**Slide 1:** Cancer is a renegade system of growth that originates within a patient's biosystem, more commonly known as the human body. There are many different types of cancers, but all share one hallmark characteristic: unchecked growth that progresses toward limitless expansion.

It is difficult to imagine anyone who has not heard of this illness. Most people have been affected because either they or their loved ones or friends are cancer survivors.

Because cancer is so prevalent, people have many questions about its biology, detection, diagnosis, possible causes, and strategies for prevention.

**Slide 2:** Cancer can originate almost anywhere in the body.

**Carcinomas**, the most common types of cancer, arise from the cells that cover external and internal body surfaces. Lung, breast, and colon are the most frequent cancers of this type in the United States.

**Sarcomas** are cancers arising from cells found in the supporting tissues of the body such as bone, cartilage, fat, connective tissue, and muscle.

**Lymphomas** are cancers that arise in the lymph nodes and tissues of the body's immune system.

**Leukemias** are cancers of the immature blood cells that grow in the bone marrow and tend to accumulate in large numbers in the bloodstream.

**Slide 3:** Scientists use a variety of technical names to distinguish the many different types of carcinomas, sarcomas, lymphomas, and leukemias. In general, these names are created by using different Latin prefixes that stand for the location where the cancer began its unchecked growth. For example, the prefix “osteo” means bone, so a cancer arising in bone is called an osteosarcoma. Similarly, the prefix “adeno” means gland, so a cancer of gland cells is called adenocarcinoma--for example, a breast adenocarcinoma.

**Slide 4:** Cancer arises from a loss of normal growth control. In normal tissues, the rates of new cell growth and old cell death are kept in balance. In cancer, this balance is disrupted. This disruption can result from uncontrolled cell growth or loss of a cell’s ability to undergo cell suicide by a process called “apoptosis.” Apoptosis, or “cell suicide,” is the mechanism by which old or damaged cells normally self-destruct.

**Slide 5:** To illustrate what is meant by normal growth control, consider the skin. The thin outermost layer of normal skin, called the epidermis, is roughly a dozen cells thick. Cells in the bottom row of this layer, called the basal layer, divide just fast enough to replenish cells that are continually being shed from the surface of the skin. Each time one of these basal cells divides, it produces two cells. One remains in the basal layer and retains the capacity to divide. The other migrates out of the basal layer and loses the capacity to divide. The number of dividing cells in the basal layer, therefore, stays the same.
**Slide 7:** During the development of skin cancer, the normal balance between cell division and cell loss is disrupted. The basal cells now divide faster than is needed to replenish the cells being shed from the surface of the skin. Each time one of these basal cells divides, the two newly formed cells will often retain the capacity to divide, thereby leading to an increase in the total number of dividing cells.

**Slide 8:** This gradual increase in the number of dividing cells creates a growing mass of tissue called a “tumor” or “neoplasm.” If the rate of cell division is relatively rapid, and no “suicide” signals are in place to trigger cell death, the tumor will grow quickly in size; if the cells divide more slowly, tumor growth will be slower. But regardless of the growth rate, tumors ultimately increase in size because new cells are being produced in greater numbers than needed. As more and more of these dividing cells accumulate, the normal organization of the tissue gradually becomes disrupted.

**Slide 9:** Cancers are capable of spreading throughout the body by two mechanisms: invasion and metastasis. Invasion refers to the direct migration and penetration by cancer cells into neighboring tissues. Metastasis refers to the ability of cancer cells to penetrate into lymphatic and blood vessels, circulate through the bloodstream, and then invade normal tissues elsewhere in the body.

**Slide 10:** Depending on whether or not they can spread by invasion and metastasis, tumors are classified as being either benign or malignant. Benign tumors are tumors that cannot spread by invasion or metastasis; hence, they only grow locally. Malignant tumors are tumors that are capable of spreading by invasion and metastasis. By definition, the term “cancer” applies only to malignant tumors.

**Slide 11:** A malignant tumor, a “cancer,” is a more serious health problem than a benign tumor because cancer cells can spread to distant parts of the body. For example, a melanoma (a cancer of pigmented cells) arising in the skin can have cells that enter the bloodstream and spread to distant organs such as the liver or brain. Cancer cells in the liver would be called metastatic melanoma, not liver cancer. Metastases share the name of the original (“primary”) tumor. Melanoma cells growing in the brain or liver can disrupt the functions of these vital organs and so are potentially life threatening.

