READINGS FROM

Understanding Cancer

A video and discussion workshop offered by

The Ohio State University Comprehensive Cancer Center –
Arthur G. James Cancer Hospital and Richard J. Solove Research Institute and
The Ohio State University Office of Distance Education and eLearning

The James

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What is cancer?

Video presented by Richard Goldberg, MD, physician-in-chief, professor of Medicine, Division of Medical Oncology, and associate director of outreach, James Cancer Hospital and Solove Research Institute

In one way, the word "cancer" is misleading because it seems to refer to a single disease. In reality, cancer is a general name for more than 100 diseases. We fit all of these diseases under the heading "Cancer" because they all share one important feature: They are caused by the uncontrolled growth of abnormal cells.

This uncontrolled growth is caused by an accumulation of changes in the cells' genes. The diseases we call cancer also usually share the ability to invade nearby tissue and to spread, or metastasize, to other organs of the body. Metastatic cancer cells are carried by the blood or lymphatic systems to other areas of the body, where they develop into secondary tumors. These are also called metastatic tumors.

Once cancer invades nearby tissue and spreads to other areas of the body, it is more difficult to cure. About half of the 1.1 million people who are diagnosed with cancer in the United States each year die of it because the disease spreads to other organs.

On the other hand, about half of the people who get cancer in the United States survive. A diagnosis of cancer is not an automatic death warrant. Advances in treatment have extended the lives of many patients with cancer, advances in pain control have reduced the suffering of cancer patients, and drugs have been developed to ease the side effects of many chemotherapy treatments.

"Understanding Cancer" is based on "Introduction to the Science of Cancer" a free, noncredit, online course offered by The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute and The Ohio State University Office of Distance Education and eLearning

For information or to register for the course visit: **http://go.osu.edu/scienceofcancer**.

Where cancers begin

All cancers begin in cells, the fundamental building blocks of the body. Healthy cells grow and divide in a very controlled and orderly way. If a cell's genes are damaged by a chemical taken into the body, the cell can usually repair the damage and continue living normally. If the damage is so great that the cell can't repair itself, the cell dies by a process of self-destruction called programmed cell death, or apoptosis.

Sometimes, however, damage to the cell's genes rewires its internal growth controls. These changes enable the cell to grow uncontrollably, forming a tumor. This is how cancer begins. You'll learn more about cells and the genetic changes that lead to cancer elsewhere in this booklet.

What damages cells in ways that lead to cancer? Things that can cause cancer are called carcinogens. They fall into several categories:

- Certain chemicals
  - Chemicals in tobacco products – especially when tobacco and alcohol are consumed together
  - Asbestos fibers inhaled into the lungs
  - Certain workplace chemicals, such as formaldehyde
  - Certain environmental pollutants
- Grains or other foods contaminated with certain molds that grow on stored food
- Medicines and synthetic hormones
- Certain viruses, including human papillomavirus (HPV), hepatitis B virus (HBV), hepatitis C virus (HCV), Epstein-Barr virus (EBV) and the human immunodeficiency virus (HIV)
- Ionizing radiation and the ultraviolet light in sunlight and tanning booths (the risk of cancer is low for the doses of X-rays received during medical examinations)

The main types of cancer

Long-term exposure to carcinogens can lead to cancer. When doctors diagnose cancer, they categorize it into one of several broad groups, depending on the type of cell in which the tumor originates:

- Carcinomas are the largest group. They begin in epithelial tissue, which includes the skin and the tissues that cover and line the internal organs. Examples include breast, lung, prostate or colon cancers
- Sarcomas originate in cells that form bone, muscle, fat, cartilage, blood vessels or other connective tissue
- Lymphoma and myeloma are cancers that begin in cells of the immune system
- Leukemias are cancers that begin in the bone marrow and other blood-forming tissues; they produce abnormal blood cells that enter the bloodstream

These categories are extremely helpful and will likely be used for some years to come. However, over the past decade, many studies have been done to identify the exact gene mutations and other changes that drive specific cancers, and the day is coming when a patient's lung or colon cancer will be referred to according to the key mutations that drive the cells to grow out of control. This information can help identify the most effective treatment for that patient's particular cancer.

This approach is called genomic medicine, or precision cancer medicine. It is giving us a much clearer understanding of cancer's causes, which in turn is improving our ability to detect and treat cancer.

The global burden of cancer

The kinds of cancer that are most prevalent are often different from one nation to the next. However, here are a few statistics to give you an idea of the global burden of cancer. The three most commonly diagnosed cancers worldwide for the year 2012 (and their percent of the total) were:

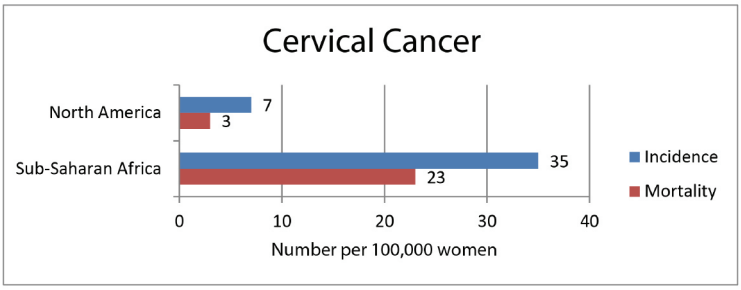
- Lung – 1.8 million cases (13 percent)
- Breast – 1.7 million (12 percent)
- Colorectal – 1.4 million (10 percent)

The most common causes of cancer death for 2012 were:

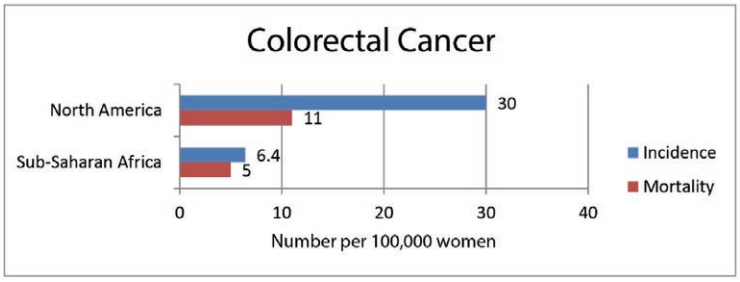
- Lung – 1.6 million (20 percent)
- Liver – 0.8 million (9 percent)
- Stomach – 0.7 million (9 percent)

A closer look reveals that cancer affects different countries and regions of the world to different degrees. Cervical cancer in North America, for example, affects about 7 per 100,000 women annually, and about 3 women per 100,000 (43 percent) die of the disease. In sub-Saharan Africa, however, it affects 35 per 100,000 women each year, and 23 women per 100,000 (63 percent) die of the disease.

For colorectal cancer, the incidence in North America is about 30 per 100,000 people annually, and 11 of 100,000 (39 percent) people die of the disease. In sub-Saharan Africa, only 6.4 new cases per 100,000 people are diagnosed yearly, and 5 people per 100,000 (83 percent) die of the disease.



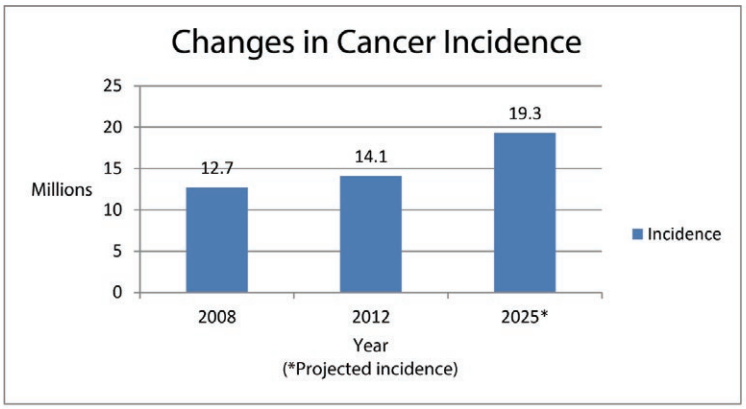
There are many reasons why certain cancers occur more commonly in some places than others. They relate to tobacco use, infectious diseases and the use of certain foods and drugs. They also include economic factors that influence the availability of screening programs, vaccination and access to early treatment. People living in affluent countries tend to have higher incidences of lung, breast, prostate and colorectal cancers. People from impoverished countries tend to have higher rates of stomach, liver, cervical and esophageal cancers, which are associated with infections.



Understanding the distribution of cancer within and between countries is essential for understanding what is causing those cancers. That, in turn, is essential for learning how to prevent them. Both cervical and colorectal cancers can be prevented through screening and early-detection programs. In fact, medical scientists believe half of cancer cases can be prevented. Cancer prevention is becoming ever more important.

In 2008, an estimated 12.7 million people worldwide were diagnosed with cancer, and 7.6 million people died of cancer-related causes. In 2012, the number of new cancer cases rose to an estimated 14.1 million, with 8.2 million cancer deaths. Also in 2012, more than half of all cancers (56.8 percent) and cancer deaths (64.9 percent) occurred in less developed regions of the world. These proportions will increase by 2025. Projections indicate that, by 2025, new cancer cases will increase to 19.3 million per year due to growth and aging of the global population.

This is an enormous cancer burden for societies and nations to bear. Preventing cancer is the only way to slow or reverse this growth in cancer incidence. This workshop, and the online course on which it is based, "*Introduction to the Science of Cancer*," are designed to help you better prevent cancer in your personal life, in your family and in your community.



Anatomy of a Cell

Video presented by Michael Ostrowski, PhD, professor and chair of Molecular Virology, Immunology and Medical Genetics, and co-leader of the Molecular Biology and Cancer Genetics at the James Cancer Hospital and Solove Research Institute

All cancers begin in a cell. This chapter will help you learn more about cells and their components. Cells are the basic building blocks of the human body. All human beings begin life as a single cell — a fertilized egg. That one cell contains all the genetic information needed to make a human being. The fertilized egg divides to produce two daughter cells, each with the same set of genetic information. The cell division continues in a very controlled way, producing generation upon generation of cells until a human being is formed. Along the way, certain cells differentiate to form the roughly 200 different types of cells that make up the tissues found in the human body. Here are a few interesting numbers about cells:

- The average human cell is about 10 microns across, or about 1/10th the thickness of a human hair
- The human body is made up of an estimated 37.2 trillion cells
- An estimated 1×10^{16} cell divisions take place in the human body over an average lifespan

Cells take many shapes, depending on their task in the body. They can be cubes, rectangles, spheres, flattened or star-like, like certain cells in the brain. Some cells even change shape as they mature. Cells of the skin, for example, begin as cubes but flatten to become squamous cells at the skin's surface, where they are sloughed off.

A typical cell has three main areas. Envision an avocado or a hard-boiled egg as a model of a cell:

- Inside, a typical cell has a nucleus, just like the avocado and egg have a pit and yolk. The cell nucleus contains the cell's genetic information, which is stored in the form of long strands of DNA
- While the avocado and egg are bounded by a skin and a shell, a cell is bounded by a membrane. But while avocado skins and egg shells are hard, the membrane surrounding a cell is a thin, delicate layer of lipid (fat) and protein
- Last, between the nucleus and the cell membrane is a region called the cytoplasm. Just as the human body has organs to maintain life and health, cells have structures called organelles that maintain the life and health of the cell. These organelles reside in the cytoplasm, and many of the important events that occur in cells, such as the making of proteins needed for life, take place there also.

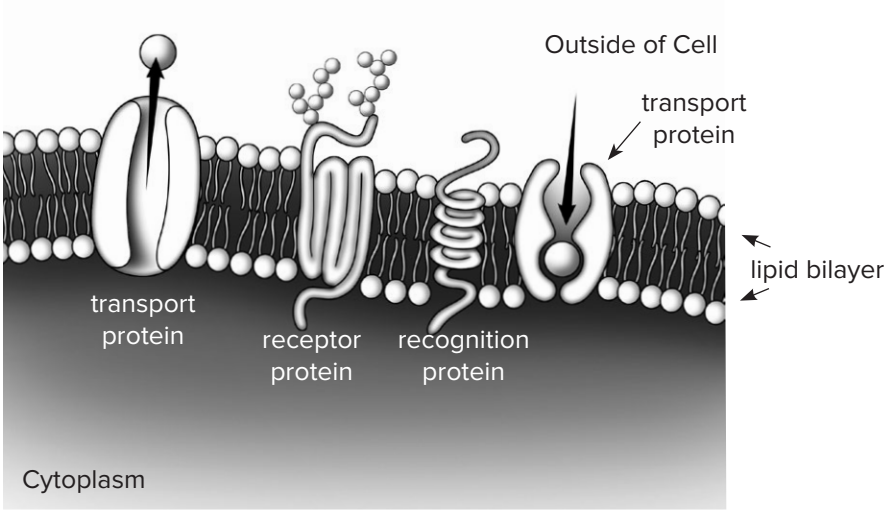
Cell membrane

The cell membrane, also called the plasma membrane encapsulates the cell and plays an important role in cancer. The membrane is made of fat-like lipid molecules. These molecules have a head that is water-loving, or hydrophilic, and two tails that are water-hating, or hydrophobic. In the cell membrane, these lipid molecules lie side by side — heads out, tails in — to form a double layer called a lipid bilayer.

The lipid bilayer is the structural framework of the cell membrane. From the outside, it might appear like a ball formed of marbles. Penetrating this spherical wall of marbles are potato-shaped and spaghetti-like objects. These are protein molecules that carry out the activities of the membrane. Many membrane proteins fall into one of three groups:

- **Receptor molecules**, also called cell-surface receptors. These molecules work like switches. They are activated by hormones, growth factors and other substances in the body and cause changes in cells. Receptor molecules play an important role in cancer

- **Transport molecules** help control what enters and leaves cells
- **Recognition molecules** function like flags and signposts. They allow cells to identify and interact with one another.



The cell membrane is made of a lipid bilayer embedded with protein molecules that do a variety of jobs.

A closer look at receptor molecules

Cell-surface receptor molecules extend from the cell surface at one end, and poke down below the cell membrane at the other end. There are many types of receptor molecules, and each is sensitive to a particular substance, such as a hormone and growth factors. When a hormone links to, or binds with, its receptor, it sends a message to one or more genes in the cell nucleus. The message can turn on or turn off the activity of that gene or genes and cause the cell to divide or behave in a certain way.

