The Role of Beef in the American Diet

Prepared for the American Council on Science and Health

by Kathleen Meister, M.S.

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

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

Art Director
Yelena Ponirovskaya

January 2003

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.

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

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

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

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

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

Virgil W. Hays, Ph.D.
University of Kentucky

Manfred Kroger, Ph.D.
The Pennsylvania State University

David Kritchevsky, Ph.D.
The Wistar Institute

William J. Miller, Ph.D.
University of Georgia

Joyce A. Nettleton, D.Sc., R.D.
Denver, CO

Stanley T. Omaye, Ph.D., F.ATS, F.ACN, C.N.S.
University of Nevada, Reno

Gilbert L. Ross, M.D.
ACSH

Harold H. Sandstead, M.D.
University of Texas Medical Branch, Galveston

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

Table of Contents

Tables and Figures

I. Executive Summary

- Beef is a highly nutritious food. It is particularly valuable as a source of zinc, iron, and other minerals; B vitamins and choline; and protein. Beef also contains components that may have health benefits, such as conjugated linoleic acid (CLA).

- Lean beef, in moderate servings, fits well in a heart-healthy diet and can be used interchangeably with other lean red meats and lean poultry and seafood. It is not necessary for people to substitute poultry and fish for red meat in their diets in order to meet the U.S. government's and American Heart Association's dietary recommendations for saturated fat and cholesterol intake.

- Only about one-third of the fatty acids in beef are cholesterol-raising fatty acids. About half of the fat in beef is monounsaturated fat, which does not raise cholesterol levels. The amount of trans fatty acids in beef is small, and the potential physiological impact of these fatty acids is not the same as that of the cholesterol-raising trans fatty acids in hydrogenated vegetable fats.

- The results of some scientific studies have linked high intakes of red meat with increased risks of colon or prostate cancers (though probably not breast cancer). Other studies, however, have had conflicting results.

- Substances called heterocyclic amines may form in meat during some cooking procedures that use high temperatures. These substances, like the many other naturally occurring animal carcinogens in food, are not a major cause for concern when consumed in small amounts. However, consumers who wish to reduce their exposure to heterocyclic amines can do so by adjusting their cooking methods.

- The use of hormones to promote growth in beef cattle helps to keep the cost of beef down. These hormones, when used correctly, pose no health risks for human consumers.

- The correct use of antibiotics in the production of beef cattle and other animals does not create residue problems. However, this practice, like other uses of antibiotics, may contribute to the development of antibiotic resistant bacteria. The extent to which the use of antibiotics in animal agriculture contributes to the overall problem of antibiotic resistance is uncertain. Nevertheless, experts agree that antibiotics should be used judiciously and only when necessary, and the Food and Drug Administration has begun to take the issue of antibiotic resistance into account when making decisions about the approval of new animal drugs.

- Efforts are currently being made in the production system to reduce the likelihood that beef will be contaminated with *E. coli* O157:H7 or *Salmonella.* Nevertheless, adequate cooking and proper food handling techniques by consumers and food service personnel are the final and most important defense against these foodborne bacteria. Another bacterium, *Listeria monocytogenes*, is sometimes found in processed, refrigerated food products, including beef products (such as deli meats). This organism poses special hazards for pregnant women. It has been recommended that high risk individuals should thoroughly reheat processed meats, such as hot dogs and cold cuts, before eating them.

- Raw foods of animal origin, including beef and other meats, need to be handled carefully and cooked adequately for safety. Although intact pieces of beef (steaks and roasts) can be served medium rare (cooked to 145°F), ground beef should always be cooked thoroughly, to at least 160°F. Consumers should use a food thermometer to determine when foods are sufficiently cooked, rather than relying on color

changes. Precautions should be taken to ensure that drippings from raw meats, which may contain harmful bacteria, do not contaminate other foods.

- The process of irradiation has been approved as a means of enhancing the microbiological safety of meat and poultry, including beef. The increased use of this process would have important benefits for consumers, particularly in ensuring the safety of ground meats.

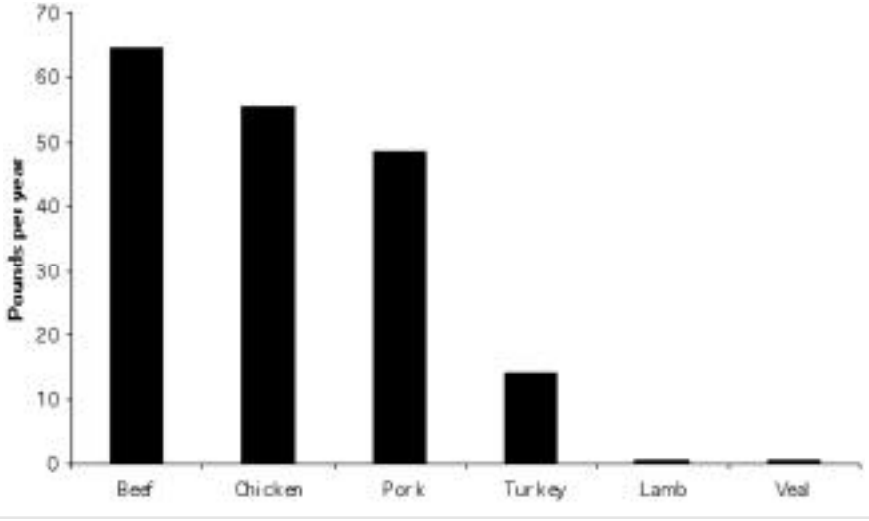
- Some countries outside North America are currently experiencing serious problems with two cattle diseases: bovine spongiform encephalopathy (BSE) and foot-and-mouth disease. BSE can be transmitted to humans in rare instances; foot-and-mouth disease is not a human health problem. Neither disease is present in the U.S., and precautions are being taken to keep both out of the country. U.S. consumers need not be concerned about these diseases except when traveling to affected parts of the world.

- Although producers of “natural” and “organic” beef products use production methods that differ from conventional ones, these types of beef have not been shown to differ from other beef in terms of nutrition or safety. Grass-fed beef differs somewhat from conventionally raised (grain-finished) beef in that its fatty acid profile is more desirable. However, the impact of this small difference on consumers’ overall diets is uncertain, and grass-fed beef does not offer any special advantages in terms of safety.

II. INTRODUCTION

Beef is America's most popular meat (see Figure 1). Per capita consumption of beef in the U.S. is about 65 pounds per year (1).*

Figure 1. **WHAT KINDS OF MEAT AND POULTRY DO AMERICANS EAT?**



Although most American consumers like beef, many are uncertain about its role in a healthful diet. Some people have the mistaken idea that beef and other red meats need to be avoided because of their saturated fat and cholesterol content. Others may be concerned about substances used in beef production or confused about the precautions that need to be taken to ensure the microbiological safety of beef and other animal products.

This report by the American Council on Science and Health (ACSH) presents an up-to-date summary of the scientific evidence on the role of beef in the diet, including both nutrition and food safety issues.

NUTRITION OVERVIEW: BEEF IN A HEALTHFUL DIET

Beef is a nutritious food. It contributes important nutrients to the diet, and it can be incorporated into a diet that meets current dietary guidelines for disease prevention. The following sections discuss the nutritional aspects of beef.

*Numbers in parentheses refer to the references listed at the end of this report.

III. Positive Contributions of Beef to the Diet

Minerals

Red meats — especially beef — are richer in some nutrients, particularly zinc and iron, than most of the other foods in the Meat, Poultry, Fish, Dry Beans, Eggs, and Nuts Group (Meat Group for short) of the Food Guide Pyramid.

Zinc is involved in many functions in the human body, including growth, maturation, immunity, wound healing, reproduction, and the senses of taste and smell. Zinc deficiency is a major problem worldwide, and even in the U.S., some people's intakes of this mineral may be too low. A comparison of 1994–98 national dietary survey data with the Recommended Dietary Allowances (RDAs) for zinc established in 2001 showed that at least 40% of adolescent girls and adult women are not meeting the zinc RDA (2). About 60 percent of men over the age of 70 also consume less than the recommended amount of zinc.

Getting enough zinc may be especially difficult for vegetarians because substances in plant foods, such as phytate, interfere with the body's ability to make use of zinc from food. The plant foods that are richest in zinc, such as legumes, whole grains, seeds, and nuts, are also high in phytate (3). The requirement for zinc intake may be as much as 50% higher for vegetarians than for other people (4).

Beef is one of the best food sources of zinc. A single 3-oz. serving of lean beef provides at least one-fourth of the Daily Value of this mineral. The zinc in beef and other foods of animal origin is more bioavailable than the zinc in plant foods (3). Because beef is high in zinc and is frequently consumed, it is the number one source of zinc in the U.S. diet, accounting for 26 and 22% of the total zinc intake of adults and children, respectively (5,6). Table 1 compares the zinc content of beef with that of other animal products from the Meat Group.

Iron is essential for transporting oxygen in the bloodstream; insufficient intakes can lead to iron-deficiency anemia and to impaired cognitive development in infants and young children. Adolescent girls and women of childbearing age have a greater need for iron than other people do because they lose iron every month during menstruation. They, along with young children, need plenty of good iron sources in their diets (8). Adult men and postmenopausal women, on the other hand, have lower needs for iron and rarely have difficulty meeting those needs. A comparison of national dietary survey data from 1994–1998 with the RDAs for iron established in 2001 showed that 25% of children age 5 and younger (both sexes), 60% of adolescent girls (ages

Table 1. **ZINC CONTENT OF BEEF AND OTHER ANIMAL PROTEIN FOODS**

Food	Zinc Content per Serving*	
	Milligrams	% of Daily Value
Beef, top sirloin steak	5.5	37
Ground beef, 95% lean/5%fat	5.5	37
Pork, top loin chop	2.0	13
Lamb, leg	3.2	22
Veal, loin	2.7	18
Chicken breast, skinless	0.9	6
Chicken thigh, skinless	2.2	15
Turkey breast, skinless	1.5	10
Tuna	0.6	4
Salmon	0.4	3
Eggs (2 large)	1.1	7

* 3 ounces unless otherwise specified

Data from reference 7.

12–19), and more than 80% of women aged 20–49 years were getting less than the recommended amount of iron from their diets (2).

