald A. Henderson, M.D., M.P.H.
Johns Hopkins University
- James D. Herbert, Ph.D.
MCP Hahnemann University
- Victor Herbert, M.D., J.D., M.A.C.P.
Bronx Veterans Affairs Medical Center
- Gene M. Heyman, Ph.D.
McLean Hospital/Harvard Medical School
- Richard M. Hoar, Ph.D.
Williamstown, MA
- Robert M. Hollingworth, Ph.D.
Michigan State University
- Edward S. Horton, M.D.
Joslin Diabetes Center
- Joseph H. Hotchkiss, Ph.D.
Cornell University
- Steve E. Hrudez, Ph.D.
University of Alberta
- Susanne L. Huttner, Ph.D.
University of California, Berkeley
- Robert H. Imrie, D.V.M.
Seattle, WA
- Lucien R. Jacobs, M.D.
University of California, Los Angeles
- Alejandro R. Jadad, M.D., D.Phil., F.R.C.P.C.
University of Toronto
- Rudolph J. Jaeger, Ph.D.
Environmental Medicine, Inc.
- William T. Jarvis, Ph.D.
Loma Linda University
- Daland R. Juberg, Ph.D.
Rochester, NY
- Michael Kamrin, Ph.D.
Haslett, MI
- John B. Kaneene, Ph.D., M.P.H., D.V.M.
Michigan State University
- Philip G. Keeney, Ph.D.
Pennsylvania State University
- John G. Keller, Ph.D.
Olney, MD
- Kathryn E. Kelly, Dr.P.H.
Delta Toxicology
- George R. Kerr, M.D.
University of Texas, Houston
- George A. Keyworth II, Ph.D.
Progress and Freedom Foundation
- Michael Kirsch, M.D.
Highland Heights, OH
- John C. Kirschman, Ph.D.
Emmaus, PA
- Ronald E. Kleinman, M.D.
Massachusetts General Hospital
- David M. Klurfeld, Ph.D.
Wayne State University
- Kathryn M. Kolasa, Ph.D., R.D.
East Carolina University
- Alan R. Kristal, Dr.P.H.
Fred Hutchinson Cancer Research Center
- David Kritchevsky, Ph.D.
The Wistar Institute
- Mitzi R. Krockover, M.D.
Humana, Inc.
- Manfred Kroger, Ph.D.
Pennsylvania State University
- Laurence J. Kulp, Ph.D.
University of Washington
- Sandford F. Kuvin, M.D.
Hebrew University of Jerusalem
- Carolyn J. Lackey, Ph.D., R.D.
North Carolina State University
- J. Clayburn LaForce, Ph.D.
University of California, Los Angeles
- James C. Lamb, IV, Ph.D., J.D.
Blastand, Bouck & Lee, Inc.
- Lawrence E. Lamb, M.D.
San Antonio, TX
- Lillian Langseth, Dr.P.H.
Lyda Associates, Inc.
- Brian A. Larkins, Ph.D.
University of Arizona
- Larry Laudan, Ph.D.
National Autonomous University of Mexico
- Tom B. Leamon, Ph.D.
Liberty Mutual Insurance Company
- Jay H. Lehr, Ph.D.
Environmental Education Enterprises, Inc.
- Brian C. Lentle, M.D., FRCP, DMRD
University of British Columbia
- Floy Lilley, J.D.
Amelia Island, FL
- Paul J. Lloy, Ph.D.
UMDNJ-Robert Wood Johnson Medical School
- William M. London, Ed.D., M.P.H.
Fort Lee, NJ
- Frank C. Lu, M.D., BCFE
Miami, FL
- William M. Lunch, Ph.D.
Oregon State University
- Daryl Lund, Ph.D.
University of Wisconsin
- George D. Lundberg, M.D.
Medscape
- Howard D. Maccabee, Ph.D., M.D.
Radiation Oncology Center
- Janet E. Macheleidt, M.D., M.S., M.P.H.
Houston, TX
- Roger P. Maickel, Ph.D.
Purdue University
- Henry G. Manne, J.S.D.
George Mason University Law School
- Karl Maramorosch, Ph.D.
Rutgers University, Cook College
- Judith A. Marlett, Ph.D., R.D.
University of Wisconsin, Madison
- James R. Marshall, Ph.D.