In some cancers, cells have too many of certain receptor molecules, causing the cells to grow when they shouldn't. For example, in many cases of breast cancer, breast cells have too many receptors for the hormone estrogen. As a result, estrogen in the body stimulates the growth of such tumors. Similarly, many cases of prostate cancer occur because certain prostate cells have too many androgen (male hormone) receptors. The hormone testosterone promotes the growth and progression of these tumors. Such estrogen-receptor-positive and androgen-receptor-positive tumors are treated with drugs that block the receptors so that the hormone cannot activate the receptor and promote tumor growth. (Note: Estrogen and androgen receptors are found inside the cell, not on the cell surface.)

Transport molecules help control which molecules enter and leave cells. Some form pores in the cell membrane; others open and close like gates to control the movement of molecules into and out of the cell. Certain transport proteins are present in cancer cells at abnormally high levels enabling the cells to resist chemotherapy drugs. When the transport protein called P-glycoprotein, for example, is overactive in cancer cells, it pumps an anticancer drug out of the cell before the drug can kill the cancer cell.

Recognition proteins help cells identify and interact with one another. Recognition proteins or the lack of them play important roles in cancer. Normally, cells touching other cells through recognition proteins help control the growth of healthy cells. Cancer cells overcome this control to form a tumor, invade neighboring tissues and spread or metastasize—to other areas of the body.

Immune cells use recognition proteins to tell whether another cell is part of the body or whether it is foreign and should be destroyed. Bone marrow transplants are used to treat leukemias and other cancers. If the donated immune cells come from another person, they can sometimes recognize the patient's tissue as foreign and attack it. This response is called graft-versus-host disease, and it can be fatal if not successfully treated.

The nucleus

The nucleus is a sphere within the cell that contains genetic information. The nucleus is also bounded by a lipid bilayer and has pores that allow molecules to move from the nucleus into the cytoplasm and back. The genetic information in the nucleus is stored as 23 pairs of chromosomes—one pair comes from the person's mother and one from the father.

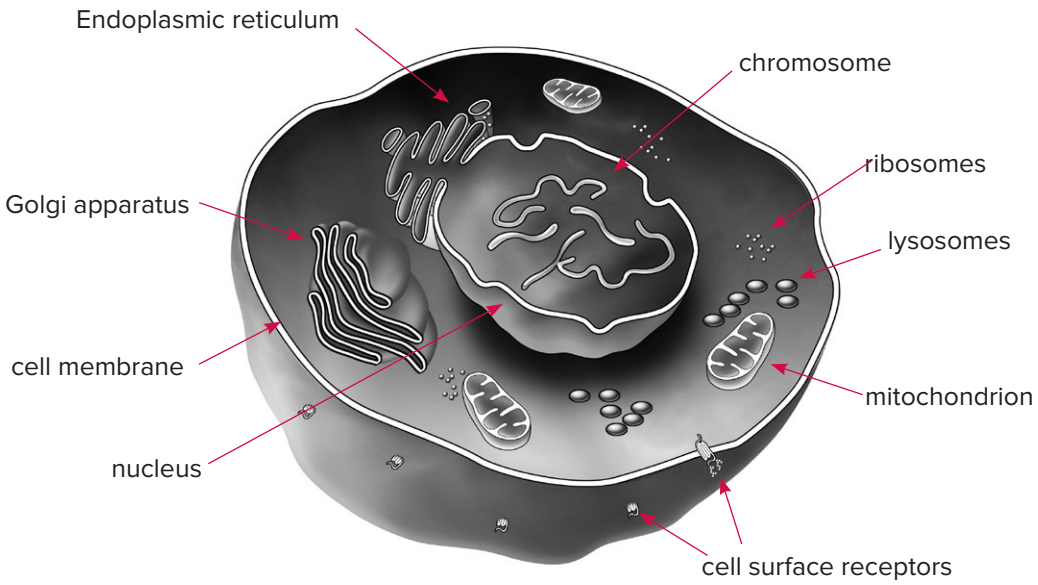
Each chromosome is a strand of DNA that is divided into genes and has a coating of proteins. Human beings have about 20,000 genes total. The entire set is called the genome. Damage to a cell's DNA results in changes to one or more genes, and sometimes to chromosomes. Such damage is the fundamental cause of cancer.

Cell cytoplasm

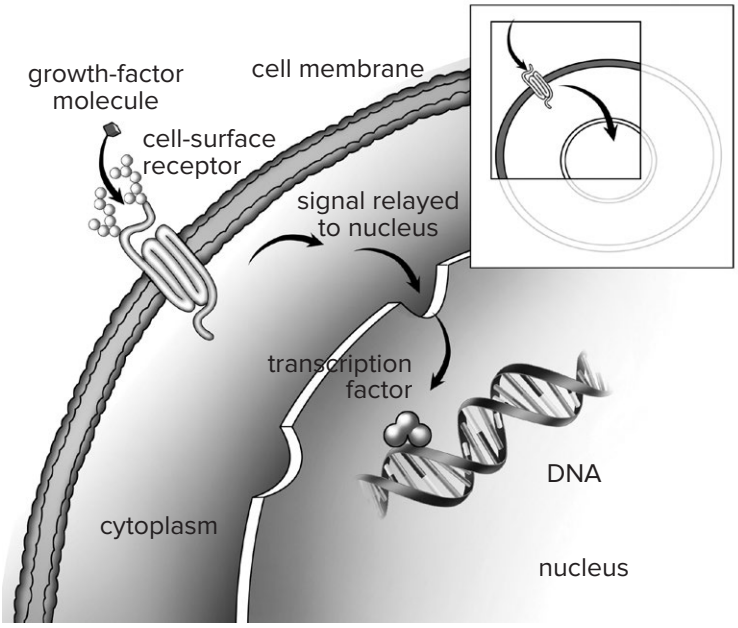
Cells have a variety of organelles located in the cytoplasm. Each performs specific functions that help maintain the life and health of the cell and enable the cell to carry out its function. The types of cell organelles include:

- **Nucleus with chromosomes**
- **Mitochondria**, which are factories that produce the energy needed by the cell—and the body—for life; they produce this energy using glucose, oxygen and water
- **Lysosomes**, which are packages of enzymes
- **Ribosomes**, which are tiny organelles involved in synthesizing proteins
- **Endoplasmic reticulum**, which form channels within cells that are involved in synthesizing proteins and lipids
- **Golgi complex**, which is layers of sack-like spaces that package proteins that are to be released, or secreted, by the cell
- **Microtubules** (not shown), which form a cell's skeleton and help move chromosomes during cell division.

Much of the business of cells involves producing energy and making proteins and other molecules needed for life. Cancer cells in particular need energy and produce molecules needed for growing and dividing. Cells complete these tasks using the information stored in their DNA and the organelles in their cytoplasm. Often, how cells behave, whether they grow and divide, is controlled by chemical messages received by the receptor molecules on their surface.



A generalized cell.



Signal transduction pathways

How do messages received by receptors at the cell surface cause changes in genes deep inside the cell nucleus? Such signals can tell breast tumors to grow, for example. Cells in a woman's breast have receptors for growth factors. When growth factors molecules in the bloodstream attach to, or bind with, these receptors, they activate the receptor, causing the end of the molecule inside the cell to change shape.

Here's a simplified diagram showing how signals are transmitted through cells. When a growth factor binds with the receptor, it triggers a chemical signal that travels through the cytoplasm to the nucleus. There, special proteins called transcription factors bind with DNA and activate genes that cause the cancer cells to grow and divide.

DNA, RNA and Proteins

Video presented by Kathleen Boris-Lawrie, PhD, professor and researcher, James Cancer Hospital and Solove Research Institute

DNA, RNA and proteins are three fundamental constituents of living cells. They form a tightly coordinated trio that maintains the life and the health of cells. They also play an important role in cancer.

- DNA stores genetic information
- RNA transports and translates that genetic information to make proteins
- Proteins make up the enzymes and other elements essential for the life of the cell and the health of the body

DNA, or deoxyribonucleic acid

DNA is found mainly in the cell nucleus, in the form of chromosomes.

- DNA is the genetic material in human beings and in nearly all living animals and plants
- It stores the information that cells use to make the proteins they need
- These proteins enable the cell to produce all the other substances needed for life
- DNA uses a four-letter code to store this information. The four-letter code is spelled out by the arrangement of molecules called bases that form the cross pieces in the DNA strand, as in the DNA figure. For this reason, DNA is said to “encode” or “code for” the proteins needed by the cell. In human cells, molecules of DNA take the form of a double-stranded helix that occurs in long filaments.

RNA, or ribonucleic acid

The DNA in human cells has one function: storing information. RNA, however, has several functions and takes different forms. RNA is also the genetic material in many types of viruses, including HIV. RNA helps the cell make proteins. For example, one type of RNA carries genetic messages from the cell nucleus to the cytoplasm. This is called messenger RNA, or mRNA. Another type of RNA, called microRNA, helps control the kinds and amounts of proteins cells make.

Proteins

Protein molecules are composed of chains of amino acids. The sequence of amino acids in the chains determines the final shape of a protein. The shape is critical to the function of the protein. Proteins in the food we eat serve as a source of essential amino acids that are used by cells to make the proteins they need. Cells make many kinds of proteins that are vital to the life of the cell and to the health of the body.

How information stored in DNA becomes a protein

It happens through a process called protein synthesis, which occurs in three basic steps:

Step 1: Gene transcription

A chromosome is a length of DNA that is divided into genes, much like a roll of paper towels is divided into sheets. During gene transcription, the DNA strand around the gene unwinds and the information in the gene, or the message it contains, is copied into the form of RNA. The RNA is called messenger RNA, or mRNA.

Step 2: Processing of the messenger RNA, or mRNA

Portions of the mRNA are cut out and removed. The remaining, edited, mRNA molecule then leaves the nucleus and enters the cell cytoplasm.

Step 3: Translation
In cytoplasm, the information encoded in the strand of mRNA is “read” by small structures called ribosomes. The ribosomes move along the strand of mRNA reading the sequence of base and as they do so, amino acids are incorporated one by one to a growing chain that will become the final protein.

Genes and the Changes That Lead to Cancer

Mutations are flaws that occur in genes. They are the fundamental cause of cancer. They can occur spontaneously, and usually the cell can repair the mutation. But sometimes the damage is serious; the cell cannot repair it. In fact, sometimes the cell's DNA repair machinery is itself damaged and is unable to make the repairs. DNA damage that remains unrepaired is a gene mutation.

Cancer-causing agents are called carcinogens. Examples of this include: chemical agents such as benzene, which is in paint thinner; physical agents such as ultraviolet light, which is felt as sunburn; and viruses such as human papillomavirus and hepatitis C.

Genes carry information that a cell uses to make a protein. A gene mutation causes an error, a typo, in that information. When cells make that protein, they first make a copy of the gene in the form of messenger RNA. The mRNA leaves the cell nucleus and travels to the cytoplasm. There, the protein-making machinery reads the RNA message and assembles amino acids into the protein.

The presence of a typo, a gene mutation, in the DNA can cause the mRNA to carry information that leads to a defective or incorrectly made protein. Sometimes, the error, has minimal effect. Other times, the defect can lead to an abnormal protein, such as an enzyme that works too much or too little. Either way, mutations that cause defective proteins often cause cells to become cancerous.

Exposure to carcinogens causes gene DNA damage to accumulate over time, which is why cancer usually takes years to develop. There are three important ways that gene mutations can affect cells and lead to cancer:

- They can cripple DNA repair mechanisms, allowing mutations to accumulate
- They can make genes overactive, like an automobile with a stuck accelerator. These genes constantly churn out their protein, causing cells to grow and divide without regulation. When normal genes become hyperactive because of mutations and cause the cell to proliferate, they are called oncogenes. The prefix "onco-" means tumor
- Mutations can also turn off genes that should be active, including tumor-suppressor genes, which normally protect cells from becoming cancerous.

The presence of oncogenes and the silencing of tumor-suppressor genes are the critical events that transform healthy cells into cancer cells. To summarize, oncogenes make too much mRNA and protein. The silencing of tumor-suppressor genes causes genes to produce too little of their cancer-protecting protein. Both are examples of changes in gene expression. You can learn more about this critical event in the supplemental reading called "How Genes Express Themselves...Or Not."

Diagnosing Cancer

Video presented by Tanios Bekaii-Saab, MD, associate professor of Medicine and of Pharmacology, and section chief, Gastrointestinal Oncology

A diagnosis of cancer can begin in several ways. A person might notice one of cancer's warning signs. There can be many causes for each of these warning signs, but a person who is experiencing one of them should see a doctor to learn why. These warning signs include:

- A lump under the skin, such as one detected during a breast or testicular self-exam
- Blood in the urine or stool, stool that is black, or an unusual discharge from the nipples
- Bleeding from the vagina that is not related to the menstrual cycle
- A change in bowel or bladder habits
- An obvious change in a mole or wart, or a new skin change
- A sore that does not heal, gets bigger over time or starts bleeding
- A nagging cough or hoarseness
- Difficulty swallowing due to pressure in the throat or chest
- Unplanned weight loss of 10 pounds or more

A diagnosis of cancer might also begin if a physician notices something unusual during a physical exam; during a screening exam for breast, cervical, prostate or colorectal cancers; or while treating a person for a noncancerous condition. Individuals who are concerned they might have cancer should see their primary care physician. If that doctor believes the person might have cancer, he or she is likely to refer the person to an oncologist, a physician who specializes in the diagnosis and treatment of cancer. The oncologist will coordinate the tests needed to confirm a cancer diagnosis and develop a treatment plan.

The oncologist will then obtain a detailed personal history of the patient and order several laboratory tests, which usually include blood counts, blood chemistry and liver function. Other tests the oncologist might order include imaging and a biopsy, which involves taking a sample of the tumor tissue. The biopsied tissue might then be tested for tumor markers or cell-receptor status.