Many grain products are fortified with iron. Because of fortification, ready-to-eat cereal and bread are the two top sources of iron in the U.S. diet; beef, which is naturally rich in iron, is the number three source, accounting for 9.4 and 7.7% of total iron intake among adults and children, respectively (5,6). Beef, however, is a more important contributor of iron than these numbers would seem to indicate. About half of the iron in beef is present in a form called “heme” iron, which is more readily absorbed by the body than the non-heme iron found in other foods, including iron-fortified foods.

Table 2 compares the iron content of beef with that of other animal products from the Meat Group.

Another important mineral in beef is selenium, which plays a role in the body’s antioxidant defense system. One serving of beef provides 24% of the Daily Value and about one half of the RDAfor this mineral (7,7a).

Other Nutrients

Beef, other red meats, poultry, seafood, and eggs are all rich in protein. Protein from animal sources is of higher quality than protein

Table 2. **Iron Content of Beef and other Animal Protein Foods**

Food	Iron Content per Serving*	
	Milligrams	% of Daily Value
Beef, top sirloin steak	2.9	16
Ground beef, 95% lean/5%fat	2.4	13
Pork, top loin chop	0.7	4
Lamb, leg	2.7	15
Veal, loin	0.7	4
Chicken breast, skinless	0.9	5
Chicken thigh, skinless	1.1	6
Turkey breast, skinless	1.3	7
Tuna	0.8	4
Salmon	0.3	2
Eggs (2 large)	1.2	7

* 3 ounces unless otherwise specified

Data from reference 7.

from plant sources.

Beef is also rich in B vitamins, particularly vitamin B_{12} (a vitamin only found in foods of animal origin), thiamin, riboflavin, niacin, and vitamin B_6. All of these are important nutrients.

Beef also provides choline. The human body manufactures its own choline, but it may not always be able to make enough to fully meet the body's needs (9). Therefore, dietary sources of choline may be necessary. Choline is also being investigated for possible beneficial effects on cognitive function (10). The National Academy of Sciences, which establishes the recommendations for nutrient intake in the U.S., has established recommended intake levels for choline (9). An intake of 550 mg/day is considered adequate for men, 425 mg/day for women. A three-ounce serving of ground beef contains 67.4 mg of choline (11), which is about 12% of the amount that a man needs daily and 16% of the amount needed by a woman.

Another substance of interest in beef is conjugated linoleic acid (CLA). CLA is a mixture of unsaturated fatty acids with an unusual chemical structure. Some CLAs are of the trans configuration (thus, they are trans fatty acids); some are not. In test tube and animal experiments, various forms of conjugated linoleic acid have been associated

with a variety of potentially beneficial effects, including inhibition of mammary carcinogenesis (12), inhibition of mutagenesis (13), increased muscle mass and decreased body fat (14), inhibition of the development of atherosclerosis (15,16), and increased bone density (17). It remains to be clearly demonstrated whether CLAs have these same beneficial effects in humans.

IV. BEEF IN THE HEART-HEALTHY DIET

The federal government's Dietary Guidelines for Americans and the dietary guidelines published by the American Heart Association (AHA) advise all healthy Americans (except those under the age of two years) to limit their intakes of saturated fat and cholesterol to reduce the risk of atherosclerosis and its consequences, including coronary heart disease (8,18,19).* People often interpret this recommendation to mean that they should eliminate red meat from their diets — or at least severely restrict it — and eat poultry or fish instead. In a survey conducted for a food industry trade group in 2000, 22% of consumers reported that they were eating less red meat and 9% reported that they were eating more poultry in an effort to make their diets healthier (20). However, dietary changes of this type may not be necessary — or even desirable.

Current Dietary Recommendations

Contrary to what many people think, the federal and AHA dietary recommendations do *not* call for the replacement of red meat with poultry and fish. Instead, they call for:

1. *Limiting intake of meat, poultry, and fish to moderate amounts.* The recommended intake of these foods is approximately two three-ounce servings per day. A three-ounce serving is about the size of a deck of cards.
2. *Cooking without added fat.* Broiling, boiling, and roasting are preferable to frying.
3. *Removing easily separated fat.* This means trimming all visible fat off red meat and removing poultry skin and the visible fat under the skin.

*In September 2002, the National Academy of Sciences (NAS) committee that establishes dietary reference intakes for the U.S. released a new report that made no quantitative recommendations on saturated fat and cholesterol intake but instead called for keeping consumption of these two food components as low as possible while maintaining a nutritionally adequate diet. The report also stated that total fat should account for between 20 and 35% of total calories; this is a change from previous advice that it should not exceed 30%. The new NAS recommendations have not yet been incorporated into the Food Guide Pyramid, the Dietary Guidelines for Americans, or the Daily Values used in food labeling.

4. *Choosing lean cuts of meat.* In the case of beef, the leanest cuts are those of "select" or "choice" (not "prime") grade, with the words "round" or "loin" in their names, such as eye round and top sirloin. "Lean" has a specific meaning when used in food labeling in the

Table 3. **EXAMPLES OF LEAN MEAT AND POULTRY***

	Total Fat (per 3 oz. serving)		Saturated Fat (per 3 oz. serving)		Cholesterol (per 3 oz. serving)	
	Grams	Percent of Daily Value	Grams	Percent of Daily Value	Milli-grams	Percent of Daily Value
Beef eye round	4.2	6	1.5	8	59	20
Beef bottom round	6.3	10	2.1	11	66	22
Beef top sirloin steak	6.1	9	2.4	12	76	25
Beef tenderloin steak	8.1	12	3.0	16	71	24
Ground beef, 95% lean	5.0	7	2.2	11	65	22
Pork top loin chop	6.6	10	2.3	12	68	23
Pork tenderloin	4.1	6	1.4	7	67	22
Lamb leg	6.6	10	2.3	12	76	25
Chicken breast, skinless	3.0	5	0.9	5	72	24
Chicken thigh, skinless	9.2	14	2.6	13	81	27
Turkey breast, skinless	0.6	1	0.2	1	61	20
Turkey, light and dark meat, skinless	2.2	3	0.7	4	83	28

* Veal was not included in this table because the cholesterol content of most cuts of veal is slightly higher than the limit the U.S. government allows for "lean" meat. However, the total fat and saturated fat content of lean veal is similar to that of the other red meats listed here. Data from reference 7.

U.S. (21). The term "lean" means that meat, poultry, or seafood contains less than 10 g of total fat, 4.5 g or less of saturated fat, and less than 95 mg of cholesterol per serving (usually, 3 oz.) and per 100 g (about 3.5 oz.).* Table 3 gives some examples of lean meat and poultry.

Producers of beef and other meats have responded to consumers' concerns about fat and cholesterol by raising leaner animals, trimming more outer fat from retail cuts of meat, and producing lower-fat ground and processed meat products (23). Lean beef and other lean red meats are now readily available to American consumers.

Because of changes in production methods, combined with changes in consumers' food choices, the proportions of total fat and saturated fat in the U.S. food supply contributed by meat/poultry/seafood decreased from 35 to 25% and from 37 to 26%, respectively, between 1970 and 1994, even though total consumption of meat/poultry/seafood actually *increased* slightly during the same period of time (23).

Several studies in people with high blood cholesterol levels have shown that a cholesterol-lowering diet that includes lean red meat is just as effective in reducing blood cholesterol levels as a similar diet that includes only lean "white" meats (poultry or fish) (24–28). The results of these studies make sense because the cholesterol-raising saturated fatty acids in meat are found primarily in the fatty portion of the meat. Since lean meats — of whatever color — contain relatively little fat, they would be expected to raise cholesterol levels less than higher-fat meats do.

Of course, this does not mean that it is acceptable to eat unlimited quantities of meat. As the data in Table 3 show, meats do contain saturated fat and cholesterol, and a person who eats these foods in excessive quantities could exceed the maximum intake levels of these food components called for by the Dietary Guidelines for Americans and the Food Guide Pyramid. In general, though, people don't eat too much meat. The Food Guide Pyramid calls for 2–3 servings per day from the Meat Group, for a total of 5–7 ounces of meat or its equivalent. A comparison of the Pyramid recommendations with national dietary survey findings from 1994–98 indicated that men eat an average of 6.7 ounces

*Ground beef is an exception. At the time of this writing, the U.S. Department of Agriculture had not yet established rules for the use of terms such as "lean" and "extra lean" on ground beef, although a proposed rule is currently in process (22). Until a final ruling is made, different supermarkets may choose to label these products in different ways. Consumers who are looking for the leanest ground beef should select products on the basis of the lean/fat percentages that appear on the label. For example, a product labeled 95% lean (5% fat) is preferable to one labeled 85% lean (15% fat). These percentages refer to the percent of fat or lean by weight, not the percent of calories.

of Meat Group foods daily, while women eat an average of 4.0 ounces (29). Thus, the typical man's consumption of foods from this group is within the recommended range, while the typical woman's intake is lower than recommended.

The Fats in Beef

Many people believe, incorrectly, that all of the fat in animal foods is saturated, while all of the fat in plant foods is unsaturated. Actually, no fat is 100% saturated or unsaturated; fats from both animal and vegetable sources include both types of fatty acids, in different proportions.

