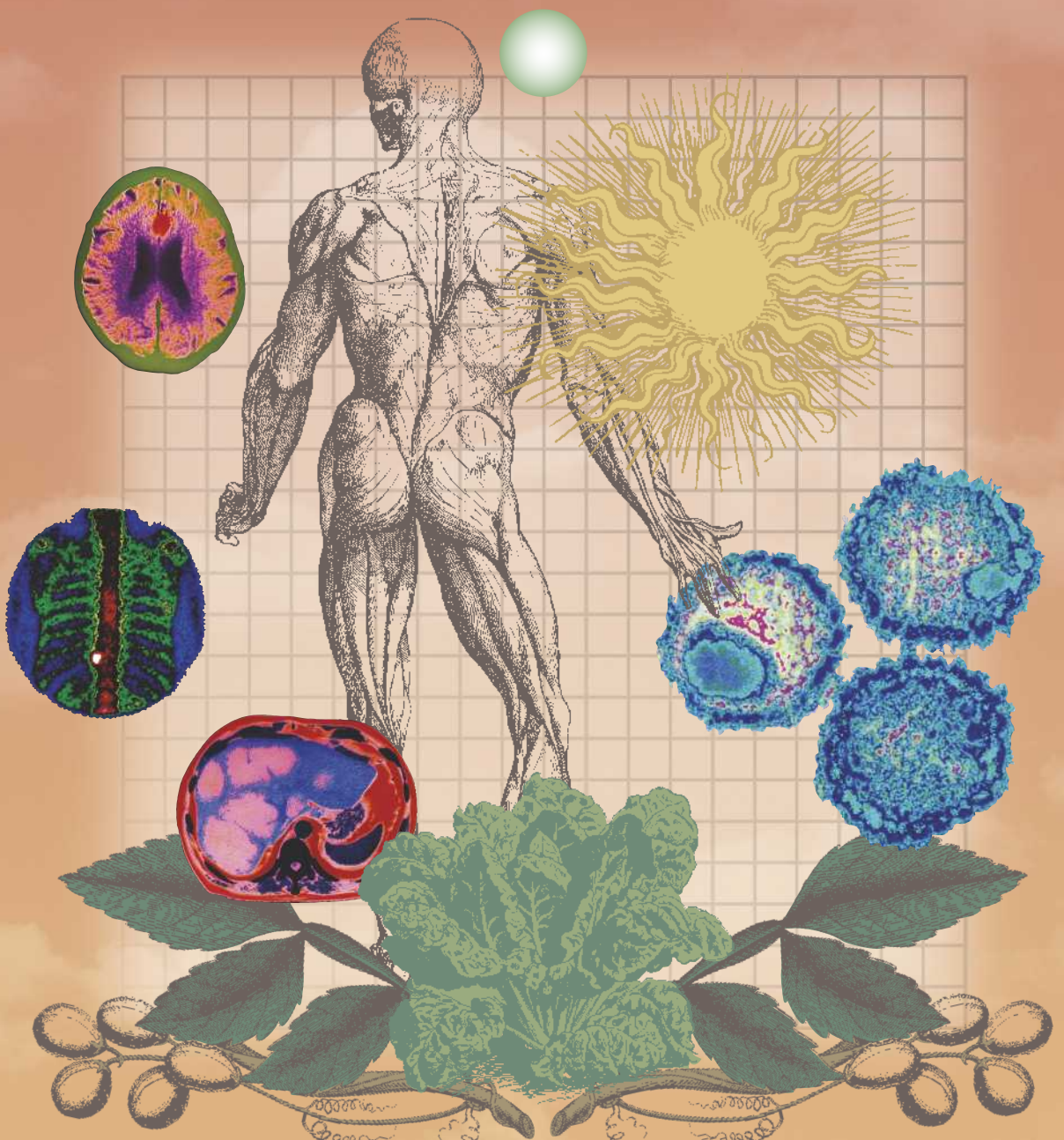
The GALE ENCYCLOPEDIA *of* CANCER

A GUIDE TO CANCER AND ITS TREATMENTS



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FOURTH EDITION

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A–E

KRISTIN FUST, EDITOR

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A number of experts in the medical community provided invaluable assistance in the formulation of this encyclopedia. Our advisory board performed myriad duties, from defining the scope of coverage to reviewing individual entries for accuracy and accessibility. The editor would like to express her appreciation to them.

CONTENTS

PLEASE READ—IMPORTANT INFORMATION

The *Gale Encyclopedia of Cancer: A Guide to Cancer and Its Treatments* is a health reference product designed to inform and educate readers about a wide variety of cancers; other diseases and conditions related to cancers; diagnostic tests and procedures; nutrition and dietary practices beneficial to cancer patients; and various cancer treatments, including drugs. Cengage Learning believes the product to be comprehensive, but not necessarily definitive. It is intended to supplement, not replace, consultation with a physician or other healthcare practitioner. While Cengage Learning has made substantial efforts to provide information that is accurate, comprehensive, and up to date, Cengage Learning makes no representations or warranties of any kind, including without limitation, warranties of merchantability or fitness for a particular purpose, nor does it guarantee the accuracy, comprehensiveness, or timeliness of the information contained in this product. Readers should be aware that the universe of medical knowledge is constantly growing and changing, and that differences of opinion exist among authorities. Readers are also advised to seek professional diagnosis and treatment for any medical condition, and to discuss information obtained from this book with their healthcare provider.

FOREWORD

Unfortunately, man must suffer disease. Some diseases are totally reversible and can be effectively treated. