Cancer Vaccines

Key Points

- Vaccines boost the immune system's natural ability to defend the body against infection and to protect it from dangers posed by certain types of damaged or abnormal cells, including cancer cells (see Questions 1 and 2).
- Some cancer vaccines, known as *cancer preventive vaccines*, are designed to prevent cancer from developing in healthy people. Other cancer vaccines, known as *cancer treatment vaccines*, are intended to treat cancers that have already occurred (see Question 3).
- The U.S. Food and Drug Administration (FDA) has approved two types of cancer preventive vaccines: A vaccine against the hepatitis B virus, which can cause liver cancer in chronically infected people, and a vaccine against human papillomavirus types 16 and 18, which are responsible for about 70 percent of all cases of cervical cancer (see Question 5).
- Cancer treatment vaccines are designed to treat cancer by stimulating the immune system to recognize and attack cancer cells. The FDA has not yet approved a cancer treatment vaccine (see Questions 7 and 8).
- Effective cancer treatment vaccines are difficult to develop because some cancers can escape detection by the immune system or weaken natural immune responses against cancer cells (see Questions 7 and 15).
- Researchers are developing treatment vaccines against many types of cancer and testing them in clinical trials (see Questions 9 and 14).
- The side effects of cancer vaccines vary from patient to patient and according to the type of vaccine being used. Most of the side effects reported thus far have been mild and limited to inflammation at the site of the vaccine injection (see Question 13).

1. What are vaccines?

Vaccines are medicines that boost the immune system's natural ability to protect the body against "foreign invaders" that may cause disease. These invaders are primarily

microbes, which can be seen only under a microscope. Microbes include bacteria, viruses, parasites, and fungi.

The immune system is a complex network of organs, tissues, and specialized cells that act collectively to defend the body. When a particular type of microbe invades the body, the immune system recognizes it as foreign, destroys it, and "remembers" it to prevent another infection. Vaccines take advantage of this response.

Traditional vaccines usually contain harmless versions of microbes—killed or weakened microbes, or parts of microbes—that do not cause disease but are able to stimulate an immune response. When the immune system encounters these substances through vaccination, it responds to them, eliminates them from the body, and develops a memory of them. This vaccine-induced memory enables the immune system to act quickly to protect the body if it becomes infected by the same microbe in the future.

The immune system's role in defending against disease-causing microbes has long been recognized. Scientists have also discovered that the immune system can protect the body against threats posed by certain types of damaged, diseased, or abnormal cells, including cancer cells (1).

2. How do vaccines stimulate the immune system?

White blood cells, or leukocytes, play the main role in immune responses. These cells carry out the many tasks required to protect the body against disease-causing microbes and abnormal cells.

Some types of leukocytes patrol the body, seeking foreign invaders and diseased, damaged, or dead cells. These white blood cells provide a general—or nonspecific—level of immune protection.

Other types of leukocytes, known as lymphocytes, provide targeted protection against specific threats, whether from a specific microbe or a diseased or abnormal cell. The most important groups of lymphocytes responsible for carrying out immune responses against such threats are B cells and cytotoxic (cell-killing) T cells.

B cells make antibodies, which are large proteins secreted by B cells that bind to, inactivate, and help destroy foreign invaders or abnormal cells. Most preventive vaccines, including those aimed at hepatitis B virus (HBV) and human papillomavirus (HPV), stimulate the production of antibodies that bind to specific, targeted microbes and block their ability to cause infection. Cytotoxic T cells, which are also known as killer T cells, kill infected or abnormal cells by releasing toxic chemicals or by prompting the cells to self-destruct (apoptosis).

Other types of lymphocytes and leukocytes play supporting roles to ensure that B cells and killer T cells do their jobs effectively. Cells that help fine-tune the activities of B

cells and killer T cells include helper T cells and dendritic cells, which help activate killer T cells and enable them to recognize specific threats.