Figure 2. **FATTY ACIDS IN BEEF**

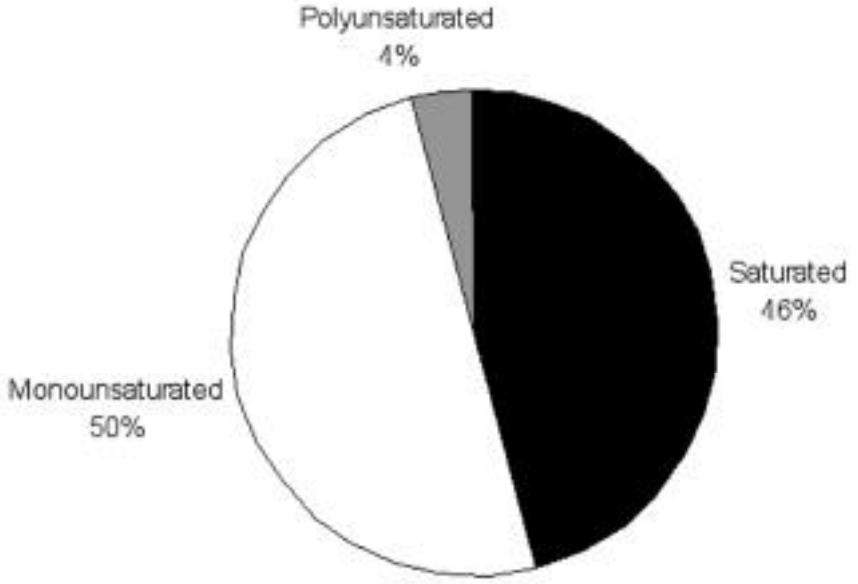
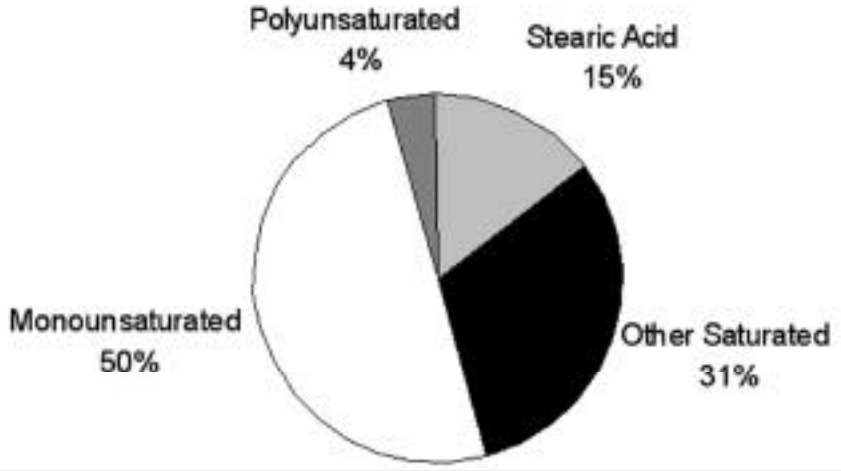


Figure 2 shows the percentages of the total fatty acids in beef that consist of saturated, monounsaturated, and polyunsaturated fatty acids. As the graph indicates, about half of the fat in beef is monounsaturated (the same sort of fat found in olive and canola oils); monounsaturated fatty acids do not have detrimental effects on cholesterol levels. Beef is the single largest source of monounsaturated fatty acids in the U.S. diet, accounting for 12.9% of total monounsaturated fat intake among U.S. adults (5). Even the saturated fatty acids in beef, which make up about 45% of its total fat content, are not all cholesterol-raising. As Figure 3 shows, about one-third of the saturated fatty acid content of beef consists of stearic acid, which neither raises nor lowers cholesterol (30).

Thus, of the total fatty acids in beef, only about one-third are cholesterol-raising fatty acids.

Figure 3. **FATTY ACIDS IN BEEF INCLUDING STEARIC ACID**



Recently, concerns have been raised about levels of trans fatty acids in the diet. Trans fatty acids are unsaturated but, because of their unusual chemical configuration, they raise levels of undesirable low-density lipoprotein (LDL) cholesterol and lower levels of desirable high-density lipoprotein (HDL) cholesterol. The National Academy of Sciences (NAS) recently recommended that consumption of these fatty acids should be kept as low as possible within the context of a nutritionally adequate diet (31) because they have an undesirable effect on cholesterol levels and no nutritional benefit. However, the NAS noted that completely eliminating trans fatty acids from a typical person's diet would make it very difficult to meet other nutritional guidelines.

The principal source of trans fatty acids in the U.S. diet is hydrogenated vegetable fats such as margarine, shortening, and foods that contain them. The trans fatty acids are produced during the hydrogenation process that transforms liquid oils into solid fats. Trans fatty acids are also produced naturally by ruminant animals and therefore are present in foods derived from those animals, including beef, lamb, and dairy products. However, unlike the trans fatty acids in hydrogenated vegetable fats, those in foods of animal origin are of little concern for two reasons:

1. As shown in Table 4, the amount of trans fatty acids in beef and other animal products is small in comparison with the amount in foods made with hydrogenated vegetable fats.

Table 4. **Examples of trans fatty acid contents of foods**

Food	Trans Fatty Acid Content*	
	Grams per 100 Grams of Food	% of Total Fat
Milk, whole	0.07–0.1	2.7–3.4
Ground beef, 79% lean/21% fat	0.7	4.5
White bread, commercially baked	0.1–1.4	9.2–25.5
Doughnuts, cake-type	0.5–6.9	3.8–29.2
Crackers, snack-type	5.9–8.4	25.2–39.7
Chocolate chip cookies	4.0–9.0	18.7–36.2
French fries, fast-food	1.2–5.2	11.3–34.1
Potato chips	0–10.6	0–29.7
Margarine, stick	13.0–25.1	20.1–31.9

* The values in this table were compiled by the U.S. Department of Agriculture (reference 7). In some instances, values for multiple samples or brands of the same type of product differed substantially, presumably reflecting differences in the type or amount of fat used in the recipe.

2. The proportions of various kinds of trans fatty acids found in beef and other foods from ruminant animals are not the same as those found in hydrogenated vegetable fats. Thus, they may not have the same cholesterol-raising effect as the trans fatty acids in hydrogenated vegetable fats do (32).

BEEF AND HEALTH

Concerns have been raised that some components of beef may be unhealthful. The following sections discuss the scientific evidence on whether beef, or substances produced during the cooking of beef, might be linked to cancer risk, and present current information on the use of animal health products (drugs) in beef production.

V. Is Meat Intake Related to Cancer Risk?

A substantial body of scientific evidence indicates that people's eating habits may influence their risk of some types of cancer. However, the relationship between dietary composition and cancer risk is very complex and therefore not clearly understood.The results of scientific studies of diet and cancer have often been inconsistent and inconclusive.

Inconsistent Findings

In 1997, the World Cancer Research Fund published a comprehensive review of the scientific evidence on diet and cancer, which ranked various links between specific foods and cancer as "convincing," "probable," or "possible." The most notable conclusion of this report was that there was "convincing" evidence that ample intakes of vegetables and fruits reduce the risk of a variety of cancers; that conclusion remains valid today. More tentatively, the report concluded that there was a "probable" link between high intake of red meat and increased risk of colon cancer, and "possible" links between red meat and breast and prostate cancers (33).

Since 1997, additional scientific studies have been completed, with inconsistent results. One recent expert review noted that the majority of additional studies of colon cancer published since 1997 have not associated meat intake with increased risk; thus, the weight of evidence pertaining to colon cancer may be weaker than the "probable" status it had in 1997 (34). A recent combined analysis of eight major breast cancer studies found no association between red meat intake and the risk of this type of cancer (35). In fact, there is little convincing evidence for an association of *any* specific dietary factors with breast cancer risk, although obesity may play a role (36). Uncertainties also remain with regard to prostate cancer; the evidence for a link with dietary factors is still considered tentative rather than conclusive (37).

Until more is learned about the relationship between cancer risk and specific dietary factors such as red meat intake, moderation rather than drastic dietary change is the best course of action. A well-balanced diet that includes reasonable amounts of foods from all the major food groups, without excessive intakes of saturated fat or total calories, is the most prudent choice.

Substances Produced by Cooking

Concerns have been raised about the presence of substances called heterocyclic amines in some cooked meat and poultry, including beef. Laboratory experiments have shown that heterocyclic amines can cause mutations in a cell's genetic material and that, like many other mutagens, heterocyclic amines can cause cancer when fed to laboratory animals in very high doses (38).

Heterocyclic amines are formed when components of proteins react with another substance, called creatine, when subjected to intense heating. This reaction is almost entirely limited to muscle foods (meats) because most other foods do not contain creatine. Heterocyclic amines

are produced in greatest quantities when foods are cooked at very high temperatures, particularly if they are cooked for long periods of time. The type of cooking is important; more heterocyclic amines are produced during pan-frying, broiling, or grilling than during stewing, boiling, or poaching (39). Roasting generates heterocyclic amines, but practically all of them end up in the drippings rather than the meat (40). Although fast food meats, including hamburgers and chicken, are usually grilled or fried, the levels of heterocyclic amines in these products are very low or not even detectable (41), presumably because of the short cooking times and moderate temperatures used.

Even though heterocyclic amines have been shown to be carcinogenic in animal experiments, their presence in food is not a cause for alarm. Foods contain trace amounts of numerous substances that can be shown to be carcinogenic when concentrated and fed to laboratory animals in very high doses. Most of these substances are naturally occurring food components, others are synthetic, and still others are produced by cooking. Many common foods contain these substances. For example, consider a lunch consisting of a hamburger on a bun, carrot sticks, an apple, and a cup of coffee. Or perhaps you would prefer a turkey sandwich, a lettuce and tomato salad, grapes, and tea. In either case, *every item in your meal would contain animal carcinogens.*[*] And some of these foods, along with many other foods, also contain anticarcinogenic substances.

Obviously, it would be unrealistic to attempt to remove all traces of carcinogens from the food supply. Current scientific knowledge indicates that these substances pose little or no risk when consumed in the trace amounts found in food. The kind of "zero tolerance" philosophy that's appropriate for proven human cancer-causing agents with no health benefits, such as cigarettes, is inappropriate for foods that happen to contain tiny amounts of naturally occurring or synthetic carcinogens.

Heterocyclic amines differ from other animal carcinogens found in small amounts in food in only one respect: because these substances are a product of cooking, exposure can be decreased by choosing cooking methods carefully. Table 5 gives some cooking suggestions based on publications of the National Cancer Institute and the beef industry. If you choose to implement these suggestions, please remember that *the most important consideration when cooking meat, poultry, or seafood is*

[*] For additional examples of foods that contain carcinogens and a more complete explanation of the science pertaining to this topic, see ACSH's Holiday Dinner Menu, available online at http://www.acsh.org/publications/booklets/menu99.html

Table 5. **TIPS FOR MINIMIZING HETEROCYCLIC AMINE FORMATION**

- Cook these foods to the correct temperatures, but do not overcook.
- When it's practical, choose cooking methods that don't generate heterocyclic amines, such as stewing, simmering, braising, poaching, or deep-frying.
- When roasting, don't make gravy from drippings.
- Don't char food.
- Cook over a low-to-moderate temperature heat source rather than using very high heat.
- When grilling, use small pieces of food rather than large ones, so that the food will cook more quickly.
- To decrease the heterocyclic amine content of grilled foods, partially cook the food in a microwave oven, pour off the drippings, and finish the cooking on the grill.*

* This technique is safe only if grilling *immediately* follows microwaving. It is not safe to partially cook food at one time and then finish cooking it later because bacteria can grow in the partially cooked food.

microbiological safety. Foods of animal origin must be cooked adequately in order to be safe. The very real risk of foodborne illness from inadequately or improperly cooked food far outweighs any theoretical health risk from heterocyclic amines.