**Slide 12:** Detecting cancer early can affect the outcome of the disease for some cancers. When cancer is found, a doctor will determine what type it is and how fast it is growing. He or she will also determine whether cancer cells have invaded nearby healthy tissue or spread (metastasized) to other parts of the body. In some cases, finding cancer early may decrease a person’s risk of dying from the cancer. For this reason, improving our methods for early detection is currently a high priority for cancer researchers.

**Slide 13:** Some people visit the doctor only when they feel pain or when they notice changes like a lump in the breast or unusual bleeding or discharge. But don’t wait until then to be checked because early cancer may not have any symptoms. That is why screening for some cancers is important, particularly as you get older. Screening methods are designed to check for cancer in people with no symptoms.

**Slide 14:** A screening technique called the Pap test (or Pap smear) allows early detection of cancer of the cervix, the narrow portion of the uterus that extends down into the upper part of the vagina. In this procedure, a doctor uses a small brush or wooden scraper to remove a sample of cells from the cervix and upper vagina. The cells are placed on a slide and sent to a laboratory, where a microscope is used to check
for abnormalities. Since the 1930s, early detection using the Pap test has helped lower the death rate from cervical cancer more than 75 percent.

Should abnormalities be found, an additional test may be necessary. There are now 13 high-risk types of human papillomaviruses (HPV) recognized as the major causes of cervical cancer. The U.S. Food and Drug Administration has approved an HPV test that can identify their presence in a tissue sample. This test can detect the viruses even before there are any conclusive visible changes to the cervical cells.

**Slide 15:** The U.S. Food and Drug Administration has approved the PSA test along with a digital rectal exam to help detect prostate cancer in men age 50 and older. Doctors often use the PSA test and DRE as prostate cancer screening tests; together, these tests can help doctors detect prostate cancer in men who have no symptoms of the disease. Most men with an elevated PSA test, though, turn out not to have cancer; only 25 to 30 percent of men who have a biopsy due to elevated PSA levels actually have prostate cancer, so researchers are working hard to find new clues. Experts are trying to develop better blood tests that might alert people to malignancies while the cancers are still in their early stages. For example, several new blood tests for ovarian or prostate cancer are under development.

**Slide 16:** To diagnose the presence of cancer, a doctor must look at a sample of the affected tissue under the microscope. Hence, when preliminary symptoms, Pap test, mammogram, PSA test, FOBT, or colonoscopy indicate the possible existence of cancer, a doctor must then perform a biopsy, which is the surgical removal of a small piece of tissue for microscopic examination. (For leukemias, a small blood sample serves the same purpose.) This microscopic examination will tell the doctor whether a tumor is actually present and, if so, whether it is malignant (i.e., cancer) or benign. In addition, microarrays may be used to determine which genes are turned on or off in the sample, or proteomic profiles may be collected for an analysis of protein activity. This information will help doctors to make a more accurate diagnosis and may even help to inform treatment planning.

**Slide 17:** Cancer tissue has a distinctive appearance under the microscope. Among the traits the doctor looks for are a large number of irregularly shaped dividing cells, variation in nuclear size and shape, variation in cell size and shape, loss of specialized cell features, loss of normal tissue organization, and a poorly defined tumor boundary.

**Slide 20:** Instead of finding a benign or malignant tumor, microscopic examination of a biopsy specimen will sometimes detect a condition called “hyperplasia.” Hyperplasia refers to tissue growth based on an excessive rate of cell division, leading to a larger than usual number of cells. Nonetheless, cell structure and the orderly arrangement of cells within the tissue remain normal, and the process of hyperplasia is potentially reversible. Hyperplasia can be a normal tissue response to an irritating stimulus. An example of hyperplasia is a callus that may form on your hand when you first learn to swing a tennis racket or a golf club.

**Slide 21:** In addition to hyperplasia, microscopic examination of a biopsy specimen can detect another type of noncancerous condition called “dysplasia.” Dysplasia is an abnormal type of excessive cell proliferation characterized by loss of normal tissue arrangement and cell structure. Often such cells revert back to normal behavior, but occasionally they gradually become malignant. Because of their potential for
becoming malignant, areas of dysplasia should be closely monitored by a health professional. Sometimes they need treatment.

**Slide 22:** The most severe cases of dysplasia are sometimes referred to as “carcinoma in situ.” In Latin, the term “in situ” means “in place,” so carcinoma in situ refers to an uncontrolled growth of cells that remains in the original location. However, carcinoma in situ may develop into an invasive, metastatic malignancy and, therefore, is usually removed surgically, if possible.