Cancer treatment vaccines work by activating B cells and killer T cells and directing them to recognize and act against specific types of cancer. They do this by introducing one or more molecules known as antigens into the body, usually by injection. An antigen is a substance that stimulates a specific immune response. An antigen can be a protein or another type of molecule found on the surface of or inside a cell.

Microbes carry antigens that "tell" the immune system they are foreign—or "non-self"—and, therefore, represent a potential threat that should be destroyed. In contrast, normal cells in the body have antigens that identify them as "self." Self antigens tell the immune system that normal cells are not a threat and should be ignored (2).

Cancer cells can carry both types of antigens. They have self antigens, which they share in common with normal cells, but they may also have antigens that are unique to cancer cells. These cancer-associated antigens mark cancer cells as abnormal, or non-self, and can cause B cells and killer T cells to mount an attack against the cancer.

Cancer cells may also make much larger than normal amounts of certain self antigens. These overly abundant self antigens may be viewed by the immune system as being foreign and, therefore, may trigger an immune response against the cancer (1–6).

3. What are cancer vaccines?

Cancer vaccines are medicines that belong to a class of substances known as biological response modifiers. Biological response modifiers work by stimulating or restoring the immune system's ability to fight infections and disease. There are two broad types of cancer vaccines:

- ***Preventive (or prophylactic) vaccines***, which are intended to prevent cancer from developing in healthy people; and

- ***Treatment (or therapeutic) vaccines***, which are intended to treat already existing cancers by strengthening the body's natural defenses against cancer (7).

Two types of cancer preventive vaccines have been successfully developed and are available in the United States (see Question 5). However, cancer treatment vaccines remain an experimental form of therapy.

4. How do cancer preventive vaccines work?

Cancer preventive vaccines target infectious agents that cause or contribute to the development of cancer (8). They are similar to traditional vaccines, which help prevent

infectious diseases such as measles or polio by protecting the body against infection. Both cancer preventive vaccines and traditional vaccines are based on antigens that are carried by the infectious agents and that are relatively easy for the immune system to recognize as foreign.

5. Have any cancer preventive vaccines been approved for use in the United States?

In 2006, the U.S. Food and Drug Administration (FDA) approved the vaccine known as Gardasil®, which protects against infection by two types of HPV—specifically, types 16 and 18—that cause approximately 70 percent of all cases of cervical cancer worldwide. At least 17 other types of HPV are responsible for the remaining 30 percent of cervical cancer cases (9). Gardasil also protects against HPV types 6 and 11, which are responsible for about 90 percent of all cases of genital warts. However, these two HPV types do not cause cervical cancer.

In 2008, the FDA expanded Gardasil's approval to include its use in the prevention of HPV-associated vulvar and vaginal cancers.

Gardasil, manufactured by Merck & Company, is based on HPV antigens that are proteins. These proteins are used in the laboratory to make four different types of "virus-like particles," or VLPs, which correspond to HPV types 6, 11, 16, and 18. The four types of VLPs are then combined to make the vaccine. Because Gardasil targets four HPV types, it is called a quadrivalent vaccine (10). In contrast with traditional vaccines, which are often composed of weakened, whole microbes, the VLPs in Gardasil are not infectious. However, they are still able to stimulate the production of antibodies against HPV types 6, 11, 16, and 18.

A second HPV vaccine manufactured by GlaxoSmithKline and known by the name Cervarix® has also been developed. Although Cervarix has been approved for use in Europe, it has not yet been approved by the FDA for use in the United States. In contrast with Gardasil, Cervarix is a bivalent vaccine. It is composed of VLPs made with proteins from HPV types 16 and 18. Therefore, it provides protection only against these two HPV types.

The public health benefits of vaccines against HPV types 16 and 18 may extend beyond reducing the risks of cervical cancer, vaginal cancer, and vulvar cancer. Evidence suggests that chronic infection by one or both of these virus types is also associated with cancers of the anus, penis, and oropharynx (11).

The FDA has approved one other type of cancer preventive vaccine, which protects against HBV infection. Chronic HBV infection can lead to liver cancer. The first HBV vaccine was approved in 1981, making it the first cancer preventive vaccine to be successfully developed and marketed. Today, most children in the United States are vaccinated against HBV shortly after birth (12).