Another type of mutagen that may be produced in meat by cooking is polycyclic aromatic hydrocarbons (PAHs). These substances are associated with burnt meat, especially if the meat is cooked at extremely high temperatures, and their production can be avoided by using more moderate temperatures and not allowing meat to char.

VI. USE OF DRUGS IN BEEF CATTLE

In the course of raising cattle and other animals, producers may use various animal health products, such as hormones and antibiotic drugs, to protect the animals'health, treat or control animal diseases, and promote nutritional efficiency and growth. As is the case with drugs used in humans, drugs used in animals must be approved by the Food and Drug Administration before they can be used in the U.S. The effect of a drug on the safety of human food derived from animals is taken into account when decisions are made about the acceptability of particular animal drugs.

Concerns have been raised about two classes of products used in food animal production — hormones and antibiotics. The following sections present up-to-date information on these topics.

Hormones

Three natural and three synthetic steroid hormones have been approved for use at very low concentrations to increase the rate of weight gain in beef cattle (42). These hormones are used because they allow cattle producers to raise animals on a smaller amount of feed, thus lowering the cost of beef for consumers. The hormones are administered in an implant in the ear, an inedible part of the animal.

There is no risk to consumers from eating meat from animals treated with natural hormones because the amounts of hormones left in the meat are very low in comparison with the amounts naturally present in the human body (42). For example, a three-ounce serving of beef from an animal treated with the natural hormone estradiol (estrogen) contains 1.9 nanograms of estrogen; the same amount of meat from an untreated animal would contain 1.2 nanograms. A nanogram is one billionth of a gram. Although the meat from the treated animal does contain more estrogen, the difference (less than one billionth of a gram) is negligible in comparison to the 136,000 nanograms produced each day in a man's body or the 480,000 nanograms produced daily in a woman's body (43). The total amount of estrogen in a serving of beef from a treated animal is also low in comparison with the amount naturally present in animal products such as eggs and milk or the amount of plant estrogens found in foods such as wheat germ and soybean oil, all of which are safe (44).

The situation with synthetic hormones is slightly different, since these hormones are not naturally produced. However, they too have been evaluated for safety. Before these hormones were approved, the Food and Drug Administration required extensive toxicological testing in animals to determine safe levels in edible tissues (42). The manufacturers were also required to demonstrate that the amount of hormone left in edible tissues after treatment was within the safety limit (42).

Antibiotics

Antibiotics are used in animals in much the same ways that they are used in humans — that is, to treat or prevent bacterial diseases. They may also be used in low doses to enhance growth and feed efficiency (the amount that an animal grows on a given amount of feed). Antibiotics may enhance feed efficiency at least in part by allowing the ani-

mal to devote more of the nutrients it consumes to growth, rather than using them to fuel its body's defenses against bacterial infections (45). When antibiotics are administered in low doses (for disease prevention rather than disease treatment), they are often given to entire groups of animals in their feed or water.

In beef cattle, antibiotics are used in low doses as a disease preventive during periods of stress when the animals are most likely to get sick, such as after being shipped for a long distance or after arrival at a feedlot, where they are exposed to many other animals (45). They are also used in higher doses to treat disease. The beef industry has developed guidelines based on the principle that antibiotic use should be limited to controlling and preventing disease as the primary goal (46).

The use of antibiotics in animal agriculture has both benefits and risks. There has been much public discussion about the potential risks, but people who do not work in agriculture may be less aware of the benefits. Because antibiotics help keep animals healthy, they can help to prevent the spread of diseases to other animals and to people. In addition, antibiotics have played a major role in making modern animal agriculture possible. Many experts say that the move toward more intensive animal production after World War II, which has allowed fewer people to produce greater quantities of food at lower cost, would not have been possible without antibiotics (45). In the absence of these drugs, producers would not have been able to raise large numbers of animals in relatively small areas because infection would have spread among the animals too easily.

In terms of risks, the first concern that may come to mind is the possibility that residues of antibiotics administered to animals might be present in meat derived from those animals. However, this is almost never a problem. A "withdrawal" period is required after the end of antibiotic use before it is legal to slaughter the animal (47). The purpose of the withdrawal time is to allow residues of the drug to exit from the animal's body. The USDA randomly samples cattle at slaughter and tests them for residues of antibiotics and other drugs. Data from this monitoring system show that residues that violate the standards are very rare (45,47).

A more significant concern is the fact that all uses of antibiotics can promote the development of antibiotic resistance among bacteria, which can make human diseases more difficult to treat. The use of antibiotics in human medicine — especially their inappropriate or incorrect use — plays a major role in promoting the development of resistance. The use of antibiotics in animal agriculture is also a contributing factor, but

experts disagree about its relative importance and about the changes that may need to be made in antibiotic use practices (45, 48–50). One reason why views differ is that gaps exist in the available data on how antibiotics are being used and on the connections between patterns of antibiotic use and the development of antibiotic resistance. Better monitoring and more research are needed. All experts agree, however, that antibiotics should be used judiciously, and only when truly necessary.

The Food and Drug Administration, which regulates the use of animal drugs, is changing the way in which it regulates antibiotics used in livestock to place more emphasis on the problem of antibiotic resistance (51). The new policies are likely to lead to the discontinuation of use in animals of certain antibiotics of special importance in human medicine (this has already happened with one antibiotic formerly used in poultry production). In addition, FDA now requires that effects on antibiotic resistance must be assessed when new antibiotics intended for use in food animals are evaluated (52).

MICROBIOLOGICAL FOOD SAFETY ISSUES

Contrary to popular belief, chemicals in food are not the major cause of foodborne illnesses. The real danger is disease-causing microorganisms. Some experts estimate that foodborne diseases caused by microorganisms account for roughly 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the U.S. each year (53).

The following sections of this report discuss food safety issues as they pertain to beef. First, the specific types of disease-causing microorganisms that may be found in beef will be discussed. Then, information on the safe handling of beef and other foods will be presented. Finally, the technology of irradiation — which has much to offer in terms of improving the microbiological safety of many foods, including beef — will be briefly summarized.

VII. Specific Disease-Causing Microorganisms

Different types of food are at risk of contamination with different microorganisms. In the case of beef, three organisms of special concern are *E. coli* O157:H7, *Salmonella*, and *Listeria monocytogenes.*

E. coli O157:H7

Escherichia coli, more commonly known as *E. coli,* is a type of bacterium commonly found in the intestines of warm-blooded animals, including livestock and humans. Most strains of this bacterium are harmless, but a few can cause illness.

E. coli O157:H7 is a strain of *E. coli* that can cause serious illness in people. It was first recognized in 1982 and is now considered one of the most important foodborne disease-causing microorganisms. Infection with this organism can cause severe bloody diarrhea. In 2–7% of all cases, the disease also leads to a complication called hemolytic uremic syndrome, which can cause kidney failure (54). This complication occurs most often in young children or elderly people. About 3–5% of all cases of hemolytic uremic syndrome are fatal, and about one-third of survivors develop long-term kidney problems (54). *E. coli* O157:H7 has been estimated to be responsible for roughly 73,000 illnesses, 2,100 hospitalizations, and 61 deaths in the U.S. each year (55).

Healthy cattle (and some other types of domestic and wild animals) sometimes carry *E. coli* O157:H7 in their intestinal tracts; the bacterium does not make the animals ill and therefore cannot be detected by ordinary inspection procedures at the slaughterhouse, which are designed to identify signs of disease in the carcasses. If an animal carries the bacterium, the meat may become contaminated during or after slaughter. The meat can still be eaten safely, provided that it is cooked thoroughly. Cooking meat to at least 160°F kills *E. coli*. However, if the meat is undercooked, or if bacteria from the meat are allowed to contaminate other foods, people can get sick.

Besides beef, other foods that have been associated with illness caused by *E. coli* O157:H7 include raw (unpasteurized) milk, unpasteurized apple juice and cider, alfalfa sprouts, and dry-cured sausage (54,56). The microorganisms can also be transmitted by contaminated water, including swimming pool water, and by person-to-person contact. Table 6 lists precautions that people should take to protect themselves and their families against this organism.

E. coli O157:H7 is one of the most difficult foodborne microorganisms to deal with, for several reasons. As mentioned earlier, the disease can be very severe, and ordinary visual inspection of food can't detect contamination. In addition, it takes only a few bacteria to cause disease, and this makes it difficult for contamination to be detected even by sophisticated microbiological testing methods. The fact that this microorganism has only been recognized as a cause of disease for 20 years adds to the problem. Scientists are playing catch-up on this one; they simply don't have as broad a base of knowledge of this organism as they do with long-recognized foodborne microorganisms such as *Salmonella*.

Despite the difficulties, though, much is being done to reduce the

Table 6. **HOW TO PROTECT AGAINST E. COLI O157:H7***

- Cook ground beef thoroughly, to 160°F or higher, and verify the temperature with a food thermometer.
- Take precautions while shopping and in your kitchen to prevent bacteria from raw meat from cross-contaminating cooked meat or other foods.
- If you are served a visibly undercooked hamburger in a restaurant, don't eat it.
- Drink only pasteurized milk, fruit juice, and cider.
- Wash fruits and vegetables thoroughly, especially those that will not be cooked.
- Avoid eating raw sprouts, such as alfalfa sprouts. This is especially important for children under age 5, immunocompromised persons, and the elderly.
- Drink municipal water that has been treated with chlorine or other effective disinfectants.
- Avoid swallowing water while swimming.
- Make sure that individuals with diarrhea (especially children) wash their hands after bowel movements, and that people who change diapers wash their hands afterwards. Anyone with diarrhea should not go swimming, share a bath with other people, or prepare food for others.

* Adapted from reference 54.

risks posed by *E. coli* O157:H7 in beef. In 1994, the U.S. Department of Agriculture (USDA) declared *E. coli* O157:H7 in ground beef to be an adulterant — meaning that any ground beef found to contain the organism must be further processed to kill the microorganism or be destroyed. The agency now tests random samples of ground beef for this organism. In the year 2001, 7009 samples were analyzed, and 59 were found to contain the bacterium (57). Many meat producers also test their products for this bacterium.