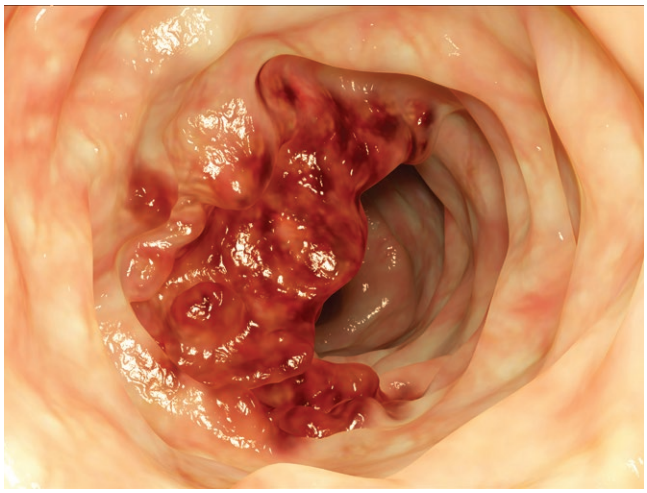
Imaging tests

Imaging tests might be ordered to help locate a tumor in the body and learn whether it has spread from its original site to other parts of the body. Common kinds of imaging studies include:

- **X-rays**, which use low levels of radiation to produce one-dimensional images. They are useful for seeing bone and joint problems, and images of the lung, bowel, bladder and kidneys
- **Mammography**, specialized X-rays of the breast that show details of breast tissue and can confirm whether a lump is suspicious for cancer
- **Ultrasound**, which uses high-frequency sound waves that bounce off organs and tissues to produce images called sonograms. Special ultrasound machines called Doppler flow machines can show whether blood is moving smoothly through vessels
- **Computerized tomography (CT) scans**, which are X-ray-like images compiled by a computer that show 2-D cross-sectional images of the body. By stacking the slices, a computer can produce 3-D images that provide additional information about some cancers

- **Magnetic resonance imaging (MRI)**, which uses powerful magnets, rather than radiation, to create cross-sectional images of the body. MRI scans are another way to see certain cancers. They may be used instead of a CT scan or to complement a CT scan
- **Nuclear medicine scans**, which use substances such as radioactive sugar that release low levels of radiation. Certain cancers absorb the substances, and this confirms activity of a tumor identified by CT scan or MRI

Imaging tests are extremely useful in cancer diagnosis, but they have limitations. For example, tumors must reach a certain size before they can be detected by these imaging methods. Occasionally these methods detect something that looks like cancer but that a biopsy subsequently shows is not.



A colon tumor seen through a colonoscope.

Examining hollow organs

Using instruments that consist of tubes with cameras and a light, doctors can inspect, photograph and biopsy cancers located in hollow organs such as the esophagus, larynx, bronchi, stomach, large intestine and bladder. Examples of these instruments include endoscopes, which are used to examine the esophagus and stomach, and colonoscopes, which are used to examine the colon. Here, for example, is how colon cancer can look during a colonoscopy.

Endoscopes and similar instruments allow direct visualization of a tumor. Some of these instruments also include ultrasound, which provides a view of surrounding tissues and lymph nodes.

Biopsy

A definitive diagnosis of cancer requires a biopsy. Biopsies involve removing a small amount of tumor tissue from the body and examining it under a microscope to confirm that cancer cells are present. Solid-tumor biopsies can be done in several ways, depending on the size and type of tumor:

- Needle biopsy uses a large-bore needle and local anesthetic to obtain a small core of tumor tissue
- Incisional biopsy involves surgically removing a small area of tumor tissue. It can often be performed with a local anesthetic on an outpatient basis
- Excisional biopsy is the surgical removal of an entire tumor for analysis. It requires local or general anesthesia and is frequently used for breast tumors less than about an inch in diameter. This is also called a lumpectomy
- Fine-needle aspiration uses a syringe with a thin needle to suction cells from a suspected tumor.

Tumor markers

Tumor markers are generally substances made by cancer cells or by other cells in the body in response to a tumor. They can be proteins, hormones or enzymes that are present at higher-than-normal levels when certain cancers are present. Most of them are found in blood or urine. Some help in making a cancer diagnosis or determining that a patient's cancer has returned. Others are used to help determine a patient's treatment and prognosis.

Chromosomal changes that occur in cancer cells, particularly in hematologic bloodcancers, have long played a critical role as prognostic markers for leukemias and lymphomas, and for determining the best treatment for a particular patient.

Doctors sometimes use the gene mutations present in a patient's tumor cells to identify tumors that will respond to certain targeted therapies. These tests use genomics and gene-sequencing technologies, and they are playing an increasingly valuable role in cancer diagnosis and in determining the most effective treatment for individual patients.

Receptor testing

Biopsied cancer cells from breast and prostate tumors are often tested for the presence of hormone receptors. These receptors are molecules forward inside cells that are sensitive to estrogen in breast cancer and to testosterone in prostate cancer. The presence of the receptors in tumor cells suggests that estrogen and testosterone promote the growth of the tumor and that drugs that block the receptors will help control the cancer. The absence of these receptors, generally indicates a more aggressive form of the disease and suggests that more aggressive therapy is needed.

Sometimes the extent of a tumor's development is not known until a patient undergoes surgery. At that point, the surgical oncologist can determine the size and extent of the tumor's spread, a process known as pathologic tumor staging. Tumor staging helps determine a patient's prognosis (an estimate of how well a patient is likely to do following treatment), which therapy is appropriate and whether the therapy is working.

When visiting a doctor for a possible cancer diagnosis

When you go to the doctor to learn your diagnosis, take a loved one or trusted friend with you. Hearing that you have cancer can leave you in shock or disbelief, which makes it very difficult to pay close attention to the rest of the doctor's message. You could miss important information that is related to your treatment and other preparations. A loved one or friend can help you take notes and recall what was said. It's also important to know certain things about your diagnosis before you leave the doctor's office. If you don't know the answers to the following questions, ask your doctor or nurse. The information could be helpful to you later:

- What type of cancer do I have?
- Where is it located?
- What is the stage of my cancer—has it spread to other areas of my body?
- What treatments are available for my cancer?
- What symptoms should I expect from this type of cancer?
- What support services are available to me and to my family?
- Is it possible to identify genetic mutations that will help determine if this is an inherited cancer or a cancer that can be matched to available therapies?
- Is there anything else I should know?

If you discover a lump, experience an unusual discharge or detect another early warning sign of cancer, see a doctor. The problem might not be cancer at all—in fact, most often it is not. But if the problem is cancer, the earlier it is found, the better the chance of a successful treatment.

Treatment of Cancer

Video presented by Joseph Flynn, MD, co-director, Division of Hematology and director of clinical operations

When it comes to cancer, we should do all we can to lower our risk of cancer. But even if we do, cancer can occur. In the United States alone, about 1.7 million new cancer cases are expected to be diagnosed in 2015, and an estimated 590,000 people are expected to die of cancer with about 171,000 of these deaths due to tobacco smoking. When cancer happens, it's important to detect it early, when treatment is often most successful. See a doctor if you experience any of cancer's early warning signs, which were described in "Diagnosing Cancer."

Once cancer is diagnosed, the oncologist will determine a treatment plan that is best suited for that patient and type of cancer. Critical factors that influence treatment decisions may include:

- The type of cancer and its location in the body
- The cancer's stage and grade
- The patient's age and general physical condition
- The patient's other medical conditions, such as diabetes, hypertension or heart disease
- The presence or absence of chromosome damage in the patient's cancer cells
- Certain gene mutations in the patient's cancer cells
- The presence or absence of molecules within the patient's cancer cells or molecules called cell-surface receptors that may be on them.

In many cases, oncologists will present the diagnosis and important details of the case at a tumor board, which is a meeting of surgical oncologists, medical oncologists, radiation oncologists and others who specialize in cancer treatment. The group discusses the case and possible treatment options and then recommends a treatment plan for the patient and family. In difficult cases, a patient's oncologist might consult with specialists at other institutions for additional recommendations.

Evidence-based medicine – treatment guidelines

To help determine the optional treatment for a patient's cancer, doctors might also refer to journal articles, Internet resources and treatment guidelines that are developed and published by professional organizations such as the National Comprehensive Cancer Network in the United States. These guidelines are developed by experts who review the evidence from clinical trial findings and other research, judge the strength of that evidence and write the recommendations, which caregivers worldwide may follow. The recommendations often also note whether the strength of the evidence is strong, moderate or weak.

Standard of care vs. clinical trials

These guidelines also help define the standard of care for a disease. The standard of care is the treatment that is accepted as optimal for a particular disease and is widely used by healthcare professionals. Other names for standard of care include standard therapy or best practices.

Some types of cancer, and many advanced cancers, lack standard of care, or the standard of care might be no treatment at all. In these cases, an oncologist might recommend that a patient enroll in a clinical trial. Clinical trials are studies that test the safety and effectiveness of new, innovative anticancer drugs in humans. The treatments available through clinical trials may not have been fully tested, and they are often not available to doctors generally.

People with cancer who have few remaining treatment choices should always be offered palliative care. The goal of palliative care is not to cure the cancer, but to help improve the patient's overall quality of life whether it be to keep the patient comfortable, to control pain, or to provide other support to patients and their families.

Main forms of cancer treatment

Cancer therapy may be given for a number of reasons, including:

- To cure the disease
- To prevent an early-stage tumor from progressing to advanced cancer
- To prevent cancer by eliminating precancerous cells before they become malignant

The methods and technologies available for treating cancer are typically used in various combinations. The chief forms of cancer treatment are:

- Surgery
- Medications such as chemotherapy and targeted therapies
- Radiation therapy
- Transplantation of blood-forming stem cells

Each type of treatment is administered by oncologists who specialize in that particular treatment. Here's a look at each modality and examples of how they've been modified to improve effectiveness, reduce treatment side effects and improve patients' quality of life.

Surgery

Surgery involves the removal of a cancerous tumor, or as much of the tumor as possible, in an operation. Some cancers, such as skin cancers, can be cured by surgery alone. Often, surgery is combined with chemotherapy or radiation therapy. Here are some examples of the different ways that surgery can be done to treat cancer:

- **Open surgery** is the typical kind of operation that involves removal of the tumor through an incision.
- **Minimally invasive surgery**, also called laparoscopic surgery, is performed with a long, flexible, tube-like instrument called a laparoscope. The laparoscope, which is equipped with a light and lens for viewing, is inserted through a small incision. A separate similar instrument that has a tool on the end for removing tissue may be inserted through a second small incision.
- **Robot-assisted surgery** is a form of minimally invasive surgery. In this instance, the surgeon sits at a console and manipulates mechanical arms with tiny surgical instruments to perform surgical procedures.
- **Cryosurgery** uses a probe to apply extreme cold to kill cancer or precancerous cells. Cryosurgery is important in the prevention of cervical cancer in developing countries, for instance. Programs that screen women for precancerous changes on the cervix use cryosurgery as an effective, inexpensive way to kill these precancerous cells before they progress to cervical cancer. Doctors can also apply heat or use laser therapy to achieve similar outcomes.

Drug therapy

Chemotherapy is the oldest form of drug therapy for cancer. It may be used to treat both solid tumors and hematologic malignancies (cancers of the blood), often in combinations of two, three and sometimes more drugs. When treating solid tumors, doctors often use chemotherapy agents in conjunction with surgery or radiation. The drugs can be given before, during or after surgery.

- For instance, chemotherapy can be used before surgery to shrink the size of a tumor, allowing the surgeon to remove it more easily. This use is called "neoadjuvant chemotherapy."
- Chemotherapy is often used after surgery to kill any small or hidden clusters of cancer cells and keep the tumor from returning. This use is called "adjuvant chemotherapy."
- Finally, chemotherapy can be used to kill metastatic cancer that is not amenable to surgery or radiation.

Other forms of drug therapy for cancer include:

- **Targeted therapies**, which are drugs designed by pharmaceutical chemists to attack specific molecules found on or inside cancer cells, thus inhibiting or blocking their activity.
- **Hormone therapy**, which is used to either mimic or prevent certain hormones from nurturing the growth of certain cancers.
- **Immunotherapy (or immune therapy)**, which involves the use of drugs that are designed to stimulate the patient's immune system to attack the tumor. For example, antibodies can be developed to target specific molecules on cancer cells. The antibodies bind to the target molecule, causing the cells to die.
- **Oncolytic virus therapy**, which is an innovative cancer treatment being tested at Ohio State and elsewhere for the treatment of brain cancer and certain other cancers. It involves special viruses that are altered in the laboratory to kill cancer cells. The cancer-killing, or oncolytic, virus is injected into the tumor during surgery, or into the tissue that surrounds the tumor. The viruses then replicate in cancer cells, killing them.
- **Biological therapy**, which includes a variety of substances made by living organisms that are used to treat disease. Examples include antibodies used in immune therapy and agents that stimulate immune responses.

Radiation therapy

Radiation therapy uses high-energy forms of radiation to kill cancer cells. You may be familiar with the two main categories of radiation treatments for cancer:

- **External beam radiation** treats cancer using a beam of high-energy X-rays that originates outside the body. The X-rays are produced by a large machine called a linear accelerator. Radiation technology has greatly advanced in recent years. These advances allow radiation therapists to adjust the beam in ways that kill tumor cells more effectively while protecting healthy cells.
- **Internal radiation**, also called brachytherapy, uses small seeds of radioactive material that are implanted in the tumor or in tissue surrounding the tumor. In this case, the radiation used to kill the cancer cells originates inside the body.

Transplantation of blood-forming stem cells

Stem-cell transplantation is most often recommended for the treatment of certain leukemias, multiple myeloma and some lymphomas. It is also sometimes used to treat solid tumors. Blood-forming stem cells are immature blood cells found in the bone marrow and, in lower numbers, in the bloodstream. They are called stem cells because they can give rise to other kinds of blood cells, such as white blood cells that make up the immune system, red blood cells and blood platelets, which enable healing by forming blood clots.

Leukemia, multiple myeloma and lymphoma are all cancers of blood cells. Treating these cancers can require the use of high-dose chemotherapy that kills the malignant white cells. Unfortunately, these drugs also may kill healthy blood cells. In effect, the treatment wipes out the immune system, which leaves the patient vulnerable to infections. So before the chemotherapy is given to the patient, blood-forming stem cells are isolated from the bone marrow or blood of the patient or a donor and stored in a laboratory. After the chemotherapy treatment, the cells are infused back into the patient, where they migrate to the bone marrow and restore the patient's blood system.