6. Have other microbes been associated with cancer?

Many scientists believe that microbes cause or contribute to between 15 percent and 25 percent of all cancers diagnosed worldwide each year, with the percentages being lower in developed countries than in developing countries (4, 8, 13, 14).
The International Agency for Research on Cancer (IARC) has classified several microbes as carcinogenic (causing or contributing to the development of cancer in people), including HPV and HBV (15). These infectious agents—bacteria, viruses, and parasites—and the cancer types with which they are most strongly associated are listed in the table below.

Infectious Agents	Type of Organism	Associated Cancer(s)
hepatitis B virus (HBV)	virus	hepatocellular carcinoma (a type of liver cancer)
hepatitis C virus (HCV)	virus	hepatocellular carcinoma (a type of liver cancer)
human papillomavirus (HPV) types 16 and 18, as well as other HPV types	virus	cervical cancer; vaginal cancer; vulvar cancer; oropharyngeal cancer (cancers of the base of the tongue, tonsils, or upper throat); anal cancer; penile cancer
Epstein-Barr virus	virus	Burkitt lymphoma; non-Hodgkin lymphoma; Hodgkin lymphoma; nasopharyngeal carcinoma (cancer of the upper part of the throat behind the nose)
human T-cell lymphotropic virus 1 (HTLV1)	virus	acute T-cell leukemia
Helicobacter pylori	bacterium	stomach cancer
schistosomes (*Schistosoma hematobium*)	parasite	bladder cancer
liver flukes (*Opisthorchis viverrini*)	parasite	cholangiocarcinoma (a type of liver cancer)

7. How do cancer treatment vaccines work?

Cancer treatment vaccines are designed to treat cancers that have already occurred. They are intended to delay or stop cancer cell growth; cause tumor shrinkage; prevent cancer from coming back; or eliminate cancer cells that are not killed by other forms of treatment, such as surgery, radiation therapy, or chemotherapy.

Developing effective cancer treatment vaccines requires a detailed understanding of how immune system cells and cancer cells interact. The immune system often does not "see" cancer cells as dangerous or foreign, as it generally does with microbes. Therefore, the immune system does not mount a strong attack against the cancer cells.

There are many reasons the immune system does not easily recognize the threat posed by an already growing cancer. Most important is the fact that cancer cells carry normal self antigens in addition to any cancer-associated antigens. Furthermore, cancer cells sometimes undergo genetic changes that lead to the loss of cancer-associated antigens. Finally, cancer cells can produce chemical messages that suppress specific anticancer immune responses by killer T cells. As a result, even when the immune system recognizes a growing cancer as a threat, the cancer may still escape a strong attack by the immune system (16).

8. Has the FDA approved any cancer treatment vaccines?

The FDA has not approved any type of cancer treatment vaccine. Producing effective treatment vaccines has proved much more difficult and challenging than developing cancer preventive vaccines (17).

To be effective, cancer treatment vaccines must achieve two goals. First, similar to traditional vaccines and cancer preventive vaccines, cancer treatment vaccines must stimulate specific immune responses and direct them against the correct target. Second, the immune responses stimulated by cancer treatment vaccines must be powerful enough to overcome the barriers that cancer cells use to protect themselves from attack by B cells and killer T cells. Recent advances in understanding how cancer cells escape recognition and attack by the immune system are now giving researchers the knowledge required to design cancer treatment vaccines that can accomplish both goals (18, 19).

9. What types of vaccines are being studied in clinical trials?

Vaccines to prevent HPV infection and to treat several types of cancer are being studied in clinical trials.