The meat industry is working to develop methods to decrease *E. coli* O157:H7 contamination in their products. In addition to modifying procedures to reduce the risk of contamination, meat packing plants have started to use special technologies, such as steam vacuuming and the use of hot water and organic acids, to decrease contamination on beef carcasses. The use of irradiation to kill disease-causing microor-

ganisms such as *E. coli* O157:H7 in meat has also been approved and is beginning to be used for ground beef by some retailers (including Wegman's, Dairy Queen, Omaha Steaks, and very recently, Giant — a major supermarket chain in the Washington, DC area). Irradiation is discussed in more detail below.

Although all of these steps are valuable, none of them guarantees that ground beef will be free from *E. coli* O157:H7. Steam vacuuming and similar technologies are not always 100% effective, and the fact that a sample from a particular batch of ground beef tested negative for the organism does not provide 100% assurance that other portions of the same batch are not contaminated. Therefore, it is extremely important for consumers to protect themselves by always cooking ground beef to at least 160°F and preventing raw meat from cross-contaminating other foods.

Salmonella

The bacterium *Salmonella* is one of the leading causes of foodborne illness. It causes diarrhea, fever, and abdominal cramps, usually lasting for 4–7 days (58). The disease, which is called salmonellosis, can be serious or even fatal in infants, the elderly, and those with impaired immune systems, but it is usually not serious in other people. Salmonellosis is usually a foodborne disease, but it can also be spread by contact with pets or other animals, especially reptiles, and by person-to-person contact. Fortunately, *Salmonella* bacteria in foods can be destroyed by cooking.

Salmonella is often found in raw meat and poultry — though less often in beef than in chicken or turkey. In recent U.S. Department of Agriculture tests, *Salmonella* was found in 29.2% of ground turkey samples, 15.7% of ground chicken samples, and 3.4% of ground beef samples (59).

The good news about *Salmonella* is that both the frequency of contamination of raw meat and poultry (59) and the number of cases of illness caused by this organism (60) have decreased substantially since the mid-1990s. These decreases are believed to be linked to the implementation of improved science-based inspection and a systematic hazard control program called HACCP (for Hazard Analysis and Critical Control Points) during the same time period (59).

Listeria monocytogenes

Listeria monocytogenes is commonly found in the soil, on plants, and elsewhere in the environment. In most people, exposure to this bac-

terium is unlikely to cause significant illness. However, if a pregnant woman becomes infected with *Listeria,* it can cause premature birth, miscarriage, or death or permanent harm to the fetus (61). Infants, elderly people, and those with weakened immune systems are also at risk of serious illness from *Listeria*.

Unlike most bacteria, *Listeria* can grow at refrigerator temperatures. Thus, illnesses caused by this bacterium are often linked to processed foods that are stored under refrigeration for substantial periods of time, such as delicatessen foods. There is no special link between *Listeria* and beef, but the bacterium may contaminate beef products just as it can contaminate other foods.

The U.S. government has advised women to take special precautions during pregnancy to prevent exposure to *Listeria.* With regard to meats, they recommend 1) not eating hot dogs, luncheon meats, or deli meats unless they are reheated until steaming hot; and 2) not eating refrigerated paté or meat spreads (61). These precautions apply equally to beef and other meats.

VIII. SAFE HANDLING OF BEEF AND OTHER FOODS

Everyone who handles food — farmers, processors, retailers, food service personnel, and consumers — shares the responsibility for keeping food safe from microbiological hazards. Although there is much that the food industry can do to help keep food safe, the consumer — the last step of the food chain — also plays a crucial role. Proper storage, handling, and preparation of food in the home are essential to food safety.

Raw foods of animal origin, including beef and other meats, need to be handled with special care. These foods may be contaminated with bacteria from the animals or the environment, often including contamination within the home. To prevent the bacteria from making people sick, it is essential to:

- Make sure that raw animal foods and their juices don't come into contact with and contaminate cooked animal products or other foods.
- Cook animal foods properly to ensure that any potentially harmful bacteria that may be present are destroyed.

In addition, because fresh meat is perishable, both in the raw state and the cooked state, it must be kept cold (40°F or lower) to minimize the growth of microorganisms.*

* For more information on this topic, see the ACSH report Eating Safely: Avoiding Foodborne Illness, available online at http://www.acsh.org/publications/booklets/eatsaf.pdf.

Table 7. **Four principles of food safety***

Clean

- Wash your hands before you handle food or food utensils and frequently during food preparation.
- Immediately after working with raw meat, poultry, seafood, or eggs, wash all utensils and surfaces that you used and wash your hands before going on to other tasks.
- Clean cutting boards thoroughly after each use. Replace them when they develop deep, hard-to-clean grooves.

Separate

- To prevent cross-contamination, keep raw meat, poultry, seafood, and eggs separate from other foods in your shopping cart, grocery bags, and refrigerator. Make sure that juices from these foods cannot drip onto other foods.
- Wash utensils that were used to handle raw meat, poultry, seafood, or eggs before re-using them for other foods. For example, the platter that you used to carry raw meat to the grill should be washed before being used to serve the cooked meat.

Cook

- Cook foods to a safe temperature. For beef, the minimum safe temperatures are as follows:
  - Medium-rare steaks and roasts: 145°F
  - Medium steaks and roasts: 160°F
  - Hamburgers, meat loaves, and other ground beef dishes: 160°F
  - Reheated leftovers: 165°F
  - Well-done steaks and roasts: 170°F
- Use a food thermometer every time you cook meat or poultry — even small pieces such as hamburgers or chicken breasts — to make sure that the food is cooked to a safe temperature. Never judge the doneness of food by its appearance.

* The four principles listed here are the basis for the U.S. government's educational programs on food safety. For more details on how to implement these principles, see the federal government's extensive collection of food safety information at www.foodsafety.gov.

Table 7. **FOUR PRINCIPLES OF FOOD SAFETY** (*continued*)

Chill

- Buy perishable foods such as fresh meat last when shopping, and refrigerate them immediately when you get home.
- Refrigerate perishable leftovers promptly, or freeze them if they will not be used within a day or two.
- Thaw frozen foods in the refrigerator or microwave, not at room temperature, and cook immediately after thawing.

Table 7 explains the four main principles of food safety — Clean, Separate, Cook, and Chill. Two points pertaining to the Cook step need special emphasis with regard to beef:

1. Unlike beef steaks and roasts, which can be served medium-rare, ground beef must always be cooked thoroughly. The bacteria on an intact (unground) piece of meat are almost always located on the meat's surface. Even if the piece of meat is cooked only to the medium-rare degree of doneness (145°F), the surface would receive enough heat to destroy bacteria. When meat is ground, however, surface bacteria can be transferred to the interior, which may not become hot enough to kill them if the meat is only cooked to medium-rare. Therefore, it is necessary for *all* of the ground meat to be cooked thoroughly. All dishes made with ground beef should be cooked until the center reaches at least 160°F to ensure the destruction of any bacteria that might have been distributed through the meat by the grinding process.

2. A food thermometer should always be used to determine whether meat, poultry, and other perishable foods have been cooked to a safe temperature. Traditionally, cooks judged the "doneness" of meat by color. For example, until a few years ago, people considered a hamburger that was brown on the inside to be safely cooked, while one that was pink on the inside was considered undercooked. However, recent research has shown that judging by color isn't reliable. In 1995, a study conducted at Kansas State University showed that ground beef may turn brown before it has reached a safe internal temperature (62). Subsequent research by the U.S. Department of Agriculture showed that more than one-fourth of all hamburgers turn brown before reaching 160°F (57). In other instances, hamburgers that have been cooked to 160°F or higher may retain some pink color in the center. The differences in hamburger color depend on many factors including length of storage of the meat before cooking, contact with air, the amount of pigment in the meat, and the meat's fat content (63).

Using a Food Thermometer

Since color is not a reliable indicator of whether beef or other meat or poultry is safe to eat, a food thermometer should be used *every* time these foods are prepared. Many types of food thermometers are available, and they all work well with large pieces of food. For small pieces of food, such as a hamburger or chicken breast, the most convenient type of thermometer to use is a digital instant-read thermometer. If the food is thick enough, it may be possible to insert the thermometer from the top. If not, or if you must use a dial instant-read thermometer, insert the thermometer from the side and make sure that it reaches the center of the food. It may be necessary to remove the food from the heat and transfer it to a clean plate before inserting the thermometer. If the thermometer shows that the food has not yet reached a safe temperature, continue cooking and wash the thermometer probe (the part that goes into the food) thoroughly before checking the food's temperature again.

Figure 4. **PROPER USE OF MEAT THERMOMETER ON HAMBURGERS**

Courtesy of the National Cattlemen's Beef Association & Cattlemen's Beef Board.

Freezing Beef

People sometimes buy beef in quantities greater than they can use right away, with the intention of freezing some of the meat for later use. Freezing is a safe way to store beef and other foods, provided that the

temperature of the freezer is maintained at 0°F or lower. Food that is stored constantly at 0°F or lower will stay safe indefinitely, but its quality will deteriorate over time. The recommended maximum frozen storage times for beef and other foods are based on quality rather than safety concerns. For specific information on how long you can freeze beef and other foods without an unacceptable decrease in quality, consult the U.S. Department of Agriculture's Web site at http://www.fsis.usda.gov/OA/pubs/freezing.htm and http://www.fsis.usda.gov/oa/pubs/focusbeef.htm.

IX. Irradiation

Food irradiation is the controlled treatment of foods with ionizing radiation, such as gamma rays or X-rays.* This process can be used to kill disease-causing bacteria. It can be particularly useful in situations where the bacteria may be distributed throughout the product, such as with ground meats. Most other techniques for killing bacteria either work only on the surface (e.g., steam vacuuming of carcasses at a meat packing plant) or dramatically change the food (e.g., cooking). Irradiation can kill bacteria in the *inside* of the meat without causing unacceptable changes in flavor or nutritive value and without cooking the food. Meat can be irradiated within its packaging, thus protecting it against recontamination until the package is opened by the user. In many ways, irradiation is much like the heat pasteurization process used on milk and fruit juices. Both processes kill disease-causing bacteria without causing major changes in the food product, and both are particularly useful in situations where good sanitation alone may not be able to ensure the microbiological safety of a raw food.