Does treatment cure cancer?

Physicians have a vast array of tools for treating and potentially curing cancer. The odds that cancer will not recur depend on the type of cancer and the extent of the disease when treated. Extent of disease refers to whether the tumor was localized (confined to the organ in which it originated) or whether it had spread to nearby lymph nodes or to distant areas of the body.

Treating cancer when it is still localized can often cure the disease. This means it is vital to be vigilant for early signs of cancer and, as much as possible, adhere to cancer prevention strategies.

The future of cancer treatment

We live in an era that has brought extraordinary improvements in our ability to prevent, diagnose and treat cancers. We will see continued progress in the development of targeted therapies that will change how we think of cancer care. Patients can expect specific combinations of medications that bind to different targets on the tumor, allowing clinicians to personalize care. This will allow us to expand the number of survivors and to offer safer, better-tolerated and more-effective cancer treatments.

Treatment Regimens

Video presented by Michael R. Grever, MD, professor of Internal Medicine, co-leader of the Leukemia Research Program at Ohio State's Comprehensive Cancer Center James Cancer Hospital and Solove Research Institute

When physicians treat cancer with the intent to cure the disease, they generally combine several treatments in an attempt to eliminate all cancer cells from. Even a single surviving cancer cell can cause a cancer to return. For solid tumors, combination therapy can mean:

- Using surgery to remove the cancer locally
- Using radiation therapy to kill cancer cells regionally (that is, in tissues surrounding the tumor)
- Treating the cancer systemically by using chemotherapy or targeted drugs that are carried by the blood throughout the body to kill tumor cells that might have lodged in distant tissues

In the case of leukemia or another cancer of the blood, there is no solid tumor to remove, but physicians use combinations of drugs over several treatments to drive the leukemia into remission. The treatment of acute myeloid leukemia, or AML, is an example of using chemotherapy to achieve a cure. In contrast, chemotherapy for patients with chronic leukemia is targeted for disease control.

- **For patients with acute leukemia, induction therapy** is the first treatment given for the disease after diagnosis. The goal is to drive the leukemia into remission. The treatment is designed to decrease or eliminate cancer cells from the blood and bone marrow.
- **Consolidation therapy** is used after induction therapy to kill any cancer cells that might be left in the body. The goal is to keep the patient in remission and attempt to cure the leukemia. Consolidation therapy can include stem-cell transplantation, or chemotherapy or targeted drugs to kill any remaining leukemia cells.

Intensive therapy is used for patients with relapsed AML or those whose leukemia doesn't respond to induction therapy. Best supportive care is given to patients who are too old, too frail or have other conditions that leave them unable to endure the rigors of induction and consolidation therapy.

Genomic instability

Why are cancer cells so difficult to kill? It has to do with their biology and the genetic differences that arise among them as the disease develops. When healthy cells divide, they repair any DNA damage and replicate their entire genome very precisely. The resulting "daughter cells" are genetically identical and genetically stable. Cancer cells divide in spite of having gene mutations and other changes, and the two resulting cells often have many genetic differences. When gene mutations knock out DNA repair mechanisms, additional mutations can accumulate even faster. This condition is called genetic instability. It means that there are many genetic differences between cancer cells within malignant tumors.

Each gram of tumor tissue has millions of cells, and so many mutations occur in that cluster of cells that chance alone dictates that at least one cell will likely have the needed mutation. That one cell will survive and produce another tumor. Cancer therapy can often wipe out the disease entirely, sending leukemia into remission or dissolving solid tumors. But if one cell acquires the right assortment of mutations, it will survive and might produce another tumor, causing the cancer to recur. The recurrent tumor will consist of cells that are ever-more resistant to one or more anticancer drugs or to radiation therapy.

The same events can occur with targeted therapies. Patients can achieve almost complete remission, but the tumor returns because the tumor cells develop resistance to the drug. Resistance to targeted drugs can involve a small mutation that changes just one amino acid in the target protein in the tumor cell.

This is a serious problem. Recurrent cancer and metastatic cancer are often incurable. The best opportunity for curing cancer is when it is detected early and treated with therapies that will, as much as possible, eliminate the tumor and all cancer cells from the body to prevent disease recurrence.

Treatment regimen examples

Here are brief overviews of how several common cancers—prostate, cervical and chronic lymphocytic leukemia—are treated when diagnosed at an early stage and when diagnosed at a late stage. Prostate and cervical cancers can be detected early when appropriate treatment can often cure them. Many factors influence the treatment that is best for each cancer patient, such as the patient's general physical condition, age and the presence of other illnesses such as diabetes or cardiovascular disease. Test results and molecular features of the tumor also have an impact on outcome. All of these factors contribute to the complexities of cancer therapy.

Prostate cancer treatment

Prostate cancer, the second-most-common cancer in men worldwide, can often be detected early by annual digital-rectal exam screening and by monitoring the level in the blood of prostate-specific antigen, or PSA. This is secreted into the blood by prostate cells, and rising PSA levels suggest that a man should be examined further for prostate cancer.

In men with early-stage prostate cancer, the tumor is often still confined to the prostate gland. These tumors can be treated in one of three ways. Which treatment to choose should be discussed with the patient's multidisciplinary care team. The team should include both a urologist and a radiation oncologist. The team can recommend the best approach, which could include radiation, surgery or, in selected elderly patients, watchful waiting.

In advanced-stage prostate cancer, the tumor has spread beyond the prostate and cannot be cured by surgery or radiation therapy alone, so hormone therapy is used. Rather than trying to kill the cancer, hormone therapy starves the tumor of the male hormones called androgens, such as testosterone and dihydrotestosterone, which stimulate its growth. The goal is to slow, stop or reverse tumor growth. This treatment is called androgen-deprivation therapy. Strategies to deprive the tumor of androgen hormones include:

- Surgical removal of the testicles, which is called an orchiectomy
- Drugs that stop the testicles from making androgens
- Anti-androgen drugs, which block androgens from working.

Often, prostate cancer develops resistance to these drugs, and they stop working. At that point, it may be advisable to enroll the patient in a clinical trial evaluating new agents for treating prostate cancer. They may include monoclonal antibodies (a form of immune therapy), cancer vaccines, and new smart drugs or targeted therapies. Research is also under way to develop new therapies to overcome resistance.

Cervical cancer treatment

Cervical cancer can be prevented through early detection and treatment of precancerous changes on the cervix. These changes can be identified through cervical screening using the Pap test, HPV DNA test or the low-tech screening method called visual inspection with acetic acid, or VIA.

When a woman is diagnosed with early cervical cancer (stage I-II), the treatment usually involves a hysterectomy to remove the tumor. In patients who want to preserve fertility, it means removal of the cervix. Additionally, lymph nodes are usually removed to make sure there is no spread of the cancer. In

about 30 percent of early-stage cases, the cancer has spread from the cervix to nearby tissues or lymph nodes. This requires treatment with radiation and low-dose chemotherapy after surgery. Patients who are not good candidates for surgery, or who are not recommended to have surgery, are treated using radiation. The prognosis for early-stage patients treated with radiation and those treated with surgery is the same.

Treatment of advanced cervical cancer, stage IIB-IVA, generally includes radiation plus chemotherapy. Surgery is not done to remove the tumor at this stage because surgery does not improve survival but adds to the risks of treatment.

For cervical cancer that has spread to distant organs, stage IVB cervical cancer, the goal is to control the cancer's growth as much as possible using palliative systemic chemotherapy. Palliative therapy is designed to relieve pain and other symptoms of cancer, rather than to cure it. Cervical cancer that has spread to distant organs is curently incurable.

Radiation for cervical cancer involves daily treatments with external-beam radiation for five to six weeks. In addition, patients receiving radiation usually also receive chemotherapy once weekly during each week of the radiation. In brachytherapy, tiny radioactive seeds are implanted in the cervix to kill cancer cells.

Chronic lymphocytic leukemia (CLL)

Hematologic malignancies such as CLL usually involve the bone marrow, blood, and often lymph nodes and spleen. Therefore, even when detected early, these malignancies, sometimes known as cancers of the blood, usually show widespread involvement, and local measures of cancer treatment like radiation therapy or surgery rarely apply.

Patients may present with bleeding, bruising, infection and fatigue, reflecting anemia and decreased blood cell production. The malignant diagnosis is usually confirmed by examining the blood or bone marrow. Diagnostic studies of the malignant cell confirm the type of leukemia and often provide information about the prognosis. CLL is the most common form of adult leukemia. After diagnosis, patients are followed until symptoms develop or the blood tests show progressive anemia or low-level platelet counts.

The aim of treatment is to control the leukemia and improve the blood counts. The disease is disseminated, so treatment involves using systemic therapy (for example, chemotherapy or immune-based therapy). Older patients or those with multiple complex medical conditions are usually treated with less intense therapies. Patients with either progressive or less responsive disease may receive a stem cell transplant.

Cancer treatment can be complex and varied, depending on multiple factors such as the type of cancer, a patient's age, general health, and the extent or stage of the disease. Today there are more ways to treat cancer than ever before, and even better treatments are on the way. Even so, the treatment of cancer will remain complex and costly. In the end, the challenges of cancer treatment underscore the importance of preventing cancer whenever possible.

Preventing Cancer

Video presented by Cassandra N. Grenade, MD, assistant professor in the Division of Medical Oncology and Hematology; and Darrell M. Gray, II, MD, MPH, deputy director, Center for Cancer Health Equity

Cancer touches us all, whether through a personal battle with the disease, experiences with a loved one, friend or colleague who has had cancer, or a story about a couples survivor whom we've never met.

Research suggests that our connections with cancer will continue to grow. The World Health Organization expects the number of people who develop cancer to grow to 22 million per year in 20 years, up from 14 million cases in 2012. This can be a source of suffering and economic hardship for families, and it can contribute to poverty and hunger. Some 60 percent of the world's cancer cases and 70 percent of cancer deaths occur in low- and middle-income countries. But there's a hopeful side to this otherwise bleak news:

- About half of all cancer cases can be prevented by following current evidence-based guidelines
- Some of the most common cancers—breast, colorectal and cervical—are curable if detected early using screening tests such as mammography for breast cancer screening, colonoscopy for colorectal cancer screening, and Pap or HPV DNA testing for cervical cancer screening
- Other methods of cancer prevention, including but not limited to diet and lifestyle modifications, can also help prevent cardiovascular disease, obesity, diabetes and other noncommunicable diseases.

Efforts to reduce the burden of cancer happen at the personal, community and national levels.

- **Cancer prevention** refers to measures individuals can take to lower their risk of developing certain cancers.
- **Cancer control** refers to **public health** initiatives designed to reduce the number of new cancer cases and cancer deaths.

Cancer control projects often involve communities working with partner organizations to reduce cancer risk, find cancers earlier and improve treatments. Successful cancer-control initiatives use evidence-based strategies, strategies that scientific research has shown are effective for preventing and detecting cancer.

Types of cancer prevention

There are three types of cancer prevention: as primary, secondary and tertiary.

- **Primary prevention** refers to avoiding or eliminating exposure to cancer-causing substances. The goal is to prevent the cancer process from starting. Examples of primary prevention are avoidance of smoking or using tobacco products, vaccination against cancer-causing viruses, and eliminating carcinogens in the workplace. Primary prevention is possible only when the cause of a cancer is known.
- **Secondary prevention** refers to early detection and screening. The goal is to detect premalignant cells before they become cancerous or early-stage cancer. Secondary prevention includes Pap testing and visual inspection with acetic acid (VIA) for cervical cancer; mammography for breast cancer; digital-rectal exams for prostate cancer; testicular self-exams for testicular cancer; and colonoscopy for colon cancer.
- **Tertiary prevention** refers to the treatment of cancer patients. The goal is to prevent premature death and to maintain quality of life.

Tobacco

Tobacco use is a leading cause of preventable death. Smoking is the main form of tobacco use and the major cause of cancer and other diseases. Tobacco use is linked to at least 13 forms of cancer. Currently,

46.5 million Americans smoke, including 26 percent of men and 21 percent of women. Globally, according to the World Health Organization:

- Tobacco kills about 6 million people a year, with 5 million deaths due to direct tobacco use and 600,000 deaths of nonsmokers exposed to second-hand smoke
- Nearly 80 percent of the world's 1 billion tobacco users live in low- and middle-income countries, where cancer treatment and tobacco control programs are limited
- Tobacco use is also a major contributor to heart disease, emphysema, and lung and mouth diseases.

Tobacco smoke contains more than 60 cancer-causing chemicals along with other disease-causing toxins. In addition, tobacco smoke induces inflammation of the airways and lungs that can facilitate cancer development. Tobacco products come in many forms cigarettes, cigars, bidis, smokeless tobacco and electronic cigarettes. All deliver nicotine to the user. Nicotine is the main psychoactive substance in tobacco, and it is highly addictive.

Nicotine's addictive power makes it difficult to quit tobacco use, and there are many programs and products to help those who set out to quit. Some people succeed with their first attempt; others try a number of times before quitting for good. The experience of quitting may be difficult, but the rewards are many: better health, improved taste and smell, no coughing, lower risk of heart disease...the list goes on.

Alcohol

Alcoholic beverages contain a number of carcinogens, but the most important is ethanol itself. The risk of cancer increases with the amount of alcohol consumed. Alcohol consumption is tied to cancers of the lips, oral cavity, throat and larynx. Three and a half or more drinks per day, the equivalent of 50 grams of alcohol, can increase the risk of these cancers two to three times compared with nondrinkers. Smoking while using alcohol further increases one's cancer risk, probably because alcohol increases the absorption of tobacco carcinogens by the body.

Alcohol use is also a primary cause of liver cancer and increases the risk of:

- Esophageal cancer
- Colorectal cancer
- Cancer of the female breast.

Evidence also links alcohol use to kidney cancer and to non-Hodgkin lymphoma.

For those who drink alcohol, it's best to limit consumption to one drink per day for women and two drinks per day for men.