Arizona Cancer Center
- Margaret N. Maxey, Ph.D.
University of Texas at Austin
- Mary H. McGrath, M.D., M.P.H.
Loyola University Medical Center
- Alan G. McHughen, D.Phil.
University of California, Riverside
- James D. McKean, D.V.M., J.D.
Iowa State University
- John J. McKetta, Ph.D.
University of Texas at Austin
- Donald J. McNamara, Ph.D.
Egg Nutrition Center
- Patrick J. Michaels, Ph.D.
University of Virginia
- Thomas H. Milby, M.D., M.P.H.
Walnut Creek, CA
- Joseph M. Miller, M.D., M.P.H.
University of New Hampshire
- William J. Miller, Ph.D.
University of Georgia
- Dade W. Moeller, Ph.D.
Harvard University
- Grace P. Monaco, J.D.
Medical Care Management Corp.
- Brian E. Mondell, M.D.
John Hopkins at Green Spring Station
- Eric W. Mood, LL.D., M.P.H.
Yale University School of Medicine
- John W. Morgan, Dr.P.H.
California Cancer Registry
- W. K. C. Morgan, M.D.
Ontario, Canada
- Stephen J. Moss, D.D.S., M.S.
New York University
- Ian C. Munro, F.A.T.S., Ph.D., FRCPATH
Canox Health Sciences International
- Kevin B. Murphy
Merrill Lynch, Pierce, Fenner & Smith
- Harris M. Nagler, M.D.
Beth Israel Medical Center
- Daniel J. Ncayiyana, M.D.
University of Cape Town
- Philip E. Nelson, Ph.D.
Purdue University
- Malden C. Nesheim, Ph.D.
Cornell University
- Joyce A. Nettleton, D.Sc., R.D.
Aurora, CO
- John S. Neuberger, Dr.P.H.
University of Kansas School of Medicine
- Gordon W. Newell, Ph.D., M.S., F.-A.T.S.
Palo Alto, CA
- Steven P. Novella, M.D.
Yale University School of Medicine
- James L. Oblinger, Ph.D.
North Carolina State University
- John Patrick O'Grady, M.D.
Tufts University School of Medicine
- James E. Oldfield, Ph.D.
Oregon State University
- Stanley T. Omaye, Ph.D., F.-A.T.S., F.A.C.N., C.N.S.
University of Nevada, Reno
- Michael T. Osterholm, Ph.D., M.P.H.
Ican, Inc.
- M. Alice Ottoboni, Ph.D.
Sparks, NV
- Michael W. Pariza, Ph.D.
University of Wisconsin, Madison
- Stuart Patton, Ph.D.
Pennsylvania State University
- Timothy Dukes Phillips, Ph.D.
Texas A&M University
- Mary Frances Picciano, Ph.D.
National Institutes of Health
- David R. Pike, Ph.D.
University of Illinois, Urbana-Champaign
- Thomas T. Poleman, Ph.D.
Cornell University
- Charles Polk, Ph.D.
University of Rhode Island
- Charles Poole, M.P.H., Sc.D.
University of North Carolina School of Public Health
- Gary P. Posner, M.D.
Tampa, FL
- John J. Powers, Ph.D.
University of Georgia
- William D. Powrie, Ph.D.
University of British Columbia
- Kary D. Presten
U.S. Trust Company of New York
- Marvin P. Pritts, Ph.D.
Cornell University
- Daniel J. Raiten, Ph.D.
National Institutes of Health
- David W. Ramey, D.V.M.
Ramey Equine
- R.T. Ravenholt, M.D., M.P.H.
Population Health Imperatives
- Russel J. Reiter, Ph.D.
University of Texas, San Antonio
- William O. Robertson, M.D.
University of Washington School of Medicine
- J. D. Robinson, M.D.
Georgetown University School of Medicine
- Bill D. Roebuck, Ph.D., D.A.B.T.
Dartmouth Medical School
- David B. Roll, Ph.D.
University of Utah
- Dale R. Romsos, Ph.D.
Michigan State University
- Steven T. Rosen, M.D.
Northwestern University Medical School
- Kenneth J. Rothman, Dr.P.H.
Editor, Epidemiology
- Stanley Rothman, Ph.D.