Irradiation is a safe and well-tested process (64–66). It does not make food radioactive or cause dangerous chemical changes in food; in fact, the chemical changes that result from irradiation are similar to those produced by more familiar processes such as cooking. The process can be conducted without posing hazards to the environment or to workers. The necessary safety precautions are already well understood because the same process has been used for many years to sterilize medical equipment and consumer products such as contact lens solutions. Irradiation has been approved for many years for various food uses, such as killing insects and bacteria in spices and destroying the causative agent of trichinosis in pork. However, it was not until 1997 that the Food and Drug Administration (FDA) approved irradiation to

*For more information on food irradiation, see the ACSH report Irradiated Foods, available online at http://www.acsh.org/publications/booklets/irradiated.pdf.

kill bacteria in beef and other red meats.

Consumer acceptance of food irradiation is already fairly high; in a large survey conducted in several parts of the U.S. in 1998–99, 49.8% of adult respondents reported that they were willing to buy irradiated meat and poultry (67). Other studies have indicated that acceptance is even higher after consumers are educated about the food safety benefits of irradiation (65).

The increased use of irradiation to treat meat and poultry would have important benefits for consumers in the U.S.

CONTEMPORARY ISSUES IN THE NEWS

The next sections of this report discuss two diseases of cattle that have caused serious problems in some other parts of the world but that are not present in the United States. Comprehensive efforts are being made to keep both diseases out of the U.S. and to minimize their impact if they ever do appear. American consumers do not need to take either of these diseases into account when making food choices (except when traveling to affected countries). The following discussions are included so that readers will be able to put news reports about these diseases into perspective and understand the precautionary measures that are being taken to keep these diseases out of the U.S.

X. BOVINE SPONGIFORM ENCEPHALOPATHY

Bovine spongiform encephalopathy (BSE), commonly known as mad cow disease, is a degenerative disease of the nervous system of cattle that results from infection with an unusual agent. Current research suggests the agent that causes BSE is a "prion," an abnormal protein with a novel mode of replication and transmission (68). Cattle may contract the disease from feed containing animal byproducts contaminated with this protein. It takes a long time — probably years — for infection with this agent to produce detectable symptoms. Prions are very hard to destroy; in comparison with viruses and bacteria, they are unusually resistant to heat and radiation. The abnormal prion is found almost exclusively in the brain, spinal cord, eyes, and lymphoid tissue of affected cattle; it is not present in muscle tissue (meat) unless this tissue has become contaminated with nervous system tissue, and it is not present in the animal's milk.

Diseases similar to BSE occur in other species. One of the best known is scrapie, a relatively common disease of sheep that does not threaten human health. There are also several human spongiform

encephalopathies. The best known of these is Creutzfeldt–Jakob disease (CJD), a fatal neurological disorder that occurs sporadically, affecting about one person in a million, almost always older people.

A major outbreak of BSE began in the United Kingdom in the mid-1980s. By the year 2000, approximately 200,000 cases of BSE had occurred in British cattle (69); the epidemic peaked in the early 1990s, and the number of cases decreased sharply thereafter due to the imposition of stringent control measures including the destruction of millions of suspect animals. Cases of BSE have occurred in other countries as well, primarily in Europe. However, it is important to emphasize that an active surveillance program in the U.S. has not detected any cases here (70).

Scientists are not certain of the origin of BSE in Britain, but they do know that once it appeared, it was spread by the practice of including protein nutritional supplements derived from cattle in the feed given to young calves. An ordinary viral or bacterial disease would not spread in this way, since the disease agent would be killed by the heat used in processing the animal feed supplement. But prions can survive.

At first, it was thought likely that BSE was only a threat to cattle, just as scrapie is only a threat to sheep. However, in the mid-1990s, a few cases began to be reported in Britain of a fatal human disease that resembled CJD, but with some unusual features: the initial symptoms were different, the course of the disease was slower, and most of the patients were atypically young for CJD. As of April 2002, about 125 cases of this disease, now called variant CJD (vCJD) or new variant CJD (nvCJD), had been reported worldwide (71), all in people who had lived in countries where BSE exists, primarily the U.K. One probable case has been reported in the U.S., in a British citizen who was living in Florida at the time of diagnosis (72), and one case has been reported in Canada, in an individual who had spent extensive time in the U.K. at the height of the BSE epidemic (73). Both patients are believed to have contracted the disease in the U.K. There is strong epidemiologic and laboratory evidence linking vCJD with BSE (69). It is now believed that the two diseases are caused by the same agent.

Experts believe that most of the people who have contracted vCJD acquired the disease by consuming cattle products that contained central nervous system tissue contaminated with the BSE agent (71). Exposure probably occurred through consumption of ground or processed meat products that inadvertently contained small amounts of nervous system tissue.

The U.S. government has taken multiple precautions to keep BSE out of the U.S. Three of the most important precautions are the following:

1. The USDAhas placed a ban on importation of live cattle and other ruminant animals and most products made from these animals from countries where BSE is present and from all of Europe. This restriction was imposed in 1989 for the U.K. and later for some other countries (74). No beef has been imported into the U.S. from the U.K. since 1985.
2. The USDA has a surveillance program that looks for BSE in U.S. cattle by testing those that show abnormal behavior or neurological symptoms, those that cannot walk (so-called downer cattle), and a random sample of older animals (older cattle have the highest risk of BSE). This program has been in place since 1990, and no cases of BSE have been found (74).
3. There is an FDA regulation that prohibits the inclusion of protein feed supplements derived from cattle, other ruminant animals, and most mammals in feed for cattle or other ruminants. This "feed ban," which was put into effect in 1997 (74), is designed to minimize the spread of BSE if the disease is ever imported into the U.S.

To evaluate the effectiveness of these and other BSE prevention measures, the U.S. Department of Agriculture asked researchers from the Center for Risk Analysis at Harvard University to evaluate the consequences of the introduction of BSE into the U.S. by various means. On the basis of mathematical simulations, the Harvard researchers concluded that "the U.S. is highly resistant to any introduction of BSE or a similar disease. BSE is extremely unlikely to become established in the U.S." (75) The report noted, however, that the "feed ban," that is, the prohibition on feeding tissues from ruminants to ruminants, is crucial in preventing the spread of BSE if the disease is ever introduced into this country. Some instances of noncompliance with the feed ban or inadequate recordkeeping have been reported (76, 77). The federal government is now stepping up its efforts to eliminate such situations through increased education and enforcement (78). Various segments of industry are also working to ensure that correct feeding practices are followed. For example, some large buyers of beef (notably, McDonald's (79)) now require their suppliers to document the feeding history of their animals.

Because BSE is not a problem in the U.S., American consumers need not take any special precautions to avoid it except during foreign travel. Travelers to regions with BSE may wish to consult the Centers for Disease Control and Prevention's Web site at http://www.cdc.gov/travel/ for the latest guidance on precautions to be taken when visiting those areas. At the time that this report was prepared (November 2002), the CDC was giving travelers the following advice (80):

To reduce the possible current risk of acquiring nvCJD from food, travelers to Europe should be advised to consider either 1) avoiding beef and beef products altogether or 2) selecting beef or beef products, such as solid pieces of muscle meat (versus brains or beef products such as burgers and sausages), that might have a reduced opportunity for contamination with tissues that might harbor the BSE agent. Milk and milk products from cows are not believed to pose any risk for transmitting the BSE agent.

XI. Foot and Mouth Disease

Foot and mouth disease is a viral infection that can affect many types of animals, including cattle. It does not cause human illness, but people can carry the virus on their bodies, clothing, shoes, or personal items and thereby spread it to susceptible animals. The disease is extremely contagious and can quickly spread through and devastate a herd. Although there hasn't been a case of foot and mouth disease in the U.S. since 1929 (81), this disease has been present in some South American countries for many years and outbreaks occur regularly in several other parts of the world. Thus, there is great concern about the possibility that the disease could be imported into this country. Travelers returning to the U.S. from countries where foot and mouth disease is prevalent are asked to declare all food and agricultural items in their possession and report any contact they may have had with farms in foreign countries so that appropriate precautions can be taken to minimize the risk of bringing the virus into the country (82). Although these precautions may not be convenient, they are extremely important. Importation of foot and mouth disease into the U.S. could have devastating effects on American livestock and wildlife.

SPECIALTY BEEF PRODUCTS

Some beef producers market beef that is labeled "natural," "organic," or "grass-fed." Others produce beef products that conform to the Jewish (kosher) or Islamic (halal) dietary laws. Consumers sometimes wonder how these products differ from conventionally produced beef and whether they are superior to other beef products in terms of nutrition or safety.

The term "natural" has no official legal definition, but when applied to most foods, it usually means that the food has been minimally processed and contains no artificial flavors, colors, or preservatives. This description, of course, would apply to all conventionally produced fresh meats. To determine exactly what a producer of "natural" beef means by the use of the term "natural," consumers need to read the

product label or consult the producer of the meat.

Unlike "natural," the term "organic" does have an official definition. As of October 2002, the U.S. Department of Agriculture has established standards that food labeled "organic" must meet (83). In a booklet for consumers, the USDA explains the meaning of organic as follows:

> Organic meat, poultry, eggs, and dairy products come from animals that are given no antibiotics or growth hormones. Organic food is produced without using most conventional pesticides, petroleum-based fertilizers, or sewage sludge-based fertilizers; bio-engineering; or ionizing radiation. Before a product can be labeled "organic," a Government-approved certifier inspects the farm where the food is grown to make sure the farmer is following all the rules necessary to meet USDA organic standards. Companies that handle or process organic food before it gets to your local supermarket or restaurant must be certified, too. (83)

Thus, beef labeled "organic" has been produced in ways that differ from the conventional ones in several respects. However, this does not necessarily imply that it is a safer or more nutritious product. In fact, as the USDA explicitly states:

> USDA makes no claims that organically produced food is safer or more nutritious than conventionally produced food. Organic food differs from conventionally produced food in the way it is grown, handled, and processed. (83)

Consumers sometimes think that beef labeled "organic" or "natural" is better than conventionally produced beef in that it is less likely to contain illegal residues of various chemicals. However, the scientific evidence indicates that the products do not differ in this regard. In two studies conducted at Colorado State University, large numbers of samples of "natural," "organic," and conventionally produced beef (both muscle meat and organ meats) were tested for a variety of drugs used in beef production, pesticides, and other contaminants. In the first study, no violative residues of any kind were found in any of the samples (84). In the second study, no violative drug residues were found. However, a small number of the samples contained residues of pesticides in excess of government standards (85). These residues were found in 0.002% of conventionally produced samples, 0.004% of "natural" samples, and 0.004% of "organic" samples, and all of the affected samples were liver, not muscle meat.