Factors that modify cancer risk

A person's risk of preventable cancer caused by these sources depends on three things: the extent of exposure to the cancer-causing agent, or carcinogen; an individual's general behavior; and an individual's genetic makeup. Tobacco and alcohol are good examples. A person who smokes has a higher risk of lung cancer and other diseases than someone who doesn't. How much greater depends on:

- The extent of exposure—the number of cigarettes smoked per day and how long the person has smoked
- Other behaviors—consuming alcohol while smoking further increases cancer risk

- The person's genetic makeup—some people are born with genes that enable them to more effectively metabolize the toxins in cigarette smoke, which might lower cancer risk; others are born with weaker DNA-repair systems, making them more susceptible to cancer-causing chemicals.

Diet and obesity

Several cancers—esophageal, colorectal, kidney, pancreatic, endometrial and postmenopausal breast cancer—are associated with being overweight or obese. Some of these cancers are also linked to insufficient physical activity. Excess weight might also be associated with thyroid, gallbladder and blood cancers such as leukemia and myeloma. In addition, being overweight is associated with cardiovascular disease, diabetes and osteoarthritis.

You can lower your risk of diet-related cancers and other diseases by eating nutritiously and maintaining a healthy body weight. Maintaining a healthy body weight comes down to a simple equation—the calories you consume should about equal the calories you burn through physical activity. The body stores excess calories as fat. If you want to lose weight, avoid dieting. Instead, modify your diet. Remove high-calorie items and replace them with healthy alternatives. Here are some recommendations:

Reduce consumption of:

- Red meat and other high-fat foods
- Processed and smoked foods, which are high in salt
- Potato chips and similar snacks
- Simple carbohydrates that are rapidly absorbed, such as sugar, jam and refined cereals
- Soda and other sugar-sweetened beverages

Eat more:

- Fruits and vegetables — blueberries and blackberries, for example, have antioxidants that help fight cancer
- Whole grains
- Nuts
- Yogurt

Another means of limiting excess calorie intake is to take smaller portions of food.

Chronic infections and cancer

Currently, 11 infectious agents are known to cause cancer in humans. Most are viruses, along with type of bacteria and three parasites. Cancers caused by chronic infections are more common in less economically developed countries. Cancers linked to infectious agents cause almost 22 percent of cancer deaths in the developing world versus 6 percent in industrialized countries. In sub-Saharan Africa, chronic infections cause one-third of all cancers. Importantly, as nations become more prosperous, infection-caused cancers can become less common while cancers related to tobacco use, consumption of alcohol and high-fat, highly processed food, and lack of physical activity become more common.

Here's a look at the infection agents known to cause cancers.

- Viruses:
    - Epstein-Barr virus (EBV) is a human herpesvirus. More than 90 percent of the world population is infected with EBV. It can cause Burkitt lymphoma, Hodgkin lymphoma, nasopharyngeal carcinoma, and post-transplant lymphoproliferative disorder.

- Hepatitis B virus (HBV) and hepatitis C virus (HCV) can cause liver cancer.
- Human papillomavirus (HPV) can cause cancers of the cervix and of the penis, vulva, vagina and anus. In addition, HPV is linked to oropharyngeal (throat) and other oral cancers.
- Human T-cell lymphotropic virus type 1 (HTLV-1) is endemic mainly in Japan, the Caribbean and central Africa, and causes a type of lymphoma/leukemia in about 5 percent of infected people.
- Kaposi sarcoma herpes virus can cause Kaposi sarcoma, a cancer that occurs mainly in people with weakened immunity, such as those with HIV/AIDS.
- HIV type 1 (HIV-1) infection can cause cancer indirectly by damaging the immune system. Loss of immune protection allows silent/quiescent infections by viruses such as EBV and HPV to become active, leading to higher rates of cancer in some people with AIDS.

- One type of bacteria, *Helicobacter pylori*, or *H. pylori*, is a leading cause of gastric and duodenal ulcers. It can also cause stomach cancer and gastric lymphoma.
- Three parasites have been identified as causes of human cancer:
  - Two are liver flukes endemic in China, North and South Korea, and Southeast Asia, and they cause liver cancer. The number of people infected by these parasites globally is estimated to be 45 million.
  - The third is a schistosome parasite in Africa and the Middle East. It causes urinary schistosomiasis, which can progress to bladder cancer.

Measures to prevent cancers caused by infectious agents include:

- Vaccination against HBV to prevent liver cancer
- Vaccination of girls and boys against HPV before they become sexually active

Occupation

Certain occupations and industries can expose people to risky levels of known carcinogens:

- Asbestos, used in insulation and roofing material, causes cancers of the larynx, lung and ovaries, as well as mesothelioma, a cancer of the lining of the chest wall. Construction workers and remodelers can be at risk
- The solvent benzene can cause leukemia
- Formaldehyde exposure raises the risk of leukemia and nasopharyngeal carcinoma
- Diesel-engine exhaust is linked to lung cancer
- Inhaling silica, zeolite, nickel or wood dust also poses a risk of lung cancer and cancers of the head and neck.

Preventing these cancers involves avoiding, or at least reducing, exposure to the harmful agent.

Radiation, UV

Exposure to ionizing radiation and ultraviolet radiation can also cause cancer. Natural sources of radiation include cosmic rays from outer space and radiation from the Earth. Inhalation of radon gas is the leading source of natural radiation exposure, and it is linked to cancers of bone and the sinuses. Other sources of ionizing radiation include nuclear accidents, fallout from nuclear weapons testing and routine releases from nuclear power plants. Certain diagnostic procedures such as CT scans can also pose a cancer risk

and should be done only when necessary. (Cancer risk is low for doses of X-rays used for diagnostic procedures.)

The sun is the main source of ultraviolet (UV) radiation. UV is a highly energetic form of light, and it is invisible to the human eye. It causes sunburn and can lead to skin cancer. UV can be separated by wavelength into three classes: A, B and C. The Earth's ozone layer blocks some UV-A, nearly all UV-B and all UV-C, the most energetic part of the UV spectrum.

UV-B causes sunburn and can cause chronic skin damage and cancer, especially in fair-skinned Caucasians. Long-term exposure to UV-A also damages the skin and causes cancer. Tanning beds, another source of UV light, emit mostly UV-A and a small amount of UV-B. Some states ban tanning beds for people under 18. Most people can prevent cancers caused by radiation by avoiding unnecessary diagnostic imaging, and applying sunscreen when outdoors for prolonged periods.

Pollution

Other causes of cancer include environmental pollution from vehicle emissions, electrical-power generation, and household burning of wood and other solid fuels. Cancer-causing water pollutants can include arsenic, nitrates, nitrites and some pesticides.

Aflatoxin

One natural environmental carcinogen worth mentioning is called aflatoxin. It is produced by a fungus called Aspergillis that contaminates cereal grains and groundnuts, also called peanuts. Aflatoxins can cause liver cancer, particularly in people infected with HBV.

Heredity

People cannot inherit cancer itself, but they can inherit a gene mutation that in some cases almost guarantees they will develop breast, colorectal or other cancer during their lifetime, usually at a younger age. These cancers are often aggressive, so it's important to detect and treat them early. Of key importance is knowing your family's cancer history. Talk about this with your parents, grandparents, aunts and uncles to learn if cancer runs in your family. Then take that information to your doctor or talk with a genetics counselor to learn if you have an elevated risk of cancer based on your family history. Genetic testing can be done to confirm the suspicion, and regular checkups can help prevent cancer from developing or possibly increase the chance for curing a cancer that is detected early.

Tobacco, eCigarettes and Cancer

Video presented by Peter Shields, MD, deputy director of The Ohio State University Comprehensive Cancer Center, professor of Medicine, Division of Medical Oncology, and an oncologist at the OSUCCC – James

Tobacco is the world's leading cause of cancer and of cancer-related deaths. It is also the most preventable cause of avoidable premature death. Each year, almost 6 million people worldwide die of tobacco-related causes. Some 80 percent of these deaths are in low- and middle-income countries.

Smoking

Cigarettes are the most common tobacco product used worldwide. Nearly 20 percent of the world's adult population about 800 million men and 200 million women smoke cigarettes. In some countries, almost 60 percent of men smoke. Cigars, pipes, bidis, kreteks and water pipes are other ways that tobacco is smoked. In the United States:

- 46.5 million people smoke
- 64 percent of the population has tried smoking
- 26 percent of men and 21 percent of women smoke; in some parts of the country, 40 percent of men are smokers.

Cigarettes deliver nicotine, a powerful drug that stimulates certain pleasure centers in the brain, influences mood and eases anxiety. It makes some people less depressed and helps others think more clearly. But the positive effects are offset by significant harms. Because nicotine is highly addictive, cigarettes become devices to transfer money from your pocket to the tobacco industry and the medical industry.

When people inhale tobacco smoke, they take in more than nicotine. That smoke is a mix of thousands of compounds, including more than 60 chemicals that are known to cause cancer.

Cancer and other health effects

As cigarette smoke is taken in, those chemicals bathe and enter the cells that line the mouth, throat, airways and lungs. Inside the cells, the chemicals can damage the DNA and DNA-repair pathways in ways that lead to cancer of the lung, mouth and throat. As a result:

- Smoking increases a person's risk of lung cancer on average five- to ten-fold
- In developed countries, smoking is responsible for about 80 percent or more of all lung cancers
- In the United States, almost one in 10 heavy smokers develop lung cancer
- Men who smoke have a 27-times higher rate of oral cancer than nonsmokers.

Smoking also raises a person's risk of other cancers because the cancer-causing chemicals in tobacco smoke also enter the bloodstream and are carried throughout the body, where cells in other organs take them up. Epidemiologic studies have linked smoking to these cancers:

- Lung
- Larynx (voice box)
- Oral cavity
- Pharynx (back of the throat)
- Esophagus (tube that carries food to the stomach)
- Pancreas

- Bladder
- Kidney
- Cervix
- Stomach
- Liver
- Colorectal
- Acute myeloid leukemia

In addition, tobacco smoking raises the risk of numerous other noncommunicable diseases that cause premature death, including heart disease, emphysema and other lung diseases, hypertension, stroke and diabetes. Tobacco smoke also endangers those who live and work around smokers. The smoke that smokers draw into their lungs is called “mainstream” smoke. But a burning cigarette also emits “sidestream” smoke into a room, and the smoke that smokers exhale is called “second-hand” smoke. Sidestream and second-hand smoke can also raise the risk of cancer, respiratory disease and other diseases for family members and others exposed to it.

Smokeless tobacco

Smokeless tobacco is another means of delivering nicotine. Its many varieties include:

- Snuff
- Spit tobacco
- Chewing tobacco
- Betel quid, or paan

When smokeless tobacco is tucked into the cheek and mixes with saliva, or when it is sniffed into the nostrils, chemicals and nicotine leach from the tobacco and enter the delicate blood vessels that lie beneath the moist lining of the mouth and nose, where they cause harm. Smokeless tobacco exposes the body to more than 3,000 compounds and some 28 known, probable or possible carcinogens. These include N–nitrosamines, volatile aldehydes, formaldehyde, acetaldehyde, crotonaldehyde, hydrazine, arsenic, nickel, cadmium, benzopyrene and polonium–210.

Smokeless tobacco causes cancers of the mouth, throat and pancreas, along with heart disease, hypertension and diabetes. It also addicts users to nicotine and leads to the same transfer of money from the pocket of the user to the pockets of the tobacco industry.

E-cigarettes

E-cigarettes, or electronic nicotine-delivery systems, are the newest of the tobacco-industry’s nicotine-delivery devices. They consist of:

- A battery
- Heating element
- Absorbent with solution
    - Nicotine
    - Propylene glycol
    - Flavorings

These are major concerns about ecigarettes. Studies are under way investigating the health consequences of these devices. Key questions include:

- Are users exposed to harmful chemicals that lead to health effects such as lung and other cancers?
- Do consumers use these devices to help quit smoking or to start smoking and switch to cigarettes?
- Do these devices delay or undermine smoking cessation?
- Do they entice former smokers to resume smoking?
- Do they serve as a gateway for new smokers?

Tobacco control

In the United States, 80 percent of the people who smoke began before age 18, and 22 percent before age 13. Young people are drawn to smoking and other tobacco products by advertising campaigns that use celebrity endorsements, cartoon mascots, fruit and candy flavors and the depiction of smoking and tobacco use in films and television programs.

Center for Excellence in Regulatory Tobacco Science

In 2009, the U.S. Food and Drug Administration(FDA), began regulating the manufacture, marketing and distribution of tobacco products in the United States to protect public health. To help it set scientifically sound policies, the FDA and the U.S. National Cancer Institute awarded The Ohio State University nearly $19 million to establish a Center for Excellence in Regulatory Tobacco Science that is co-directed by Peter Shields, MD, along with Mary Ellen Wewers, PhD, MPH, RN. Ohio State is one of 14 such national centers.

Ohio State's tobacco center has 18 researchers studying why and how people use tobacco products, how the products are designed and promoted, and the barriers people face when attempting to quit tobacco use.

Tobacco cessation

Because tobacco is the world's leading cause of cancer and of cancer-related deaths, quitting smoking and tobacco use is important and beneficial at any age, even for people who have cancer. While it's true that some people just stop smoking or using smokeless tobacco and never go back, other people have more success when they have assistance. There are proven ways to help someone quit. Here are some ideas that might help you or someone you know end tobacco dependency.

Identify your reasons for quitting. There are many, but only one is needed:

- To avoid health problems
- To prove you can do it
- To please someone you care about
- To set a good example for your kids or other kids
- To save money
- It's banned at work or school
- Your physician or dentist told you to quit

Make a quit plan

Once you've resolved to quit, make a quit plan. This may be with or without help, but some counseling is recommended, with a tobacco quit line, for example.

- Choose a quit date in the near future.

- Cut back before you quit by tapering down your tobacco use
- When tobacco craving begins, delay acting on it, by about 10 minutes at first, then gradually lengthen the period
- Identify the moments in your life that trigger a desire for tobacco, such as meals, working out, driving or working, and avoid them as much as possible
    - Remove cigarettes from your home, car and at work
    - Avoid drinking alcohol
- To satisfy craving, stock up on items that can substitute for tobacco, such as sugar-free gum or sunflower seeds, or use short-acting nicotine gum or lozenges
- Get your teeth cleaned
- Avoid friends who smoke or use smokeless tobacco
- Rally a team of friends and family members who will support you and keep busy with them
- Use telephone quit lines or classes.