Smith College
- Edward C. A. Runge, Ph.D.
Texas A&M University
- Stephen H. Safe, D.Phil.
Texas A&M University
- Wallace I. Sampson, M.D.
Stanford University School of Medicine
- Harold H. Sandstead, M.D.
University of Texas Medical Branch
- Herbert P. Sarett, Ph.D.
Sarasota, FL
- Lowell D. Satterlee, Ph.D.
Fergus, MN
- Marvin J. Schissel, D.D.S.
Roslyn Heights, NY
- Lawrence J. Schneiderman, M.D.
University of California, San Diego
- Edgar J. Schoen, M.D.
Kaiser Permanente Medical Center
- David Schottenfeld, M.D., M.Sc.
University of Michigan
- Joel M. Schwartz, M.S.
Reason Public Policy Institute
- Patrick J. Shea, Ph.D.
University of Nebraska, Lincoln
- Michael B. Shermer, Ph.D.
Skeptical Magazine
- Sidney Shindell, M.D., LL.B.
Medical College of Wisconsin
- Sarah Short, Ph.D., Ed.D., R.D.
Syracuse University
- A. J. Siedler, Ph.D.
University of Illinois, Urbana-Champaign
- Lee M. Silver, Ph.D.
Princeton University
- Michael S. Simon, M.D., M.P.H.
Barbara Ann Karmanos Cancer Inst.
- S. Fred Singer, Ph.D.
Science & Environmental Policy Project
- Robert B. Sklaroff, M.D.
Elkins Park, PA
- Gary C. Smith, Ph.D.
Colorado State University
- Roy F. Spalding, Ph.D.
University of Nebraska, Lincoln
- Leonard T. Sperry, M.D., Ph.D.
Barry University
- Robert A. Squire, D.V.M., Ph.D.
Baltimore, MD
- Ronald T. Stanko, M.D.
University of Pittsburgh Medical Center
- James H. Steele, D.V.M., M.P.H.
University of Texas, Houston
- Robert D. Steele, Ph.D.
Pennsylvania State University
- Judith S. Stern, Sc.D., R.D.
University of California, Davis
- C. Joseph Stetler, Esq.
Potomac, MD
- Martha Barnes Stone, Ph.D.
Colorado State University
- Michael M. Sveta, Ph.D.
Gaithersburg, MD
- Glenn Swogger, Jr., M.D.
Menninger Clinic
- Sita R. Tatini, Ph.D.
University of Minnesota
- Steve L. Taylor, Ph.D.
Colorado State University, Lincoln
- Dimitrios Trichopoulos, M.D.
Harvard School of Public Health
- Murray M. Tuckerman, Ph.D.
Winchendon, MA
- Robert P. Upchurch, Ph.D.
University of Arizona
- Mark J. Utell, M.D.
University of Rochester Medical Center
- Shashi B. Verma, Ph.D.
University of Nebraska, Lincoln
- Willard J. Visek, M.D., Ph.D.
University of Illinois College of Medicine
- Donald M. Watkin, M.D., M.P.H., F.A.C.P.
George Washington University
- Miles Weinberger, M.D.
University of Iowa Hospitals and Clinics
- Janet S. Weiss, M.D.
University of California at San Francisco
- Steven D. Wexner, M.D.
Cleveland Clinic Florida
- Joel Elliot White, M.D., F.A.C.R.
John Muir Comprehensive Cancer Center
- Carol Whitlock, Ph.D., R.D.
Rochester Institute of Technology
- Christopher F. Wilkinson, Ph.D.
Burke, VA
- Mark L. Willens, M.D.
Veterans Affairs Medical Center
- Carl K. Winter, Ph.D.
University of California, Davis
- Lloyd D. Witter, Ph.D.
University of Illinois, Urbana-Champaign
- James J. Worman, Ph.D.
Rochester Institute of Technology
- Russell S. Worrall, O.D.
University of California, Berkeley
- Panayiotis M. Zavos, Ph.D., Ed.S.
University of Kentucky
- Steven H. Zeisel, M.D., Ph.D.
The University of North Carolina
- Ekhard E. Ziegler, M.D.
University of Iowa

The opinions expressed in ACSH publications do not necessarily represent the views of all ACSH Directors and Advisors. ACSH Directors and Advisors serve without compensation.