Another specialty beef product currently on the market is "grass-fed" beef. Grass-fed beef comes from animals that were grazed in pastures throughout their lives. This differs from conventional practice, in which beef cattle are raised in pastures for part of their lives but then transferred to feedlots and fed a grain-based diet for the last months before slaughter.

Unlike "natural" and "organic" beef products, which have not been shown to differ from conventional beef except in their method of production, grass-fed beef does differ somewhat in composition from conventional beef because of the difference in the animals' diets. Research has shown that the proportion of saturated fatty acids in grass-fed beef is somewhat lower and the proportions of conjugated linoleic acids (CLA) and omega-3 polyunsaturated fatty acids (the desirable fatty acids found most prominently in fatty fish) are somewhat higher than in conventionally produced beef (86,87). Whether this difference translates to a truly meaningful benefit in the context of a varied diet has not been established.

Some publications and web sites that promote the use of organic or grass-fed beef suggest that these products may have advantages in terms of microbiological safety. A few even imply that some of the food safety precautions usually taken in the preparation of beef, such as always cooking ground beef to at least 160°F, may not be necessary with these products. This is incorrect.* There is no scientific evidence demonstrating that organic or grass-fed beef is necessarily free from bacterial contamination. Consumers should handle and prepare all types of beef carefully, always cooking them to the recommended temperatures and taking precautions to prevent cross-contamination of other foods.

Consumers often perceive kosher or halal meats as being of higher quality than other meats because their production is closely supervised by religious authorities. It's important to remember, however, that the criteria for acceptability in terms of religious standards do not necessarily relate directly to the safety or nutritional value of a product. Kosher beef has fewer microorganisms on the surface than regular beef does because it undergoes a soaking and salting process that reduces bacterial numbers (88). Whether this translates into a food safety advantage has not been established. Jewish consumers do have one well-established food safety advantage, though. It is Jewish custom (although the religious dietary laws do not require it) to cook all meats thoroughly.

*Similarly, some web sites suggest that it is safe to drink unpasteurized milk from organically raised or grass-fed dairy cattle. This also has no scientific basis. No one should drink raw milk, regardless of how the milk was produced.

Adequate cooking is one of the most important steps in ensuring food safety.

CONCLUSION

The American public's taste for beef can be — and usually is — good news from the standpoint of health. Beef contributes important nutrients to the diet, and lean beef, in moderate servings, fits well into heart-healthy eating plans. As is true of all foods, beef must be handled and prepared correctly in order to ensure its microbiological safety. If appropriate precautions are not followed, consumers face a risk of food-borne illness caused by *E. coli*, *Salmonella*, or other bacteria. Most of the other "hazards" attibuted to beef, however, are merely theoretical concerns that are based on tenuous scientific evidence at most (e.g., traces of animal carcinogens produced by cooking, drug residues) or reflect problems that do not exist in the United States (e.g., bovine spongiform encephalopathy).

REFERENCES

1. Statistics published by the National Cattlemen's Beef Association (www.beef.org), based on year 2001 figures for boneless edible consumption.
2. Analysis of the 1994-96, 1998 Continuing Survey of Food Intake by Individuals (CSFII), Final Report prepared by Bermudez Consultenos International for the National Cattlemen's Beef Association, August 2002.
3. Hunt JR, Moving toward a plant-based diet: are iron and zinc at risk? *Nutrition Reviews* 2002;60:127–134.
4. Institute of Medicine, National Academy of Sciences, *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*, National Academy Press, Washington, DC, 2001.
5. Subar AF, Krebs-Smith SM, Cook A, Kahle LL, Dietary sources of nutrients among US adults, 1989 to 1991, *Journal of the American Dietetic Association* 1998;98:537–547.
6. Subar AF, Krebs-Smith SM, Cook A, Kahle LL, Dietary sources of nutrients among US children, 1989–1991, *Pediatrics* 1998;102:913–923.
7. U.S. Department of Agriculture, USDA Nutrient Database for Standard Reference, release 15, 2002. Available online at http://www.nal.usda.gov/fnic/foodcomp/Data/index.html

7a. Institute of Medicine, National Academy of Sciences, *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*, National Academy Press, Washington, DC, 2000.

8. U.S. Departments of Agriculture and Health and Human Services, *Nutrition and Your Health: Dietary Guidelines for Americans*, 5th ed., 2000, available online at http://www.usda.gov/cnpp/DietGd.pdf
9. 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.

10. Hasler CM, The changing face of functional foods, *Journal of the American College of Nutrition* 2000;19:499S–506S.
11. Zeisel S, Department of Nutrition, University of North Carolina at Chapel Hill, personal communication, October 28, 2002.
12. Belury MA, Conjugated dienoic linoleate: a polyunsaturated fatty acid with unique chemoprotective properties, *Nutrition Reviews* 1995;53:83–89.
13. Ha YL, Grimm NK, Pariza MW, Anticarcinogens from fried ground beef: heat-altered derivatives of linoleic acid, *Carcinogenesis* 1987;8:1881–1887.
14. Park Y, Storkson JM, Albright KJ, Liu W, Pariza MW, Evidence that the trans-10, cis-12 isomer of conjugated linoleic acid induces body composition changes in mice, *Lipids* 1999;34:235–241.
15. Belury MA, Dietary conjugated linoleic acid in health: physiological effects and mechanisms of action, *Annual Review of Nutrition* 2002;22:505-531.
16. Kritchevsky D, Tepper SA, Wright S, Tso P, Czarnecki SK, Influence of conjugated linoleic acid (CLA) on establishment and progression of atherosclerosis in rabbits, *Journal of the American College of Nutrition* 2000;19:472S-477S.
17. Watkins BA, Yong L, Feifert MF, Bone metabolism and dietary conjugated linoleic acid, In: *Advances in Conjugated Linoleic Acid Research*, Vol. 1, MP Yuraweca, MM Mossoba, JKG Kramer, MW Pariza, GJ Nelson (eds), AOCS Press, Champaign, IL, pp. 253–275, 1999.
18. 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.
19. 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
20. Data from the Food Marketing Institute's survey *Trends — Consumer Attitudes and the Supermarket*, 2000. Available

online at http://www.fmi.org/facts_figs/Nutrition.pdf
21. Food and Drug Administration, The Food Label, FDA Backgrounder, May 1999, available online at http://www.cfsan.fda.gov/~dms/fdnewlab.html
22. U.S. Department of Agriculture, Food Safety and Inspection Service, Nutrition Labeling of Ground or Chopped Meat and Poultry Products and Single-Ingredient Products; Proposed Rule, *Federal Register* 66(12):4969–4999, Jan. 18, 2001.
23. Putnam J, Gerrior S, Trends in the U.S. food supply, 1970–97, Chapter 7 in Frazao E, Ed., *America's Eating Habits: Changes and Consequences,* U.S. Department of Agriculture, Economic Research Report, Agriculture Information Bulletin No. 750, Washington, DC, 1999. Available online at http://ers.usda.gov/publications/aib750/aib750g.pdf
24. Davidson MH, Hunninghake D, Maki KC, Kwiterovich PO Jr, Kafonek S, Comparison of the effects of lean red meat vs. lean white meat on serum lipid levels among free-living persons with hypercholesterolemia, *Archives of Internal Medicine* 1999;159:1331–1338.
25. Hunninghake DB, Maki KC, Kwiterovich PO Jr, Davidson MH, Dicklin MR, Kafonek SD, Incorporation of lean red meat into a National Cholesterol Education Program Step I diet: a long-term, randomized clinical trial in free-living persons with hypercholesterolemia, *Journal of the American College of Nutrition* 2000;19:351–360.
26. Scott LW, Dunn LK, Pownall HJ, Brauchi DJ, McMann MC, Herd JA, Harris KB, Savell JW, Cross HR, Gotto AM Jr, Effects of beef and chicken consumption on plasma lipid levels in hypercholesterolemic men, *Archives of Internal Medicine* 1994;154:1261–1267.
27. Scott L, Kimball K, Wittels EH, et al., Effects of a lean beef diet and of a chicken and fish diet on lipoprotein profiles, *Nutrition, Metabolism, and Cardiovascular Diseases* 1991;1:25–30.
28. Weisman H, A comparison of the effects of eating beef, versus chicken and fish, as part of a no added fat and no starch

diet on cholesterol, LDL and weight levels, *Diabetes* 2000;49:A271.
29. USDA/ARS (U.S. Department of Agriculture, Agricultural Research Service). 2000. Pyramid Servings Intakes by U.S. Children and Adults, 1994-1996, 1998. *Online.* ARS Community Nutrition Research Group Web site at http://www.barc.usda.gov/bhnrc/cnrg
30. Grundy SM, Influence of stearic acid on cholesterol metabolism relative to other long-chain fatty acids, *American Journal of Clinical Nutrition* 1994;60:986S–990S.
31. Institute of Medicine, *Letter Report on Dietary Reference Intakes for* Trans *Fatty Acids*, National Academy Press, Washington, DC, 2002.
32. Aro A, Complexity of issue of dietary trans fatty acids, *Lancet* 2001;357:732–733.
33. World Cancer Research Fund and American Institute for Cancer Research, *Food, Nutrition and the Prevention of Cancer: A Global Perspective*, WCRF/AICR, Washington, DC, 1997.
34. Truswell AS, Meat consumption and cancer of the large bowel, *European Journal of Clinical Nutrition* 2002;56:S19–S24,
35. Missmer SA, Smith-Warner SA, Spiegelman D, et al., Meat and dairy food consumption and breast cancer: a pooled analysis of cohort studies, *International Journal of Epidemiology* 2002;31:78–85.
36. American Council on Science and Health, *Risk Factors for Breast Cancer,* ACSH, New York, 2000. Available online at http://www.acsh.org/publications/booklets/risk_factors.pdf
37. American Council on Science and Health, *Risk Factors for Prostate Cancer,* ACSH, New York, 2002. Available online at http://www.acsh.org/publications/booklets/prostate2002.pdf
38. Eisenbrand G, Tang W, Food-borne heterocyclic amines. Chemistry, formation, occurrence and biological activities. A literature review, *Toxicology* 1993;84:1–82.
39. National Cancer Institute, Heterocyclic Amines in Cooked Meats, fact sheet, 1996. Available online at