You might experience nicotine withdrawal symptoms. These can make you feel irritable, tense, restless or impatient. To deal with these symptoms:

- Wait them out or walk away from the situation
- Try deep breathing and exercise
- Ask others to be patient
- If you experience constipation or irregularity, add fiber to your diet by eating whole grain breads and cereals, fresh fruits and vegetables

To control hunger and avoid weight gain:

- Eat regular meals and remember that feeling hungry is sometimes mistaken for the desire to smoke, dip or chew
- Drink lots of water
- Increase physical activity to increase metabolism
- If you desire sweets, reach for low-calorie sweet snacks such as, apples, sugar-free gums and candies.

Other avenues for treating nicotine addiction

- More counseling
- Nicotine-replacement therapy (patch, gum, nasal spray, lozenge)
- Chantix (verinicline) or similar aid talk to your doctor or counselor about what might work for you.

If you slip and have a cigarette

- Do not equate it with failure
- Avoid places or behaviors that trigger a craving for tobacco
- Don't rationalize why it's OK to try it again just once more.

If you relapse and start smoking regularly

Make a new quitting plan, address why you relapsed and what did not work, and try again. Don't be discouraged. You can succeed.

Alcohol and Cancer in Men and Women

Video presented by Peter Shields, MD, deputy director of The Ohio State University Comprehensive Cancer Center, professor of Medicine, Division of Medical Oncology and an oncologist at the James Cancer Hospital and Solove Research Institute

"Alcohol" is a common term for ethanol or ethyl alcohol, which is a chemical substance found in beer, wine and liquor. It is produced by the fermentation of sugars and starches by yeast. Alcohol is also used in some medicines, mouthwashes, household products and essential oils (which are scented liquids taken from plants).

The main types of alcoholic drinks and their alcohol content are:

- Beers and hard ciders, 3-7 percent alcohol
- Wines, including sake, 9-15 percent alcohol
- Wines fortified with liquors, such as port, 16-20 percent alcohol
- Liquor, or distilled spirits, such as gin, rum, vodka and whiskey…these are produced by distilling alcohol from fermented grains, fruits or vegetables. They are usually 35-40 percent alcohol (70-80 proof) but can be higher.

The federal government's Dietary Guidelines for Americans 2010 defines moderate alcohol drinking as up to one drink per day for women and up to two drinks per day for men. Heavy alcohol drinking is defined as having more than three drinks on any day or more than seven drinks per week for women and more than four drinks on any day or more than 14 drinks per week for men.

Based on many research studies, there is a strong link between alcohol drinking and several types of cancer, particularly:

Head and neck cancer

The lips, oral cavity, throat and larynx (voice box) are especially susceptible to alcohol-related cancer. People who drink 50 grams or more of alcohol per day (approximately 3.5 or more drinks per day) have at least a two to three times greater risk of developing these cancers than nondrinkers. In addition, the risks of these cancers are still greater among those who consume this amount of alcohol and also use tobacco.

Esophageal cancer

Alcohol is a major risk factor for a particular type of esophageal cancer called esophageal squamous cell carcinoma. People who inherit a deficiency in an enzyme that metabolizes alcohol also have a higher risk of alcohol-related esophageal squamous cell carcinoma.

Liver cancer

Alcohol consumption is a primary cause of liver cancer (hepatocellular carcinoma). Chronic infection with hepatitis B virus and hepatitis C virus are the other major causes of liver cancer.

Colorectal cancer

Alcohol consumption is associated with a modest increase in colorectal cancer risk.

Breast cancer

More than 100 epidemiologic studies have consistently found that increased alcohol consumption raises the risk of breast cancer. The risk increases with just one drink per day on average in women. As an average, it means some women can consume a little more than one drink per day, and some less.

A study in the United Kingdom called The Million Women Study, which included more than 28,000 women with breast cancer, provides a more recent estimate of breast cancer risk at low to moderate levels of alcohol consumption. The study found that every drink per day produced a 12-percent increase in the risk of breast cancer. Thus, for women statistically across the board, just one drink per day increases breast cancer risk to some degree. But every woman is different. Higher-level drinkers will always have an increased risk.

There also is evidence suggesting that some alcoholic beverages reduce the risk of heart disease. Women must balance that possible protective effect of alcohol against their increased risk of breast cancer, keeping in mind that all types of alcoholic beverages increase breast-cancer risk.

Women who drink should do so in moderation and be aware of their risks.

Diet, Nutrition and Cancer

Video presented by Steven K. Clinton, MD, PhD, professor of Internal Medicine and leader of the Molecular and Carcinogenesis and Chemoprevention Program at the OSUCCC – James

Colleen Spees, PhD, assistant professor, Division of Medical Dietetics and Health Sciences, Ohio State University College of Medicine, and member of the OSUCCC – James with a focus on nutrition and cancer

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Research studies have shown important links between diet, nutrition, physical activity and cancer. Understanding these relationships can help lower your risk of developing many forms of cancer. It is very important to appreciate the concept of "evidence-based recommendations." This chapter will emphasize public health guidelines, meaning recommendations regarding diet and nutrition that are appropriate for entire populations. Several organizations, both in the United States and globally, have taken on the task of summarizing the entire history of research on this topic to formulate public health recommendations.

Each individual may have unique health issues that require a more personalized approach and guidance in meeting optimal health goals. This can be obtained by consultations with trained experts, typically registered dietitians. The key concept is that the human diet is complex, containing dozens of nutrients and thousands of potentially bioactive components, particularly from the plant world. The optimal approach to reducing cancer risk is to use the following recommendations to orchestrate a healthy diet.

Much of the evidence for a healthy diet has come from examining culturally and geographically diverse populations around the world. The risk of specific cancers is different around the globe. For example, in Japan after World War II, the risk of colon, breast and prostate cancer was very low. Remarkably, when people migrated from Japan to the United States the risk increased significantly. Certain associations with dietary patterns quickly emerged. Nations such as the United States, have shown dramatic changes in diet over the last century; we now consume diets that are rich in refined sugar, very low in fiber, high in saturated fats and often low in fruits and vegetables. Overall, this dietary pattern in the United States and other affluent nations is strongly associated with cancers of the colon, breast, endometrium (uterus) and prostate. Many of these associations are strongly supported by human clinical studies and laboratory research.

Obesity

The United States and many other nations are facing an epidemic of weight gain and obesity. The World Health Organization defines overweight and obesity as abnormal or excessive fat accumulation that might impair health. The problem of overweight and obesity is no longer limited to just high-income countries. In fact, childhood overweight and obesity are increasing at a rate more than 30 percent higher in low- and middle-income countries than in developed countries. Overweight and obesity are now linked to more deaths worldwide than underweight and malnutrition.

Overweight and obesity are directly related to an energy (or calorie) imbalance. Many people eat more calories than they burn through physical activity. The problem of excessive caloric intake has been potentiated by the ready availability of foods that are calorie-dense and rich in unhealthy fats and refined sugars.

Along with consuming excessive calories, there has also been a decline in physical activity worldwide as populations become more sedentary. Less physically demanding employment, greater time devoted to digital technology, and changing modes of transportation are all contributing factors.

These trends are creating a world where weight gain and obesity may soon rival tobacco as the major contributor to cancer risk. The good news is that we can change these behaviors. By adopting a dietary pattern primarily focused on plant-based foods, such as fruits, vegetables and whole grains, people can reduce their overall caloric intake, increase the nutritional quality of their diet, and achieve or maintain a healthy body weight.

Plants, fiber, sugar

To orchestrate an anticancer diet, consider how you will consume a diverse array of fruits, vegetables, legumes and whole grains each day. This should be a foundation, but it doesn't mean you must be a vegetarian healthy diet can include modest portions of meat. A plant-based diet will address one of the major weaknesses of the current American diet: the lack of dietary fiber, which is the component of plant material that is not readily digested. Dietitians estimate that over 90 percent of Americans do not meet the current goal of 25 grams of fiber per day.

One of the factors associated with poor fiber intake in recent decades is the enormous increase in the consumption of refined or simple sugars, particularly from sugar-sweetened beverages. The high consumption of sugar-sweetened beverages is also considered to be a major contributor to weight gain and the propensity for developing diabetes and cardiovascular disease.

Dietary fats

Diets rich in fats, particularly saturated fats, are often associated with the risk of several cancers typically found in affluent nations. In parallel, dietary patterns rich in saturated fats may promote cardiovascular disease. The optimal dietary fat pattern for cancer prevention is an area of active research. Of particular interest is the potentially beneficial role of consuming omega-3 fatty acids typically found in fish, some nuts and plant oils.

Saturated fats typically come from meats. In general, studies suggest that populations consuming larger amounts of red meat experience cancers typical of affluent nations, such as breast, prostate and colon cancers. It is recommended, therefore, that red meat be consumed in moderation and that lean meats such as poultry and fish are reasonable substitutes. It is also evident from studies that diets rich in processed meat that is high in salts and nitrates, or rich in smoked and cured meats, may enhance cancer risk. In addition, it is recommended to limit intake of charred meat, or meats cooked at high temperatures for prolonged periods.

Another concern is food preservation and safety. Throughout the food-production chain—from the farmer's gate to the consumer's plate—we need to be sure that foods are handled and processed safely. In many parts of the world, microbial contamination of food and water remains a public health problem. For example, aflatoxins are potent carcinogens produced by mold. Many foods, such as grains, legumes and nuts, are contaminated by aflatoxins in areas where storage facilities are inadequate and the climate is hot and damp.

Throughout history, salt has been one of the easier ways to preserve foods. But we now have many other ways to do this, and excessive salt intake may have health risks for hypertension and cardiovascular disease, as well as some cancers. It is suggested that people avoid salt-preserved foods and limit their intake of processed foods with added salt. Many nations now share scientific data and have instituted government testing to ensure that food-preservation processes are optimal.

Alcohol

Alcohol is one of the interesting dietary components that may be related to cancer risk. This is particularly true in smokers, for whom the combination of alcohol and tobacco greatly increases the risk of oral and esophagneal cancers. Excessive alcohol is also associated with liver cancer. In general, it is prudent to limit alcohol intake to one drink per day for women and two drinks per day for men. Research is under way regarding specific types of alcoholic beverages, such as red wine and cancer preventive properties, specific recommendations are premature at this time.

Dietary supplements

People often ask which dietary supplements they should consume to prevent cancer. Anyone who consumes a varied diet will likely meet his or her needs for known nutrients. The well-done studies of dietary supplements and cancer have thus far been unimpressive, and some suggest potential risks for excessive intake. Evidence indicates that a multivitamin and mineral supplement that meets recommended daily allowances (RDAs) likely will pose little risk for healthy men and women, but potential benefits for cancer reduction are not established. If you suffer from any conditions that may compromise your ability to consume and digest a healthy diet, personalized recommendations by a nutrition expert may be appropriate.

Final orchestration

Maintaining a healthy diet is essential for reducing cancer risk. It is not about one nutrient or supplement, or even one meal. It is how you orchestrate your diet over a longer period and how you adapt these principles as your dietary pattern. This pattern can be achieved in various ways. A Mediterranean dietary pattern is one that is frequently presented, but this is not the only way to achieve these goals.

The dietary pattern is also crucial for cancer survivors. Every survivor may benefit from individual dietary and nutritional counseling, especially because cancer treatments may affect an individual's diet and nutritional status. For example, the rigors of surgery, radiation and chemotherapy for cancers of the head and neck may make it difficult to consume a healthy diet. Patients with gastrointestinal cancers may have undergone surgical procedures that complicate digestion and absorption. Each individual needs tailored interventions to ensure optimal nutritional status and survivorship.

Overall, cancer survivors should follow the public health cancer prevention guidelines reviewed here. An added benefit is that these guidelines can help reduce one's risk for other serious noncommunicable diseases such as obesity, heart disease and diabetes.

At The Ohio State University, we strongly believe that diet and nutrition are critical to our efforts to achieve a cancer-free world. We need the same scientific rigor and experimentation to define diet and nutritional recommendations that would be used to determine optimal cancer therapies. Research must be supported to continue efforts to improve and refine dietary and nutritional guidelines for cancer prevention.

Screening and Vaccination

Video presented by Electra Paskett, PhD, MSPH, Marion N. Rowley Professor of Medicine and associate director of population sciences at the OSUCCC – James

It's important whenever possible to take steps or make lifestyle changes for preventing cancer. When cancer does happen, it is most treatable if detected early. This chapter explains the importance and role of vaccination and screening programs for cancer prevention and early detection, and why you should participate in them.

Vaccination

Vaccines are available for protecting against two infections that cause cancer:

- Hepatitis B virus, or HBV, which is responsible for 50 to 90 percent of liver cancers where the virus is most endemic: Sub-Saharan Africa, the Amazon River basin, China, the Republic of Korea, and countries in southeast Asia
- Human papillomavirus, or HPV, which causes virtually all cancers of the cervix, and some cancers of the anus, vulva, vagina, penis and oropharynx. There are many types of HPV; HPV types 16 and 18 are among the most common cancer-causing infections.

HBV

An estimated 2 billion people worldwide are infected with HBV, and more than 360 million have chronic liver infection, which can lead to chronic liver disease and liver cancer. Worldwide, liver cancer is the second-most common cause of cancer death in men and women combined. HBV vaccination is usually part of childhood inoculation. In 2010, 179 countries reported including HBV vaccination in their childhood immunization program, and nearly 70 percent of children worldwide receive three doses of the HBV vaccine. This should significantly reduce the incidence of liver cancer in coming decades.

HPV

HPV is the most common infection of the reproductive tract, and it causes a number of conditions in both females and males. Nearly 80 million people about one in four are currently infected in the United States. About 14 million people, including teens, become infected with HPV each year. HPV infection can cause cervical, vaginal and vulvar cancers in women; penile cancer in men; and anal cancer and mouth/throat (oropharyngeal) cancer, as well as genital warts, in both men and women. Most HPV infections are cleared spontaneously by the body's immune system in a year or two, but about a dozen types of HPV, when not cleared by the body, raise a person's risk of developing cancer.

