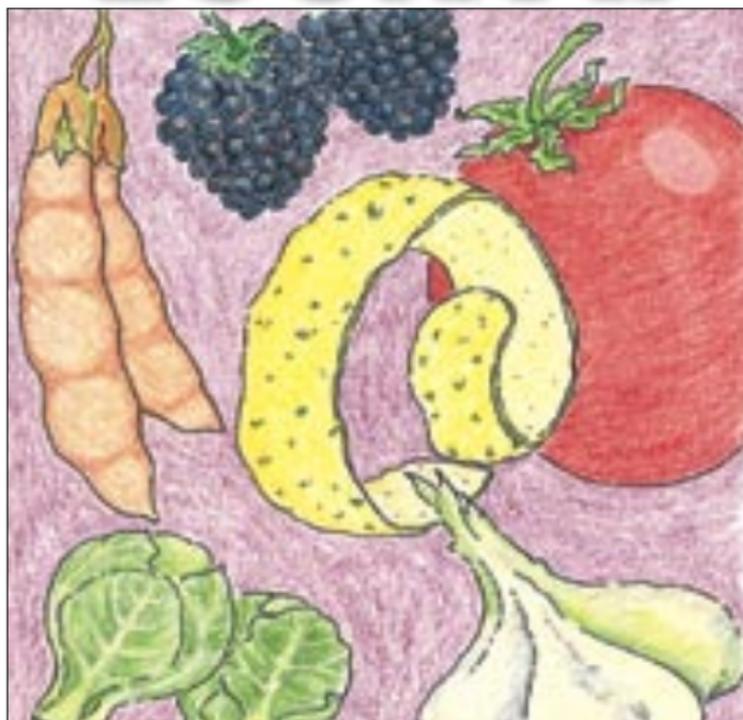




American Institute
for Cancer Research

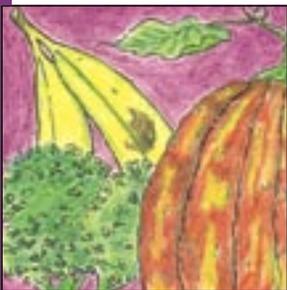
A Closer Look At



PHYTOCHEMICALS

CONCEPTS IN
CANCER RESEARCH

What Are Phytochemicals?



Phytochemicals are, literally, “plant chemicals” (*phyto* means *plant* in Greek). Their fundamental function is to provide protective coloring, odor and taste to the plants in which they are found. But research is showing that,

once ingested, they affect chemical processes in the human body.

Scientists have identified thousands of different phytochemicals in plant foods. Many of these substances seem to be involved in protecting our bodies from disease. In fact, eating plenty of plant foods rich in phytochemicals – including vegetables, fruits, beans, whole grains, nuts and seeds – may help to prevent at least one in every five cases of cancer, as well as other serious ailments such as heart disease.

Here are a few findings from research studies about what phytochemicals may do to promote health and ward off disease:

- Stimulate the immune system, the body’s defense against viruses, bacteria and other disease-causing agents.
- Block the potential for carcinogens (cancer-causing substances) to be formed in the body from substances we eat, drink and absorb from the environment.
- Reduce inflammation that provides a setting favorable for cancer growth.
- Prevent DNA damage and help with DNA repair mechanisms.
- Reduce oxidation, the damage to cells that

occurs with aging and exposure to pollution. Oxidation, caused by molecules called “free radicals,” can cause abnormalities in cells that may eventually lead to cancer.

- Slow the growth rate of cancer cells.
- Trigger death (a process known as *apoptosis*) of damaged cells that may be precursors to cancer.
- Help to regulate hormones, such as estrogen and insulin. Excess levels of these hormones are linked with increased risk for breast and colon cancers.

Many vegetables and fruits are especially rich in phytochemicals. They are often brightly colored – like broccoli, carrots, tomatoes and blueberries – or strongly flavored, like peppers and onions. A diet that emphasizes vegetables, fruit, whole grains and beans appears to be the healthiest eating pattern for lower risk of cancer and other serious diseases.