The list below shows the types of cancer that are being targeted in active cancer prevention or treatment clinical trials using vaccines. In the HTML version of this fact sheet on the Web site (http://www.cancer.gov/cancertopics/factsheet/Therapy/

cancer-vaccines), the cancer names are links to search results for cancer vaccine trials in the National Cancer Institute's (NCI) clinical trials database. This database can also be searched on NCI's Web site, http://www.cancer.gov, by visiting http://www.cancer.gov/clinicaltrials/search or http://www.cancer.gov/Search/SearchClinicalTrialsAdvanced.aspx on the Internet.

Active Clinical Trials of Cancer Treatment Vaccines by Type of Cancer:

- Bladder Cancer
- Brain Tumors
- Breast Cancer
- Cervical Cancer
- Kidney Cancer
- Melanoma
- Multiple Myeloma
- Leukemia
- Lung Cancer
- Pancreatic Cancer
- Prostate Cancer
- Solid Tumors

Active Clinical Trials of Cancer Preventive Vaccines by Type of Cancer:

- Cervical Cancer

10. How are cancer vaccines made, and what antigens are used?

Scientists make cancer preventive vaccines using antigens from microbes that cause or contribute to the development of cancer. The cancer preventive vaccines currently approved by the FDA are made using antigens from HBV and specific types of HPV (see Question 5). These antigens are proteins that help make up the outer surface of the viruses. Because only part of these microbes is used, the resulting vaccines are not infectious and, therefore, cannot cause disease.

Researchers can also create synthetic versions of antigens in the laboratory for use in vaccines. In doing this, they often modify the chemical structure of the antigens to stimulate immune responses that are stronger than those caused by the original antigens.

Similar to cancer preventive vaccines, cancer treatment vaccines can be made using antigens from cancer cells—either directly or by making modified versions of them. Antigens that have been used thus far include proteins; carbohydrates (sugars); glycoproteins or glycopeptides, which are carbohydrate-protein combinations; and gangliosides, which are carbohydrate-lipid (fat) combinations.

Cancer treatment vaccines can also be made using weakened or killed cancer cells that carry a specific cancer-associated antigen. These cells can be from a patient's own

cancer (called an autologous vaccine) or from another person's cancer (called an allogeneic vaccine).

Other types of cancer treatment vaccines can be made using molecules of deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) that contain the genetic instructions for cancer-associated antigens. The DNA or RNA can be injected alone into a patient as a "naked nucleic acid" vaccine, or researchers can insert the DNA or RNA into a harmless virus. After the naked nucleic acid or virus is injected into the body, the DNA or RNA is taken up by cells, which begin to manufacture the tumor-associated antigens. Researchers hope that the cells will make enough of the tumor-associated antigens to stimulate a strong immune response.

Scientists have identified a large number of cancer-associated antigens, several of which are now being used to make experimental cancer treatment vaccines. Some of these antigens are found on or in many or most types of cancer cells. Others are unique to specific cancer types (1, 5, 6, 20–25).

Antigens associated with more than one type of cancer include the following:

- ***Carcinoembryonic antigen (CEA)***: A glycoprotein found in developing fetal tissues and in certain types of cancer, including colorectal cancer, stomach cancer, pancreatic cancer, breast cancer, and non-small cell lung cancer.

- ***Cancer/testis antigens,*** such as NY-ESO-1: A large family of proteins found in male germ cells (sperm) and a wide variety of cancer types, including melanoma and cancers of the ovary, tongue, pharynx, brain, lung, colon, and breast.

- ***Mucin-1 (MUC1)***: A glycoprotein found in the outer membrane of mucus-producing epithelial cells (cells that make up the skin and line internal organs) and many types of cancer cells, including breast, prostate, colon, pancreatic, and non-small cell lung cancer cells. Sialyl Tn (STn) is a carbohydrate antigen related to mucin-1 that is being used in some treatment vaccines.

- ***Gangliosides,*** such as GM3 and GD2**:** Molecules that are found in the outer membrane of several types of cancer cells, including melanoma, neuroblastoma, small cell lung cancer, and soft tissue sarcomas.

- ***p53 protein:*** A protein produced by the tumor suppressor gene TP53. Mutation of TP53, which results in a loss of p53 protein function, is the most common abnormality in human cancer. Mutant p53 protein often accumulates in cancer cells, which makes p53 an attractive target for a vaccine.