Three vaccines are currently approved for HPV and cancer prevention. The vaccines are best given to boys and girls at ages 11-12, but they can be given to those ages of 9-26. However, the vaccines are most effective when given to preteens. Currently in the United States, the HPV vaccination is not being offered widely to teens due to misconceptions about the vaccine. The vaccine works, it is safe, and it lasts more than 10 years. It needs to be used. It is important to ask your doctor to give your sons or daughters the HPV vaccine when they reach the age of 11 or 12. They can still get vaccinated up to age 26. We finally have a vaccine to PREVENT cancer let's use it!

Cancer Screening

Some types of cancer can be found before they cause symptoms. Checking for conditions that might lead to cancer in people who have no symptoms is called screening. Sometimes screening tests can find signs or symptoms of cancer before the person knows of the problem. In these cases, a person will be referred to a doctor for diagnostic tests.

The evidence is strong that regular screening for breast, colorectal and cervical cancer can find cancer early. Finding cancer early means treatment will be less intensive and more likely to cure the disease. The longer you wait to get screened, the more likely that any cancer found will be at a later stage. The later that cancer is diagnosed, the lower the chances of survival. Screening saves lives!

Risks of screening tests

While screening tests can be life-saving by finding cancer early and by identifying and removing precancerous changes, screening tests also have risks that sometimes lead to serious problems. These risks include:

- False-positive test results, which erroneously suggest a cancer or precancer exist. False-positive test results can cause anxiety and lead to additional medical tests that are not needed.
- False-negative test results, which erroneously suggest that a cancer or precancer does not exist. False-negative test results can delay diagnosis and treatment.

Cancers that are commonly screened for include breast, cervial and colorectal. (Other cancers can be caught early through regular examinations by a medical professional. These include skin cancer, oral cancer and prostate cancer.)

Screening tests for breast cancer

Breast cancer is the most common form of cancer in women. Almost 1.7 million cases were diagnosed worldwide in 2012, and this disease was also the leading cause of cancer mortality in women, with almost 522,000 deaths that year. The most common method to screen for breast cancer is mammography.

Breast Cancer Screening Guidelines

There is some controversy around how often a woman should have a screening mammogram. In general:

- Women aged 40 to 49 years should talk with their healthcare provider about their risk of breast cancer and how often to have a mammogram
- For women aged 50 years and older, many organizations support having a mammogram every year, but recently the U.S. Preventive Services Task Force recommended getting a mammogram every two years.

Talk to your healthcare provider about how often you should get screened for breast cancer. In addition, women should get regular clinical breast exams by their physicians as part of their annual exams.

Screening for cervical cancer

Cervical cancer is the fourth most common cancer women worldwide. In some low-income countries, it is the leading cause of cancer death in women. There are two types of cervical screening tests:

- Pap test—annual Pap tests are no longer recommended by leading medical organizations
- HPV testing—this test identifies the presence of HPV DNA in a sample of cervical cells.

New cervical cancer screening guidelines recommend against annual testing. Instead, the new guidelines recommend:

- Testing every three years for women ages 21-65
- No routine cervical cancer screening for women under 21 or over 65
- However, HPV testing is also recommended in some women.

VIA

Visual inspection with acetic acid (VIA) is an additional screening method that is not approved in the United States but is under study in a number of low- and middle-income countries where Pap testing and HPV DNA testing are not available or are too costly. VIA is a relatively inexpensive and promising method that could reduce the incidence of cervical cancer in under-resourced countries. VIA reveals precancerous changes on the cervix that can be treated using relatively low-tech, low-cost surgical methods such as cryotherapy to kill them by freezing before they become cancerous.

Screening for colorectal cancer

Colorectal cancer is the third most common cancer worldwide. Over 1.3 million cases were diagnosed in men and women combined in 2012, and almost 694,000 people died of the disease that year. Three tests are used for colorectal cancer screening, which should start at age 50. Talk to your provider about which test is best for you:

- Stool blood test — This test identifies the presence of blood in a small sample of stool. This should be done annually alone, or with a sigmoidoscopy every five years. There are several different kinds of stool blood tests: fecal occult blood test (FOBT), a fecal immunochemical test (FIT) or a stool DNA test (sDNA).
- Sigmoidoscopy — This test uses a tube with a light to examine the lower third of the colon for polyps or other unusual growths.
- Colonoscopy — This test uses a tube with a light to check the entire colon. If polyps are detected, they can be removed during the test and sent to a laboratory to be tested for cancer. A colonoscopy should be done every 10 years.

Why some people don't want to be screened

Although population-wide screening programs that meet accepted standards do save lives, screening rates are often low, even in the United States. This is especially true among those who are older, who have lower incomes, who don't have health insurance or are under-insured, and who live in low- and middle-income countries. Reasons people don't get screened include:

- Fear of finding cancer
- Fear of treatment
- The cost of screening
- Not knowing what test to get or where to go for testing
- Embarrassment
- Cultural practices
- Waiting for symptoms to appear before getting checked
- Thinking they are not at risk because they are older or because they do not have a family history of cancer.

Fear of finding cancer: Cancer screening shows that most people DO NOT have cancer, and this leads to peace of mind.

Fear of treatment: When most cancers are caught early, the treatment is much less intensive.

Cost: Cancer screening programs are often offered for free or at reduced cost. In some cases, there are programs that pay for the tests.

Not knowing which test to get or where to go: Ask your healthcare provider to get the information you need to make screening easier and more convenient for you.

Embarrassment: Especially when dealing with body parts such as breasts or the rectum, you may feel embarrassed. Remember, the providers you talk to and the technicians who do these tests are highly trained professionals who can make you feel at ease.

Cultural Practices: People in some cultures, especially women, may need permission or support from their family to get screened. Remember that being healthy and cancer-free is beneficial to the whole family and can be discussed with the family from that perspective.

Waiting for symptoms before getting checked: Many cancers take years to grow without causing pain or other symptoms, so it is important not to wait until you have a symptom.

Older age: It may not seem fair, but getting older actually increases your risk for getting cancers such as breast and colorectal cancer. If you are over age 50, you should consider getting screened.

No family history: Only a small percentage of people who develop cancer have a family history of the disease. In fact, three out of four people who are diagnosed with cancer DO NOT have a family history of it. Get screened even if no one in your family has had cancer.

Cancer screening can save your life. Remember: A cancer diagnosis affects not only you but your whole family. Find a friend or family member who should also be screened. Make a pact to support each other through the process. Set reminders for yourselves. Talk to your healthcare provider about screening.

Psychological Responses to a Cancer Diagnosis

Video presented by Barbara Andersen, PhD, professor of Psychology at The Ohio State University, and a member of the Cancer Control Program at The Ohio State University Comprehensive Cancer Center – James Cancer Hospital and Solove Research Institute

A diagnosis of cancer can lead to a number of biobehavioral effects, including stress and emotional distress, changes in behaviors, and immune responses. In the United States, at least one in four cancer patients experience clinical stress and anxiety after diagnosis. If left untreated, this stress can lead to poor mental health, a lower quality of life and additional physical symptoms. However, research at Ohio State and elsewhere over the last decade shows that psychosocial interventions can help patients cope with cancer stress and improve their quality of life.

Here we will cover three major areas:

- Patients' reaction to a cancer diagnosis, and the model used by Ohio State's cancer program to capture this complicated phenomenon
- Ways to help patients cope with the stress of diagnosis and treatment
- How healthcare professionals can provide psychosocial care to newly diagnosed cancer patients.

Patients' reaction to diagnosis

A cancer diagnosis can be life changing. For many, it is a frightening and stressful experience. The challenges begin with the words, "You have cancer." Others arise during treatment, and still others may arise as time passes. Medical researchers now know that stress influences a person's mind, body and behavior, and many patients experience negative changes in their physical and psychological health as a result. For example:

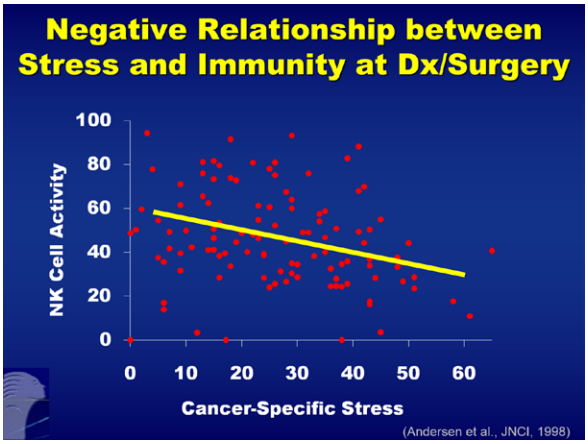
- Stress can worsen physical symptoms such as pain or fatigue
- Psychological changes can include feelings of tension or anxiety, more worries, or having a sad mood
- Behavioral changes can include eating an unhealthy diet, failing to exercise, or having low motivation for daily activities
- There is also evidence that stress levels experienced by patients at diagnosis can weaken immune responses and influence treatment outcomes.

The scatterplot diagram shows data from a recent Ohio State study investigating how stress might lower the immune system's ability to fight cancer. The data suggests that a relationship exists between patients' stress levels and the death of cancer-fighting immune cells called natural killer cells, or NK cells.

X AXIS — level of cancer stress, with higher numbers meaning more stress

Y AXIS — NK cell killing or lysis of target cells, where higher numbers mean more killing

The researchers obtained the data by using blood samples from breast cancer patients awaiting the start of chemotherapy. The data show that as patient stress increased, NK cell activity declined. Conversely, those individuals with lower stress had higher levels of NK cell activity. The researchers also observed this effect with other NK assays and with T-cell assays.



So experiencing a cancer diagnosis and undergoing treatment can produce a cascade of negative effects. While this is common for many, certain individuals are at a higher risk for persistent stress. They include:

- The unemployed or those with limited financial resources
- People with limited education
- People who are alone
- People with a psychiatric history of anxiety or depression
- People with advanced or recurrent cancer.

Coping strategies for cancer patients

Fortunately, there are ways to help patients reduce stress and improve their quality of life after diagnosis. Three common coping strategies that have strong empirical support, both for cancer patients and patients with other kinds of illnesses, are relaxation, social support and exercise.

How does a person who is stressed stop and relax? Medical professionals at The Ohio State University recommend Progressive Muscle Relaxation, or PMR. PMR is regularly used in the treatment of anxiety disorders, and it is an effective complementary treatment for many physical disorders. Cancer patients can use it to control nausea and vomiting, and to reduce pain and other symptoms. The aim of relaxation is to lower the body's tension and reduce the "wear and tear" of stress. When the body is physically relaxed, it becomes easier to control thoughts, change emotions and reduce symptoms of stress, such as difficulty sleeping. The physiological effects of relaxation are measurable:

- It decreases heart rate, blood pressure and breathing rate, and it lowers muscle tension
- It alters mood and improves concentration
- It makes you feel calmer and relaxed, as if you had a brief nap.

For those interested in trying PMR, you can listen to an audio track online at our website: **http://cancertohealth.osu.edu/index.php/for-patients.**

Social support is another aid to coping with cancer. Close relationships ease stress by providing guidance, advice and support. Support from friends, family and others can convey feelings and thoughts that we are valued and cared for. It provides a sense of satisfaction with life and of all-around better physical and mental health. Without support during cancer, stress can linger and worsen.

- Patients with cancer need help from family and friends. This can include transporting you to an appointment, caring for your children while you are away, or taking care of heavy work around your home. Family and friends can also provide emotional support by giving you someone to talk to, someone to help you solve problems, or someone to sit with.
- Not every one has a close friend or family member. Even so, it is important to not be alone when going through cancer. During difficult times, patients should be encouraged to seek new support relationships or bring more distant relationships closer. Mental health professionals, members of the clergy or specialized support groups for cancer patients can provide helpful counseling.
- Social support can be difficult to find in communities where there is a stigma to being diagnosed with cancer. Stigma can prevent early detection, delay diagnosis and prevent patients from seeking or accepting support. If that is the case in your community, think about ways to cross the stigma barriers and reach out for help.

Physical activity is perhaps the easiest stress reliever. Get out of the chair and move! Receiving and recovering from cancer treatment can take months. It can take a toll on patients' diet and activity patterns.

Curbing these effects is critical to helping the patient recover and to improving quality of life.

Many people might have had a regular routine of exercise walking, riding a bike, running before their cancer diagnosis. With the doctor's permission, it can be helpful to encourage patients, even those in treatment, to maintain some level of activity even just 15 minutes a day. Research has found that regular physical activity lowers stress, improves mood and cognition, and has cardiovascular benefits. In fact, cancer can be a teachable moment an opportunity to encourage patients to make healthy lifestyle choices.

To summarize, it is important to identify and address the stresses of a cancer diagnosis. The psychological, behavioral and biologic effects of stress that linger can worsen symptoms and lengthen recovery. Patients can reduce stress through progressive muscle relaxation, social support, physical activity and healthy eating.

Training for professionals

Healthcare professionals can help meet the psychological needs of newly diagnosed cancer patients. First, be familiar with current national and international guidelines for the screening and treatment of mental health concerns among cancer patients. The guidelines published by the American Society for Clinical Oncology, for example, recommend evaluating all cancer patients at the time of diagnosis and periodically thereafter. Two commonly used screening questionnaires are:

- For symptoms of depression, the Patient Health Questionnaire or PHQ-9 (**http://phqscreeners.com/pdfs/02_phq-9/english.pdf**)
- For symptoms of anxiety, the Generalized Anxiety Disorder Questionnaire or GAD-7 (**http://www.phqscreeners.com/pdfs/03_GAD-7/English.pdf**)

Both measures are widely used in primary care and have been translated into more than 75 languages, including Chinese, Spanish, French, German, Italian, Russian, Portuguese and Arabic.

Patients with no or mild symptoms can be referred to resources available in the community, such as those provided by a hospital. Those with moderate symptoms are recommended for low-intensity, group-based interventions such as cognitive behavioral therapy, biobehavioral interventions or structured physical activity programs. Those with moderate-to-severe or severe symptoms are recommended for more intense interventions, such as individual (face-to-face) therapies or cognitive behavioral therapy.

Supportive care low-/middle-income countries

"Resource-stratified" guidelines have been developed by organizations such as The Breast Health Global Initiative to help healthcare professionals with limited resources and in low- and middle-income countries provide supportive care. These recommendations have four tiers, starting at a basic level of resource allocation and incrementally adding services as resources become available. At the basic level, recommendations include:

- Educating health professionals about the psychosocial considerations presented above; community education to reduce stigma and burden
- Educating patients about treatment-related toxicities and side effects, such as fatigue, problems with cognition and infertility
- Educating patients and families about stress, relaxation social support, and offering peer support by trained volunteers.