**Slide 23:** Cancer is often perceived as a disease that strikes for no apparent reason. While scientists don’t yet know all the reasons, many of the causes of cancer have already been identified. Besides intrinsic factors such as heredity, diet, and hormones, scientific studies point to key extrinsic factors that contribute to the cancer’s development: chemicals (e.g., smoking), radiation, and viruses or bacteria.

**Slide 24:** One way of identifying the various causes of cancer is by studying populations and behaviors. This approach compares cancer rates among various groups of people exposed to different factors or exhibiting different behaviors. A striking finding to emerge from population studies is that cancers arise with different frequencies in different areas of the world. For example, stomach cancer is especially frequent in Japan, colon cancer is prominent in the United States, and skin cancer is common in Australia. What is the reason for the high rates of specific kinds of cancer in certain countries?

**Slide 25:** In theory, differences in heredity or environmental risk factors might be responsible for the different cancer rates observed in different countries. Studies on people who have moved from one country to another suggest that exposure to risk factors for cancer varies by geographic location. For example, in Japan, the rate of colon cancer is lower, and the rate of stomach cancer is higher, than in the United States. But this difference has been found to gradually disappear in Japanese families that have moved to the United States. This suggests that the risk of developing the two kinds of cancer is not determined primarily by heredity. The change in risk for cancer for Japanese families could involve cultural, behavioral, or environmental factors predominant in one location and not in the other.

**Slide 26:** Some atoms give off radiation, which is energy that travels through space. Prolonged or repeated exposure to certain types of radiation can cause cancer. Cancer caused by the sun’s ultraviolet radiation is most common in people who spend long hours in strong sunlight. Ultraviolet radiation from sunlight is a low-strength type of radiation. Effective ways to protect against ultraviolet radiation and to prevent skin cancer are to avoid going into strong, direct sunlight and to wear protective clothing. Sunscreen lotions reduce the risk of some forms of skin cancers.

**Slide 27:** Increased rates of cancer also have been detected in people exposed to high-strength forms of radiation such as X-rays or radiation emitted from unstable atoms called radioisotopes. Because these two types of radiation are stronger than ultraviolet radiation, they can penetrate through clothing and skin into the body. Therefore, high-strength radiation can cause cancers of internal body tissues. Examples include cancer caused by nuclear fallout from atomic explosions and cancers caused by excessive exposure to radioactive chemicals.

**Slide 28:** Among the various factors that can cause cancer, tobacco smoking is the greatest public health hazard. Cigarette smoke contains more than two dozen different chemicals capable of causing cancer.
Cigarette smoking is the main cause of lung cancer and contributes to many other kinds of cancer as well, including cancer of the mouth, larynx, esophagus, stomach, pancreas, kidney, and bladder. Current estimates suggest that smoking cigarettes is responsible for at least one out of every three cancer deaths, making it the largest single cause of death from cancer. Other forms of tobacco use also can cause cancer. For example, cigars, pipe smoke, and smokeless tobacco can cause cancers of the mouth.

**Slide 30:** Chemicals and radiation that are capable of triggering the development of cancer are called “carcinogens.” Carcinogens act through a multistep process that initiates a series of genetic alterations ("mutations") and stimulates cells to proliferate. A prolonged period of time is usually required for these multiple steps. There can be a delay of several decades between exposure to a carcinogen and the onset of cancer. For example, young people exposed to carcinogens from smoking cigarettes generally do not develop cancer for 20 to 30 years. This period between exposure and onset of disease is the lag time.

**Slide 31:** In addition to chemicals and radiation, a few viruses also can trigger the development of cancer. In general, viruses are small infectious agents that cannot reproduce on their own, but instead enter into living cells and cause the infected cell to produce more copies of the virus. Like cells, viruses store their genetic instructions in large molecules called nucleic acids. In the case of cancer viruses, some of the viral genetic information carried in these nucleic acids is inserted into the chromosomes of the infected cell, and this causes the cell to become malignant.

**Slide 32:** Only a few viruses that infect human cells actually cause cancer. Included in this category are viruses implicated in cervical cancer, liver cancer, and certain lymphomas, leukemias, and sarcomas. Susceptibility to these cancers can sometimes be spread from person to person by infectious viruses, although such events account for only a very small fraction of human cancers. For example, the risk of cervical cancer is increased in women with multiple sexual partners and is especially high in women who marry men whose previous wives had this disease. Transmission of the human papillomavirus (HPV) during sexual relations appears to be involved.