How Were Phytochemicals Discovered?

Several decades ago, scientists began to observe that people who ate mostly plant-based diets (instead of diets heavy in meat and processed foods) had lower rates of diseases like cancer. They started testing plant foods to find out what these foods contained that might be having a disease-preventing effect.

In the early 1990s, broccoli was one of the first vegetables to draw attention for health-boosting properties that went beyond its vitamin or mineral content. Researchers found that broccoli contains a phytochemical called *sulforaphane*. Laboratory experiments showed that sulforaphane could stop cells from starting to turn cancerous. Research already had shown that broccoli also contains *beta-carotene*, another phytochemical, as well as other substances

like vitamin C. The discovery of sulforaphane made broccoli a cancer-fighting star.

Since then, hundreds of research studies have shown that plant foods are treasure troves of phytochemicals with cancer-fighting properties.

Here are a few:

- Diallyl disulfides in garlic and onions, resveratrol in red grapes and terpenes in citrus fruits all appear to stop cancer cell growth.
- Ellagic acid in strawberries and raspberries seems to lessen the genetic damage caused by cancer-causing substances in tobacco smoke and air pollutants.
- Saponins in beans and other legumes, artichokes and garlic may prevent cancer cells from multiplying.

What we know about the action of phytochemicals is, then, based on two kinds of research. There are many population studies showing that people who eat more plant foods have less cancer. There are even more laboratory studies that show how chemicals in plants influence the progression of cancer.

Scientists are now attempting to verify phytochemical theory through human studies. This phase of the research is proceeding slowly, in part because such studies are difficult to do. Some require people to maintain new eating patterns consistently for years on end. Others require people to report accurately what they eat daily or ate years ago.

Many experts believe that when research methodology is fine tuned, the anti-cancer activity of phytochemicals will be demonstrated in humans. Meanwhile, AICR recommends a mostly plant-based diet to fight a variety of chronic diseases and manage your weight.

Do Phytochemical Supplements Work?

If phytochemicals are so good for our health, why not put them into dietary supplements that can be taken as capsules? At first glance, it seems like a great idea. And on the shelves of any pharmacy you'll find a dizzying array of phytochemical supplements, from garlic pills to lycopene (a carotenoid found in tomatoes and watermelon).

But there's a problem. Research suggests that some phytochemicals are less easily absorbed in pill form. If they are absorbed in an isolated state, they are often less effective. Phytochemicals tend to work most effectively in tandem with other substances in the foods that are their source.

Using supplements can also lead to overdosing. More isn't always better and sometimes it may be harmful. In one study, for example, researchers gave beta-carotene supplements to smokers, thinking that this might reduce their risk of lung cancer. But as things turned out, the smokers who took the beta-carotene supplements had higher rates of lung cancer than those who took dummy pills. A later analysis of this study also showed that men who ate fruits and vegetables high in beta-carotene, lycopene and lutein reduced their lung cancer risk. Other studies have failed to show that dietary supplements protect against cancer.

The bottom line is, it's best not to rely on dietary supplements. To get the greatest benefit from cancer-fighting phytochemicals, eat a mostly plant-based diet that includes a wide variety of vegetables and fruits every day.