In the United States, national groups such as the American College of Surgeons Commission on Cancer have mandated that "by 2016 all cancer clinics must provide psychosocial services to cancer patients and document the efficacy of so doing." The Ohio State University is participating in this effort to provide the best psychosocial services possible to patients around the country and around the world by training mental health professionals to provide those services.

Several times a year, the university conducts "From Cancer to Health Institutes" to train mental health professionals in the delivery of an evidence-based biobehavioral intervention developed by Ohio State medical researchers. This intervention is based on a conceptual model that incorporates psychological, social, behavioral and biological effects of cancer stress. The intervention uses cognitive and behavioral techniques to reverse negative emotional, behavioral and physical responses to cancer stress. Key components include:

- Stress reduction
- Assertive communication and problem solving
- Garnering social support from friends and family
- Health-behavior change focused on a healthy diet, physical activity and reducing negative health behaviors such as smoking or heavy alcohol use

The key to providing effective psychosocial support to patients is to use evidenced-based methods. This is the central tenet of modern healthcare delivery. If you are a mental health professional who works with cancer patients and would like to learn more about intervention and training institutes at Ohio State, please visit **http://cancertohealth.osu.edu** or follow us on **Twitter @cancertohealth**.

Glossary

acute leukemia
Acute leukemias are characterized by the accumulation of immature white blood cells called blasts in the bone marrow, blood and organs.

adjuvant therapy
Treatment that follows surgery.

amino acid
Small molecules that are the building blocks of proteins.

angiogenesis
The formation of new blood vessels.

antibody
A protein made and released by B lymphocytes, or B cells, to help fight infections.

antigen
A substance that induces the production of an antibody, and to which an antibody will bind. The word comes from antibody generator.

apoptosis
A natural process that causes damaged or unneeded cells to self destruct.

asymptomatic
Without symptoms.

B cells (or B lymphocytes)
A type of white blood cell (i.e., an immune-system cell) that fights infection by producing antibodies against bacteria, viruses, fungi and parasites

basic research
Research that answers an interesting biological question.

benign tumor
A tumor that does not invade other tissues, can usually be surgically removed and usually does not recur.

bind/binding
In molecular biology, one molecule clinging to another through chemical forces.

biomarker
In cancer, molecules, genes or cells that provide information that may help guide prevention or treatment.

biopsy
Removing a small amount of tissue from the body to examine it closely for cancer or other disease.

bone marrow transplant (BMT)
A procedure to restore the blood-forming cells destroyed by chemotherapy or radiation treatment. In an allogeneic transplant, another person donates the marrow to be used; in an autologous transplant, the patient's own marrow is removed, treated and returned to the patient.

brachytherapy
Radiation treatment in which tiny rods of a radioactive element are surgically placed in or near a tumor, giving the tumor a high dose of radiation.

cancer
A large group of diseases characterized by the growth and spread of abnormal cells.

carcinogen
An agent such as a chemical, virus or radiation that causes cancer.

carcinoma in situ
An early stage of some cancers when the tumor has not invaded other tissues.

carcinoma
Cancer that arises from epithelial tissue, which is the tissue that covers or lines organs of the body such as the skin, the lung, liver, breast and colon.

cell
The fundamental building block of living things. In humans and other higher organisms, it has a central nucleus that contains chromosomes, a surrounding membrane and an area in between called the cytoplasm, which contains a variety of organlles.

cell receptors
Molecules that bind with other molecules, such as hormones, drugs, neurotransmitters and growth factors. The binding triggers a signal that activates genes in the cell nucleus.

chemoprevention
Taking a drug or other substance to prevent cancer.

chromosome
A molecule of DNA plus associated proteins. Humans have two pairs of 23 chromosomes, or 46 total.

chronic leukemia
Leukemias that progress slowly, sometimes over years' several, and are seldom cured with the standard treatments available today.

clinical trial
Controlled studies that involve human volunteers to evaluate the safety and effectiveness of new drugs, devices or behavioral interventions.

combination chemotherapy
Use of two or more drugs to treat a disease.

combined modality therapy
Use of two or more treatments, such as surgery plus radiation.

CT scan
Computed tomography, which uses X-rays and a computer to produce cross-sectional images of the body. Also known as CAT scan.

cytoplasm
The region of the cell outside the nucleus.

cytogenetics
The study of chromosomal abnormalities.

cytotoxic therapy
Therapy such as chemotherapy and radiation that works by killing cells.

DNA
Deoxyribonucleic acid. The class of thread-like molecules that stores genetic information in nearly all living things.

endemic
Common or existing in a certain area.

epigenetic
Changes in gene expression that are not caused by a change in the DNA sequence.

enzyme
A molecule in living things that greatly accelerates a chemical reaction without itself being consumed in the process.

epithelium
A tissue that covers the body and lines its cavities and internal organs.

Epstein-Barr virus (EBV)
A herpes virus associated with infectious mononucleosis, non-Hodgkin lymphoma and Burkitt lymphoma.

external-beam radiation
Radiation delivered to the body from the outside. The most common type of radiation used to treat cancer.

gastrointestinal (GI)
The stomach, and intestines.

genes
The fundamental unit of heredity. Genes are lengths of DNA encoded with the information needed for cells to make proteins and other biological molecules.

gene expression
Refers to the levels in cells of messenger RNA (mRNA) or protein that is encoded by a particular gene.

gene product
The messenger RNA (mRNA) or the protein encoded by the gene, or to noncoding RNA such as microRNA.

gene sequencing
Method for determining the sequence of bases that spell out the information carried in DNA.

genetic code
The correspondence between the information encoded in the DNA of a gene and the sequence of amino acids in the final protein.

genetic testing
The analysis of DNA to detect genetic changes (i.e., mutations).

genome
The complete set of genes possessed by an organism. The human genome refers to all the genes found in a set of 46 chromosomes.

grade
See tumor grade.

growth factor
A substance that influences the growth of cells.

hematologic cancer
Cancers of the blood-forming tissues, such as the bone marrow, and cells of the immune system. They include leukemias, lymphomas, multiple myeloma.

hereditary
Genetic characteristics that are transferred from parent to offspring.

hormone
A substance produced by an organ or gland that is carried by the blood and produces a specific effect on other organs or glands. There are two main groups: steroid and nonsteroidal hormones.

immunotherapy
Treatment of disease by stimulating or enhancing the immune system.

incidence
Number of new cases of a disease within a certain population and period of time.

induction chemotherapy
The initial chemotherapy, especially in advanced cancers. Sometimes refers to the first few cycles of chemotherapy.

intraoperative radiation therapy (IORT)
External radiation therapy given during surgery.

karyotype
A photograph of chromosomes arranged so that they can be identified and studied for abnormalities.

leukemia
Cancer that primarily develops in the bone marrow and spreads into the bloodstream.

lipids
Category of organic molecules that includes the fats, oils, waxes and steroids.

localized cancer
Cancer that has not spread beyond the tissue in which it originated.

lumpectomy
Removal of a breast tumor and a small amount of surrounding tissue, leaving the rest of the breast intact.

lymphatic system
A system of vessels that assists the veins in returning fluids from the tissues to the heart. The lymph system empties into large veins at the base of the neck.

lymph node
Rounded bodies that vary in size from a pinhead to an olive and that are found at intervals along lymphatic vessels.

lymphocyte
A class of white blood cell that plays a major role in immune responses to pathogens and cancers in the body.

lymphoma
Cancer that primarily forms in the lymphoid organs, such as lymph nodes and the spleen.

magnetic resonance imaging (MRI)
A technology that uses a strong magnetic field to generate diagnostic images of soft tissues, such as the brain, heart, and major blood vessels. It does not involve exposure to radiation.

malignant tumor
A tumor that invades other tissues. A cancerous tumor.

mammogram
An X-ray of the breast.

messenger RNA (mRNA)
An RNA molecule that is a copy of the information contained in a gene and that carries it from the nucleus to the cytoplasm, where the message is translated into a protein.

metastasis
Spread of cancer cells from one part of the body to another, usually via the blood stream or lymph system. The ability of cancer cells to metastasize makes them malignant and sets them apart from benign tumors.

microRNA (miRNA)
A small RNA molecule that can turn off gene expression by attaching to a messenger RNA. This prevents the messenger RNA from being translated into a protein.

molecule
The smallest entity to which a substance can be reduced and still have the chemical characteristics of that substance, e.g., H2O—two atoms of hydrogen and one atom of oxygen is one molecule of water.

monoclonal antibody
An antibody engineered to bind to a specific protein on a cell.

mortality rate
The death rate. The number of people who die from a specific cause per unit of population and within a period of time.

mutation
A change in the DNA sequence of a gene.

myeloid
Referring to the bone marrow and to cells that develop in the bone marrow, such as granulocytes, monocytes and mast cells.

myeloma
Cancer of the immune-system cells that produce antibodies.

natural killer (NK) cells
Lymphocyte-like cells that destroy virus-infected cells and some tumor cells.

nuclear magnetic resonance imaging
Same as magnetic resonance imaging.

oncogene
A normal gene that when mutated plays an important role in causing cancer.

oncologist
A physician who specializes in treating cancer.

oncolytic virus
A natural virus that is engineered to target and kill cancer cells.

orchectomy
Removal of the testicles.

palliative treatment
A treatment that relieves pain and other symptoms without curing the disease. The goal is to improve quality of life.

Pap test
A test for detecting cervical cancer. It involves collecting cells shed from the cervix for microscopic examination. Named after its developer, George Papanicolaou.

pathogen
A virus, bacterium, protozoan, fungus or other organism or substance that causes disease.

phase I trials
The first use of an experimental drug or new drug combination by humans. They are designed to determine the safety and optimal dosage of potential new drugs.

phase II trials
Evaluate the effectiveness of a possible new drug for a particular type of cancer, as well as the agent's safety and short-term side effects.

phase III trials
Randomized, controlled trials, usually with a large number of patients, to show that a potential new drug is safer or more effective than the standard therapy.

polyp
An abnormal growth projecting from a mucous membrane, as in the colon. Often benign but may become cancerous.

preclinical research
Phase of drug development in which a potential drug is tested on animals.

prevalence
Proportion (i.e., percent) of a population having a disease at a specific point in time.

primary tumor
The original tumor in a cancer patient.

prognosis
Expected course and outcome of a disease, and the likelihood of recovery.

protein
Compounds made up of one or more chains of amino acids. Hormones, enzymes, growth factors, cell surface receptors and most other substances involved in the functioning of cells are proteins. Most proteins are between 50 and 500 amino acids long.

receptor molecule
A molecule on or inside the cell that binds with another molecule to cause some change inside the cell.

regimen
A program of treatment.

regional involvement
Cancer that has spread from the organ in which it originated to neighboring tissues or lymph nodes.

ribosome
A granular molecule that consists of RNA and protein. Ribosomes "read" messenger RNA during the translation step of protein synthesis.

risk factors
Elements in the lifestyle, environment and genetic make-up of an individual that may increase the chance of developing disease. Known cancer risk factors include smoking and exposure to ultraviolet light.

sarcoma
Cancer that arises from connective tissue such as bone, cartilage or muscle.

screening
Checking for cancer or other disease, or for conditions that might lead to the disease, in people who have no symptoms.

signaling pathway
Molecules within a cell that relay a signal from one part of a cell to another, e.g., from the cell surface to the nucleus.

squamous cell carcinoma
Cancer that begins in squamous cells, which are thin, flat cells found in the epithelial tissue that forms the surface of the skin, the lining of the hollow organs of the body, and the passages of the respiratory and digestive tracts.

staging
Process for determining the extent of cancer in the body.

stem cell transplant
A method of replacing immature blood-forming cells in the bone marrow that have been destroyed by drugs, radiation or disease. May be autologous (using stem cells from the patient), allogeneic (using stem cells donated by someone who is not an identical twin) or syngeneic (using stem cells donated by an identical twin).

T cells
Immune cells that help manage the immune system and fight infection. Certain T cells release substances that attract other immune cells to a site of infection. Some T cells destroy damaged cells, such as cancer cells, or cells that are infected with pathogens.

targeted therapy
Treatment directed to a specific molecule that is critical to cancer development or progression.

transcription
The first stage of protein synthesis during which the cell makes an RNA copy of a gene. This RNA, called messenger RNA or mRNA, carries the blueprint of the gene from the nucleus to the cytoplasm, where it is translated into a protein.

transformation
The changes that a normal cell undergoes when it becomes a cancer cell.

translation
The stage of protein synthesis when messenger RNA binds to ribosomes that decode its message and create a chain of amino acids that then folds into a protein.

translational research
The bridge between basic and clinical research. The aim of translational research is to take compounds or interventions that look promising in the laboratory and study them further for use in human trials.

tumor
A new and spontaneous growth of tissue that forms an abnormal mass.

tumor grade
The degree of abnormality of cancer cells when looked at under a microscope. A “high-grade” tumor has cells that are likely to grow more quickly than a “low-grade” tumor.

ultrasound
Sound waves that are inaudible to the human ear. Because ultrasound travels through different tissues at different velocities, it can be used for imaging body organs.

Whole-genome sequencing
Sequencing genes from an entire genome.

VIA
Visual inspection with acetic acid. A low-cost method of screening women for cervical cancer.

About The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute

The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute strives to create a cancer-free world by integrating scientific research with excellence in education and patient-centered care, a strategy that leads to better methods of prevention, detection and treatment. Ohio State is one of only 45 National Cancer Institute-designated Comprehensive Cancer Centers and one of only four centers funded by the NCI to conduct both phase I and phase II clinical trials on novel anticancer drugs. As the cancer program's 306-bed adult patient-care component, The James is one of the top cancer hospitals in the nation as ranked by *U.S.News & World Report* and has achieved Magnet designation, the highest honor an organization can receive for quality patient care and professional nursing practice. At 21 floors with more than 1.1 million square feet, The James is a transformational facility that fosters collaboration and integration of cancer research and clinical cancer care. For more information, please visit **cancer.osu.edu**.

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