- ***HER2/neu protein (also known as ERBB2):*** A protein that is overexpressed—or overproduced—in breast, ovarian, and several other types of cancer. Overexpression of HER2/neu is associated with more aggressive disease and a worse outcome.

Targeting HER2/neu with a monoclonal antibody called trastuzumab (Herceptin®) has proven to be an effective treatment for breast cancers that overexpress this protein.

Antigens unique to a specific type of cancer include the following:

- ***A mutant form of the epidermal growth factor receptor, called EGFRvIII***: An abnormal protein that contributes to uncontrolled tumor growth and is found in glioblastoma (a type of brain cancer), but not in normal brain tissue.

- ***Melanocyte/melanoma differentiation antigens,*** such as tyrosinase, MART1, and gp100: Proteins found in mature melanocytes (pigment-producing cells of the skin and eye) and in melanoma cells.

- ***Prostate-specific antigen (PSA)***: A protein that is often produced in much greater amounts by prostate cancer cells than by normal prostate cells.

- ***Idiotype (Id) antibodies***: Antibodies produced by cancerous B cells that serve as antigen markers for diseases such as multiple myeloma and several types of lymphoma. Id antibodies are unique to an individual patient's cancer.

11. Are other substances used to make cancer treatment vaccines?

Yes. Researchers can use certain immune system cells and their products, as well as antibodies created in the laboratory, to make cancer treatment vaccines.

Some examples include the following:

- ***Dendritic Cells and Costimulatory Molecules****:* Scientists can use a type of white blood cell known as a dendritic cell to make cancer treatment vaccines. Dendritic cells are powerful stimulators of immune responses. They process and present cancer-associated antigens to T cells and B cells, and they produce costimulatory molecules that enhance the cell-killing properties of killer T cells (1, 2, 23–26).

  To make autologous dendritic-cell vaccines, researchers often harvest dendritic cells from the blood of a cancer patient and grow the cells in the laboratory while "feeding" them cancer-associated antigens. Dendritic cells can be fed antigens directly, or they can be exposed to DNA, RNA, or viruses that contain the genetic instructions for the antigens. After taking up the DNA, RNA, or virus genetic material, the dendritic cells manufacture and process the antigens for display on their cell surface to other immune system cells. Researchers then inject these "antigen-presenting cells" into the patient's bloodstream. In the body, the dendritic cells interact with killer T cells and other immune system cells to generate anticancer immune responses.

Researchers can also create synthetic versions of the costimulatory molecules produced by dendritic cells and add them to other types of treatment vaccines to strengthen killer-T-cell responses. Costimulatory molecules that are frequently used in treatment vaccines include ICAM–1, B7.1, and LFA–3. When used together in a vaccine, these three molecules are designated by the abbreviation TRICOM (22, 27).

- ***Idiotype (Id) Vaccines***: Normal B cells and cancerous B cells, such as those produced in multiple myeloma and several types of lymphoma, each make only one type of antibody. In a patient with a B cell cancer, these unique antibodies, also called idiotype (Id) antibodies, can serve as antigen markers for the patient's disease. Id antibodies can also be used to create personalized, autologous vaccines (28). When injected into a patient in large amounts, Id antibodies may be able to stimulate an immune response that will target cancerous B cells for destruction.

  Autologous Id vaccines typically include other substances called adjuvants, which increase the potency of immune responses (see Question 12). Id antibodies can also be used as antigens in making autologous dendritic-cell vaccines.

- ***Anti-Idiotype (Anti-Id) Monoclonal Antibody Vaccines***: Monoclonal antibodies are substances created in the laboratory; each type of monoclonal antibody targets one specific antigen. Anti-Id antibodies have been developed that mimic antigens found on several types of cancer cells. These antibodies can trigger immune responses against cancer cells that bear the antigens that the anti-Id antibodies mimic.