Phytochemical(s)	Plant Source	Possible Benefits
Carotenoids (such as beta-carotene, lycopene, lutein, zeaxanthin)	Red, orange and green fruits and vegetables including broccoli, carrots, cooked tomatoes, leafy greens, sweet potatoes, winter squash, apricots, cantaloupe, oranges and watermelon	May inhibit cancer cell growth, work as antioxidants and improve immune response
Flavonoids (such as anthocyanins and quercetin)	Apples, citrus fruits, onions, soybeans and soy products (tofu, soy milk, edamame, etc.), coffee and tea	May inhibit inflammation and tumor growth; may aid immunity and boost production of detoxifying enzymes in the body
Indoles and Glucosinolates (sulforaphane)	Cruciferous vegetables (broccoli, cabbage, collard greens, kale, cauliflower and Brussels sprouts)	May induce detoxification of carcinogens, limit production of cancer-related hormones, block carcinogens and prevent tumor growth
Inositol (phytic acid)	Bran from corn, oats, rice, rye and wheat, nuts, soybeans and soy products (tofu, soy milk, edamame, etc.)	May retard cell growth and work as antioxidant
Isoflavones (daidzein and genistein)	Soybeans and soy products (tofu, soy milk, edamame, etc.)	May inhibit tumor growth, limit production of cancer-related hormones and generally work as antioxidant
Isothiocyanates	Cruciferous vegetables (broccoli, cabbage, collard greens, kale, cauliflower and Brussels sprouts)	May induce detoxification of carcinogens, block tumor growth and work as antioxidants
Polyphenols (such as ellagic acid and resveratrol)	Green tea, grapes, wine, berries, citrus fruits, apples, whole grains and peanuts	May prevent cancer formation, prevent inflammation and work as antioxidants
Terpenes (such as perillyl alcohol, limonene, carnosol)	Cherries, citrus fruit peel, rosemary	May protect cells from becoming cancerous, slow cancer cell growth, strengthen immune function, limit production of cancer-related hormones, fight viruses, work as antioxidants

Future Directions for Research on Phytochemicals

Research has shown that phytochemicals provide the best health protection when they work together. But questions remain as to exactly how phytochemicals act in the body to protect health. These are some of the questions scientists are now trying to answer:

- What quantities of phytochemicals in plant foods do people need to eat to get optimal health benefits?
- How long do the protective effects of phytochemicals last after the foods that contain them are eaten?
- How do phytochemicals interact with each other?
- What combinations of phytochemicals might offer the most health benefits?
- What are the effects of heating (cooking) on phytochemicals?

Scientists need to take a closer look at the effects of phytochemicals at the molecular level in the body. It appears that phytochemicals modify specific genes through complex chain reactions with proteins and other components of cells. Phytochemicals also affect communication, or signaling, between cells. These chain reactions are known as *metabolic* or *signaling* pathways. By learning precisely how these pathways work, scientists hope to find ways to get even more health benefits from phytochemicals – for example, by enhancing the levels of phytochemicals in a particular food.

Because people differ genetically, does that mean some individuals may benefit from certain phytochemicals more than from others? Understanding how phytochemicals interact with

genes may shed light on this question.

For example, recent research findings suggest that people who lack a gene called *GSTM1* miss out on some of the cancer-fighting benefits of broccoli because their bodies can't utilize sulforaphane. On the other hand, people who lack the *GSTM1* gene may get cancer protection from eating other vegetables in the broccoli family (called “cruciferous” vegetables), such as cabbage or cauliflower, which have other phytochemicals.



Steps to Take Now

While research continues to probe these questions, it is wise to get as much health protection as possible by: (1) eating a mostly plant-based diet and (2) eating a wide variety of vegetables, fruits, whole grains and beans.

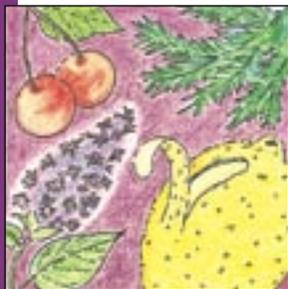
To reduce cancer risk, aim to eat between 5 and 10 servings a day of vegetables and fruits, at least three servings a day of whole grains, and at least 1 serving of legumes (dried beans, lentils and soy foods), nuts or seeds* most days of the week. If that sounds like a lot, remember that a “serving” isn't the same as a “portion.” A standard serving of most fruits and vegetables is a half-cup or, put another way, an amount about the size of half a baseball. One slice of whole-grain bread is a serving; so is a half-cup of cooked brown rice or beans.

This eating pattern will provide plenty of phytochemicals as well as vitamins, minerals and fiber that may help prevent cancer and other diseases such as diabetes and heart disease. One reason

*A serving of nuts equals $\frac{1}{3}$ cup; 1 serving of seeds equals 2 tablespoons.