http://cis.nci.nih.gov/fact/3_25.htm
40. Sinha R, Rothman N, Salmon CP, Knize MG, Brown ED, Swanson CA, Rhodes D, Rossi S, Felton JS, Levander OA, Heterocyclic amine content in beef cooked by different methods to varying degrees of doneness and gravy made from meat drippings, *Food and Chemical Toxicology* 1998;36:279–287.
41. Knize MG, Sinha R, Rothman N, Brown ED, Salmon CP, Levander OA, Cunningham PL, Felton JS, Heterocyclic amine content in fast-food meat products, *Food and Chemical Toxicology* 1995;33:545–551.
42. Food and Drug Administration, Center for Veterinary Medicine, The use of steroid hormones for growth promotion in food-producing animals, information for consumers, July 2002. Available online at www.fda.gov/cvm/index/consumer/hormones.htm
43. Smith GC, Colorado State University, Meat safety, paper presented at the Minnesota Dietary Association State Conference, March 1999 and available online at www.ansci.colostate.edu/ran/meat/meatsafety.htm
44. U.S. Department of Agriculture, Foreign Agricultural Service, A primer on beef hormones, February 1999, available online at www.fas.usda.gov/itp/policy/hormone2.html
45. National Research Council, *The Use of Drugs in Food Animals. Benefits and Risks*, National Academy Press, Washington, D.C., 1999.
46. National Cattlemen's Beef Association, A Producers Guide to Judicious Use of Antimicrobials in Cattle, 2001, available online at www.beef.org/documents//NCBA_JUAG_August_2001_color.doc
47. Food Safety and Inspection Service, USDA, Focus on Beef … from Farm to Table, consumer information, June 2002, available online at http://www.fsis.usda.gov/oa/pubs/focusbeef.htm
48. Alliance for the Prudent Use of Antibiotics, The need to improve antimicrobial use in agriculture. Ecological and human health consequences, *Clinical Infectious Diseases*

2002;34(suppl 3):S71–S144.
49. Council for Agricultural Science and Technology (CAST), Comment on Subtherapeutic Use of Antibiotics in Animal Agriculture, submitted to the U.S. Food and Drug Administration, April 1999, available online at http://www.cast-science.org/9904anti.htm
50. Gorbach SL, Antimicrobial use in animal feed — time to stop, *New England Journal of Medicine* 2001;16:1202–1203.
51. Food and Drug Administration, Center for Veterinary Medicine, Antibiotic (antimicrobial) resistance and animals, information for consumers, October 2001. Available online at www.fda.gov/cvm/index/consumer/ar2001.htm
52. Food and Drug Administration, FDA proposes new industry draft guidance for evaluating the safety of antimicrobial new animal drugs, talk paper issued September 12, 2002. Available online at http://www.fda.gov/bbs/topics/ANSWERS/2002/ANS01162.html
53. Mead PS, Slutsker L, Dietz V, McCaig LF, Breesee JS, Shapiro C, Griffin PM, Tauxe RV, Food-related illness and death in the United States, *Emerging Infectious Diseases* 1999;5:607–625.
54. Centers for Disease Control and Prevention, *Escherichia coli* O157:H7, disease information fact sheet, June 2001, available online at http://www.cdc.gov/ncidod/dbmd/diseaseinfo/escherichia-coli_g.htm
55. Centers for Disease Control and Prevention, *Escherichia coli* O157:H7, technical information fact sheet, December 2001. Available online at http://www.cdc.gov/ncidod/dbmd/disease-info/escherichiacoli_t.htm
56. Food Safety and Inspection Service, USDA, Focus on Ground Beef, food safety focus fact sheet, September 2001. Available online at http://www.fsis.usda.gov/OA/pubs/focus-gb.htm
57. Lyon BG, Berry BW, Soderberg D, Clinch N, Visual color and doneness indicators and the incidence of premature

brown color in beef patties cooked to four end point temperatures, *Journal of Food Protection* 2000;63:1389–1398.
58. Centers for Disease Control and Prevention, Salmonellosis, disease information fact sheet, June 2001, available online at http://www.cdc.gov/ncidod/dbmd/diseaseinfo/salmonellosis_g.htm
59. U.S. Department of Agriculture, USDA data show a reduction of *Salmonella* in raw meat and poultry, news release, April 18, 2002. Available online at http://www.usda.gov/news/releases/2002/04/0154.htm
60. 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.
61. Food Safety and Inspection Service, U.S. Department of Agriculture, Listeriosis and pregnancy: What is your risk? Safe food handling for a healthy pregnancy. Available online at http://www.fsis.usda.gov/OA/pubs/lm_tearsheet.htm
62. Hunt MC, Warren KE, Mague MA, Kropf DH, Waldner CL, Stroda SL, Kastner CL, Cooked ground beef color is unreliable indicator of maximum internal temperature, paper presented to the American Chemical Society, April 6, 1995.
63. Food Safety and Inspection Service, USDA, Color of Cooked Ground Beef as It Relates to Doneness, technical information summary, 2000. Available online at http://www.fsis.usda.gov/OA/pubs/colortech.htm
64. Wood OB, Bruhn CM, Food irradiation — position of ADA, *Journal of the American Dietetic Association* 2000;100:246–253.
65. Olson DG, Irradiation of food (a scientific status summary of the Institute of Food Technologists), *Food Technology* 1998;52(1):56–62.
66. American Council on Science and Health, *Irradiated Foods*, 4th ed., New York, ACSH, 1996. Available online at http://www.acsh.org/publications/booklets/irradiated.pdf
67. Frenzen PD, DeBess EE, Hechemy KE, Kassenborg H, Kennedy M, McCombs K, McNees A, and the FoodNet

Working Group, Consumer acceptance of irradiated meat and poultry in the United States, *Journal of Food Protection* 2001;64:2020–2026.

68. Food and Drug Administration, BSE: Background, Current Concerns, and U.S. Response, backgrounder dated March 1, 2001. Available online at http://www.fda.gov/opacom/backgrounders/bse.html
69. Brown P, Will RG, Bradly R, Asher DM, Detwiler L, Bovine spongiform encephalopathy and variant Creutzfeldt–Jakob disease: background, evolution, and current concerns, *Emerging Infectious Diseases* 2001;7:6–16.
70. Centers for Disease Control and Prevention, Questions and answers regarding bovine spongiform encephalopathy (BSE) and Creutzfeldt–Jakob disease (CJD), fact sheet. Available online at http://www.cdc.gov/ncidod/diseases/cjd/bse_cjd_qa.htm
71. Centers for Disease Control and Prevention, New variant CJD: fact sheet, April 2002, available online at http://www.cdc.gov/ncidod/diseases/cjd/cjd_fact_sheet.htm
72. Centers for Disease Control and Prevention, Probable variant Creutzfeldt-Jakob disease in a U.S. Resident – Florida, 2002, *Morbidity and Mortality Weekly Report*, 51:927-929, October 18, 2002. Available online at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5141a3.htm
73. Health Canada, First Canadian Case of Variant Creutzfeldt–Jakob Disease (Variant CJD), information bulletin, August 2002, available online at www.hc-sc.gc.ca/english/diseases/cjd/index.html
74. U.S. Department of Agriculture, Government actions to prevent bovine spongiform encephalopathy in the United States, backgrounder, November 2001.
75. Cohen JT, Duggar K, Gray GM, Kreindel S, Abdelrahman H, HabteMariam T, Oryang D, Tameru B, *Evaluation of the Potential for Bovine Spongiform Encephalopathy in the United States,* Harvard Center for Risk Analysis, November 2001, available online at http://www.aphis.usda.gov/oa/bse/mainreporttext.pdf

76. Food and Drug Administration, Center for Veterinary Medicine, Ruminant feed (BSE) enforcement activities, July 6, 2001, available online at http://www.fda.gov/cvm/index/updates/bse72001.htm
77. General Accounting Office, *Mad Cow Disease. Improvements in the Animal Feed Ban and Other Regulatory Areas Would Strengthen U.S. Prevention Efforts,* January 2002. Available online at http://www.gao.gov/new.items/d02183.pdf
78. U.S. Departments of Agriculture and Health and Human Services, Administration continues to strengthen BSE protection systems, news release, February 26, 2002, available online at http://www.usda.gov/news/releases/2002/02/0070.htm
79. McDonald's corporate Web site, http://www.mcdonalds.com/corporate/social/marketplace/marketplace.html
80. Centers for Disease Control and Prevention, Bovine spongiform encephalopathy and new variant Creutzfeldt–Jakob disease, from *Health Information for International Travel, 2001–2002,* updated July 24, 2002, available online at http://www.cdc.gov/travel/madcow.htm
81. Centers for Disease Control and Prevention, Foot-and-mouth disease, May 30, 2002, available online at http://www.cdc.gov/foot_mouth.htm
82. U.S. Department of Agriculture, Foot-and-mouth disease, undated Web page, http://www.cdc.gov/foot_mouth.htm
83. U.S. Department of Agriculture, Organic food standards and labels: the facts, undated consumer brochure, available online at www.ams.usda.gov/nop/consumerbrochure.htm
84. Smith GC, Sofos JN, Aaronson MJ, Morgan JB, Tatum JD, Schmidt GR, Incidence of pesticide residues and residues of chemicals specified for testing in U.S. beef by the European Community, *Journal of Muscle Foods* 1994;5:271–284.
85. Smith GC, Heaton KL, Sofos JN, Tatum JD, Aaronson MJ, Clayton RP, Residues of antibiotics, hormones and pesticides in conventional, natural and organic beef, *Journal of Muscle Foods* 1997;8:157–172.
86. French P, Stanton C, Lawless F, O'Riordan EG, Monahan FJ, Caffrey PJ, Moloney AP, Fatty acid composition, including

conjugated linoleic acid, of intramuscular fat from steers offered grazed grass, grass silage, or concentrate-based diets, *Journal of Animal Science* 2000;78:2849–2855.
87. Moloney AP, Mooney MT, Kerry JP, Troy DJ, Producing tender and flavoursome beef with enhanced nutritional characteristics, *Proceedings of the Nutrition Society* 2001;60:221–229.
88. Regenstein J, Department of Food Science, Cornell University, personal communication, October 25, 2002.

NOTES

NOTES