**Slide 33:** Viruses are not the only infectious agents that have been implicated in human cancer. The bacterium *Helicobacter pylori*, which can cause stomach ulcers, has been associated with the development of cancer, so people infected with *H. pylori* are at increased risk for stomach cancer. Research is under way to define the genetic interactions between this infectious agent and its host tissues that may explain why cancer develops.

**Slide 34:** Cancer is not considered an inherited illness because most cases of cancer, perhaps 80 to 90 percent, occur in people with no family history of the disease. However, a person’s chances of developing cancer can be influenced by the inheritance of certain kinds of genetic alterations. These alterations tend to increase an individual’s susceptibility to developing cancer in the future. For example, about 5 percent of breast cancers are thought to be due to inheritance of particular form(s) of a “breast cancer susceptibility gene.”

**Slide 35:** Laboratory tests can determine whether a person carries some of the genetic alterations that can increase the risk of developing certain cancers. For example, women who inherit certain forms of a gene called BRCA1 or BRCA2 have an elevated risk of developing breast cancer. For women with a family history of breast cancer, taking such a test may relieve uncertainty about their future risk. However, the
information obtained from genetic tests is often complex and difficult to interpret. The decision to undergo genetic testing should therefore be a personal, voluntary one and should only be made in conjunction with appropriate genetic counseling.

**Slide 36:** Chemicals (e.g., from smoking), radiation, viruses, and heredity all contribute to the development of cancer by triggering changes in a cell’s genes. Chemicals and radiation act by damaging genes, viruses introduce their own genes into cells, and heredity passes on alterations in genes that make a person more susceptible to cancer. Genes are inherited instructions that reside within a person’s chromosomes. Each gene instructs a cell how to build a specific product—in most cases, a particular kind of protein. Genes are altered, or “mutated,” in various ways as part of the mechanism by which cancer arises.

**Slide 37:** Genes reside within chromosomes, the large DNA molecules, which are composed of two chemical strands twisted around each other to form a “double helix.” Each strand is constructed from millions of chemical building blocks called “bases.” DNA contains only four different bases: adenine, thymine, cytosine, and guanine (abbreviated A, T, G, and C), but they can be arranged in any sequence. The sequential order of the bases in any given gene determines the message the gene contains, just as the letters of the alphabet can be combined in different ways to form distinct words and sentences.

**Slide 38:** Genes can be mutated in several different ways. The simplest type of mutation involves a change in a single base along the base sequence of a particular gene—much like a typographical error in a word that has been misspelled. In other cases, one or more bases may be added or deleted. And sometimes, large segments of a DNA molecule are accidentally repeated, deleted, or moved.

**Slide 39:** One group of genes implicated in the development of cancer are damaged genes, called “oncogenes.” Oncogenes are genes whose PRESENCE in certain forms and/or overactivity can stimulate the development of cancer. When oncogenes arise in normal cells, they can contribute to the development of cancer by instructing cells to make proteins that stimulate excessive cell growth and division.

**Slide 40:** A second group of genes implicated in cancer are the “tumor suppressor genes.” Tumor suppressor genes are normal genes whose ABSENCE can lead to cancer. In other words, if a pair of tumor suppressor genes are either lost from a cell or inactivated by mutation, their functional absence might allow cancer to develop. Individuals who inherit an increased risk of developing cancer often are born with one defective copy of a tumor suppressor gene. Because genes come in pairs (one inherited from each parent), an inherited defect in one copy will not lead to cancer because the other normal copy is still functional. But if the second copy undergoes mutation, the person then may develop cancer because there no longer is any functional copy of the gene.

**Slide 41:** Tumor suppressor genes are a family of normal genes that instruct cells to produce proteins that restrain cell growth and division. Since tumor suppressor genes code for proteins that slow down cell growth and division, the loss of such proteins allows a cell to grow and divide in an uncontrolled fashion. Tumor suppressor genes are like the brake pedal of an automobile. The loss of a tumor suppressor gene function is like having a brake pedal that does not function properly, thereby allowing the cell to grow and divide continually.
Slide 42: A third type of genes implicated in cancer are called “DNA repair genes.” DNA repair genes code for proteins whose normal function is to correct errors that arise when cells duplicate their DNA prior to cell division. Mutations in DNA repair genes can lead to a failure in repair, which in turn allows subsequent mutations to accumulate. People with a condition called xeroderma pigmentosum have an inherited defect in a DNA repair gene. As a result, they cannot effectively repair the DNA damage that normally occurs when skin cells are exposed to sunlight, and so they exhibit an abnormally high incidence of skin cancer. Certain forms of hereditary colon cancer also involve defects in DNA repair.