This eating pattern will provide plenty of phytochemicals as well as vitamins, minerals and fiber that may help prevent cancer and other diseases such as diabetes and heart disease. One reason is that eating mostly plant foods can help you maintain a healthy weight.

Research also shows that getting regular physical activity reduces cancer risk and controls body weight. AICR recommends at least one hour a day of moderate activity and one hour a week of vigorous activity. If that seems more than you can manage, do what you can, maybe in 10-minute intervals throughout the day. Any level of activity is better than none at all. It's never too late to start – but check with your doctor first.



Summary

- Phytochemicals are naturally occurring substances found in plant foods such as vegetables, fruits, beans, whole grains, nuts and seeds. Many different phytochemicals work together to protect our health.

- Eating ample quantities of phytochemical-rich plant foods may help to prevent as many as one in every five cases of cancer, as well as other serious diseases such as heart disease and diabetes.
- Vegetables and fruits that are brightly colored or strongly flavored often contain the highest

The American Institute for Cancer Research (AICR) has taken a leadership role in supporting research in the area of phytochemicals, nutrition and cancer. Following is a partial list of grants awarded by AICR in this area.

Chemoprevention of Her-2 positive breast cancer by red wine phytochemicals

Nameer Kirma
University of Texas Health Science Center

Dual Effects of Soy to Treat Prostate Cancer: Inhibition of Prostaglandins and Enhancement of the Anti-Proliferative Activity of Vitamin D

David Feldman, M.D.
Stanford University School of Medicine

Chemoprevention of Colon Cancer Using Bromelain From Pineapple

Laura P. Hale, M.D., Ph.D.
Duke University

Green Tea Inhibition of Epithelial to Mesenchymal Transition of Breast Cancer Cells

Gail E. Sonenshein, Ph.D.
Boston University School of Medicine

Lycopene, Vitamin E, Selenium and Prostate Cancer

John W. Erdman, Jr., Ph.D.
University of Illinois-Urbana

Mechanisms of Cancer Chemoprevention by Constituents of Cruciferous Vegetables

Oliver Hankinson, Ph.D.
University of California-Los Angeles

Need More Help?

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Request Additional Brochures (up to 6 free)

A Closer Look at Antioxidants
A Closer Look at Nutrigenomics
Guidelines for Cancer Prevention
Recommendations for Cancer Prevention
Eating Smart for Cancer Prevention

Call the Toll-Free Nutrition Hotline

Dial 1-800-843-8114 to leave a message for a registered dietitian (who will return your call), Monday-Friday, 9 a.m.-5 p.m. Eastern Time. Or visit the AICR Hotline online at www.aicr.org.

This brochure is informed by the AICR/WCRF Second Expert Report, *Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective*. The report, produced by WCRF/AICR, is the largest study of its kind ever published and its recommendations are based on the most comprehensive review of all the available evidence. The recommendations can be grouped into three guidelines:

AICR Guidelines for Cancer Prevention



The choices you make about food, physical activity and weight management can reduce your chances of developing cancer.

- Choose mostly plant foods, limit red meat and avoid processed meat.
- Be physically active every day in any way for 30 minutes or more.
- Aim to be a healthy weight throughout life.

*And always remember –
do not smoke or chew tobacco.*

The American Institute for Cancer Research (AICR) is the cancer charity that fosters research on the relationship of nutrition, physical activity and weight management to cancer risk, interprets the scientific literature and educates the public about the results. It has contributed more than \$85 million for innovative research conducted at universities, hospitals and research centers across the country. AICR has published two landmark reports that interpret the accumulated research in the field and is committed to a process of continuous review. AICR also provides a wide range of educational programs to help millions of Americans learn to make dietary changes for lower cancer risk. Its award-winning New American Plate program is presented in brochures, seminars and on its Web site, www.aicr.org. AICR is part of the World Cancer Research Fund global network.

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