  Cancer types for which anti-Id monoclonal antibodies have been developed include melanoma, breast cancer, small cell lung cancer, colorectal cancer, ovarian cancer, peritoneal cancer, and cancer of the fallopian tube.

12. What are adjuvants, and how are they used in making cancer vaccines?

Antigens and the substances discussed in Question 10 are often not enough to make effective cancer treatment vaccines. Researchers often add extra ingredients, known as adjuvants, to treatment vaccines. These substances serve to boost immune responses that have been set in motion by exposure to antigens or other means. Patients undergoing treatment with a cancer vaccine sometimes receive adjuvants separately from the vaccine itself (29).

Adjuvants used for cancer vaccines come from many different sources. Some microbes, such as the bacterium bacillus Calmette-Guérin (BCG) originally used as a vaccine against tuberculosis, can serve as adjuvants (30). Substances produced by bacteria, such as Detox B, are frequently used. Biological products derived from nonmicrobial organisms can also be used as adjuvants. One example is keyhole limpet hemocyanin (KLH), which is a large protein produced by a sea animal. Attaching antigens to KLH has been shown to increase their ability to stimulate immune responses. Even some

nonbiological substances, such as the emulsified oil montanide ISA–51, can be used as adjuvants.

Scientists can also use natural or synthetic cytokines as adjuvants. Cytokines are substances that are naturally produced by white blood cells to regulate and fine-tune immune responses. Some cytokines increase the activity of B cells and killer T cells, while other cytokines suppress the activities of these cells. Cytokines frequently used in cancer treatment vaccines or given with them include interleukin 2 (IL2, also known as aldesleukin), interferon alpha (INF–a), and granulocyte-macrophage colony-stimulating factor (GM–CSF, also known as sargramostim).

13. What side effects have been seen with cancer vaccines?

Vaccines intended to prevent or treat cancer appear to have safety profiles comparable to those of traditional vaccines (6). However, the side effects of cancer vaccines can vary widely from one vaccine formulation to another and from one person to another.

The most commonly reported side effect of cancer vaccines is inflammation at the site where the vaccine is injected into the body. Reported symptoms include redness, pain, swelling, heightened temperature (the skin surrounding the injection site feels hot to the touch), itchiness, and occasionally a rash.

People sometimes experience flulike symptoms after receiving a cancer vaccine, including fever, chills, weakness, dizziness, nausea or vomiting, muscle ache, fatigue, headache, and occasional breathing difficulties. Blood pressure may also be affected.

Other, more serious health problems have been reported in smaller numbers of people after receiving a cancer vaccine. These problems may or may not have been caused by the vaccine. The reported problems have included asthma, appendicitis, pelvic inflammatory disease, and certain autoimmune diseases, including arthritis and systemic lupus erythematosus.

Vaccines, like any other medication affecting the immune system, can cause adverse effects that may prove life threatening. For example, severe hypersensitivity (allergic) reactions to specific vaccine ingredients have occurred following vaccination. However, such severe reactions are quite rare.

14. Can cancer treatment vaccines be combined with other types of cancer therapy?

Yes. In many of the clinical trials of cancer treatment vaccines that are now under way, vaccines are being administered with other forms of cancer therapy. Therapies that have been combined with cancer treatment vaccines include surgery, chemotherapy, radiation therapy, and some forms of targeted therapy, including therapies based on boosting immune system responses against cancer with biological response modifiers.

Several studies have suggested that cancer treatment vaccines may be most effective when given in combination with other forms of cancer therapy (24, 31). In addition, in some clinical trials, cancer treatment vaccines have appeared to increase the effectiveness of other cancer therapies (24, 31).

Additional evidence suggests that surgical removal of large tumor masses may enhance the effectiveness of cancer treatment vaccines (31). In patients with extensive disease, the immune system may be overwhelmed by the cancer and effective immune responses cannot be achieved. Surgical removal of the tumor may make it easier for the body to develop an immune response.