Slide 43: Cancer may begin because of the accumulation of mutations involving oncogenes, tumor suppressor genes, and DNA repair genes. For example, colon cancer can begin with a defect in a tumor suppressor gene that allows excessive cell proliferation. The proliferating cells then tend to acquire additional mutations involving DNA repair genes, other tumor suppressor genes, and many other growth-related genes. Over time, the accumulated damage can yield a highly malignant, metastatic tumor. In other words, creating a cancer cell requires that the brakes on cell growth (tumor suppressor genes) be released at the same time that the accelerators for cell growth (oncogenes) are being activated.

Slide 44: In addition to all the molecular changes that occur within a cancer cell, the environment around the tumor changes dramatically as well. The cancer cell loses receptors that would normally respond to neighboring cells that call for growth to stop. Instead, tumors amplify their own supply of growth signals. They also flood their neighbors with other signals called cytokines and enzymes called proteases. This action destroys both the basement membrane and surrounding matrix, which lies between the tumor and its path to metastasis—a blood vessel or duct of the lymphatic system.

Slide 46: Since exposure to carcinogens (cancer-causing agents) is responsible for triggering most human cancers, people can reduce their cancer risk by taking steps to avoid such agents. Hence the first step in cancer prevention is to identify the behaviors or exposures to particular kinds of carcinogens and viruses that represent the greatest cancer hazards.

Slide 48: While some sunlight is good for health, skin cancer caused by excessive exposure to sunlight is not among the sun’s benefits. Because some types of skin cancer are easy to cure, the danger posed by too much sunlight is perhaps not taken seriously enough. It is important to remember that a more serious form of skin cancer, called melanoma, is also associated with excessive sun exposure. Melanomas are potentially lethal tumors. Risk of melanoma and other forms of skin cancer can be significantly reduced by avoiding excessive exposure to the sun, using sunscreen lotions, and wearing protective clothing to shield the skin from ultraviolet radiation.

Slide 49: Drinking excessive amounts of alcohol is linked to an increased risk for several kinds of cancer, especially those of the mouth, throat, and esophagus. The combination of alcohol and tobacco appears to be especially dangerous. For example, in heavy smokers or heavy drinkers, the risk of developing cancer of
the esophagus is roughly 6 times greater than that for nonsmokers/nondrinkers. But in people who both smoke and drink, the cancer risk is more than 40 times greater than that for nonsmokers/nondrinkers. Clearly the combination of alcohol and tobacco is riskier than would be expected by just adding the effects of the two together.

**Slide 50:** Studies suggest that differences in diet may also play a role in determining cancer risk. Unlike clear-cut cancer risk factors such as tobacco, sunlight, and alcohol, dietary components that influence cancer risk have been difficult to determine. Limiting fat consumption and calorie intake appears to be one possible strategy to decrease risk for some cancers, because people who consume large amounts of meat, which is rich in fat, and large numbers of calories exhibit an increased cancer risk, especially for colon cancer.

**Slide 51:** In contrast to factors such as fat and calories, which appear to increase cancer risk, other dietary components may decrease cancer risk. The most compelling evidence has been obtained for fruits and vegetables, whose consumption has been strongly correlated with a reduction in cancer risk. Although the exact chemical components in these foods that are responsible for a protective effect are yet to be identified, eating five to nine servings of fruits and vegetables each day is recommended by many groups.

**Slide 52:** Because people spend so much time at work, potential carcinogens in the work environment are studied carefully. Some occupational carcinogens have been identified because coworkers exposed to the same substances have developed a particular kind of cancer at increased frequency. For example, cancer rates in construction workers who handle asbestos have been found to be 10 times higher than normal.

**Slide 54:** A common misconception arises from news stories suggesting we are experiencing a cancer “epidemic.” This only appears to be the case because the number of new cancer cases reported is rising as the population as a whole is aging, and older people are more likely to develop cancer. However, this trend is offset by the number of new births, which is also increasing, and cancer is rare among the young. So as more and more members of a 75-million-strong “baby-boomer” cohort begin shifting en masse to older, more cancer-prone ages, the number of new cancer cases is expected to increase in the next several decades. But since the birth rate is also expected to increase, the cancer rate may either stay the same or, perhaps, decline.