Researchers are also designing clinical trials to answer questions such as whether a specific cancer treatment vaccine works best when it is administered before chemotherapy, after chemotherapy, or at the same time as chemotherapy. Answers to such questions may not only provide information about how best to use a specific cancer treatment vaccine but also reveal additional basic principles to guide the future development of combination therapies involving vaccines.

15. What additional research is under way?

Although researchers have identified many cancer-associated antigens, these molecules vary widely in their capacity to stimulate a strong anticancer immune response. Two major areas of research aimed at developing better cancer treatment vaccines involve the discovery of new cancer-associated antigens that may prove more effective in stimulating immune responses than the already known antigens and the development of new methods to enhance the ability of cancer-associated antigens to stimulate the immune system. Research is also under way to determine how to combine multiple antigens within a single cancer treatment vaccine to produce optimal anticancer immune responses (22).

As mentioned in Question 14, another area of study is how best to combine cancer treatment vaccines with other types of anticancer therapy, whether surgery, chemotherapy, radiation therapy, targeted therapy, or other types of immune system therapy, including adoptive cell transfer (4, 17, 32–35). In adoptive cell transfer, which is also known as cellular adoptive immunotherapy, researchers harvest killer T cells that have anticancer activity from a patient's tumor and, in the laboratory, both stimulate their growth to greatly increase their numbers and treat them to enhance their tumor-killing activity. The T cells are then injected into the patient (32–35).

Perhaps the most promising avenue of cancer vaccine research is aimed at better understanding the basic biology underlying how immune system cells and cancer cells interact. New technologies are being created as part of this effort. For example, a group of scientists recently developed a new type of imaging technology that allows researchers to observe killer T cells and cancer cells interacting on a one-to-one basis inside the body (36).

In addition, researchers are trying to identify the mechanisms by which cancer cells evade or suppress anticancer immune responses. A better understanding of how cancer cells manipulate the immune system could lead to the development of new drugs that block those processes and thereby improve the effectiveness of cancer treatment vaccines (27). For example, research has shown that some cancer cells produce chemical signals that attract white blood cells known as regulatory T cells, or Tregs, to a tumor site. Tregs produce cytokines that can either stimulate or suppress the activity of killer T cells. When Tregs move close to a tumor, they often release cytokines that suppress the activity of nearby killer T cells (24, 37). The combination of a cancer treatment vaccine with a drug that would block the negative effects of one or more of these suppressive cytokines on killer T cells might improve the vaccine's effectiveness in generating potent killer T cell antitumor responses.

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Related NCI materials and Web pages:

- National Cancer Institute Fact Sheet 4.21, *Human Papillomavirus (HPV) Vaccines: Questions and Answers* (http://www.cancer.gov/cancertopics/factsheet/Prevention/HPV-vaccine)
- National Cancer Institute Fact Sheet 7.2, *Biological Therapies for Cancer: Questions and Answers* (http://www.cancer.gov/cancertopics/factsheet/Therapy/biological)
- *Taking Part in Cancer Treatment Research Studies* (http://www.cancer.gov/clinicaltrials/Taking-Part-in-Cancer-Treatment-Research-Studies)
- *Understanding Cancer Series: The Immune System* (http://www.cancer.gov/cancertopics/understandingcancer/immunesystem)
- *Understanding Cancer Series: HPV Vaccine* (http://www.cancer.gov/cancertopics/understandingcancer/HPV-vaccine)

How can we help?

We offer comprehensive research-based information for patients and their families, health professionals, cancer researchers, advocates, and the public.

- ***Call*** NCI's Cancer Information Service at 1–800–4–CANCER (1–800–422–6237)
- ***Visit*** us at http://www.cancer.gov or http://www.cancer.gov/espanol
- ***Chat*** using LiveHelp, NCI's instant messaging service, at http://www.cancer.gov/livehelp
- ***E-mail*** us at cancergovstaff@mail.nih.gov
- ***Order*** publications at http://www.cancer.gov/publications or by calling 1–800–4–CANCER
- ***Get help*** with quitting smoking at 1–877–44U–QUIT (1–877–448–7848)

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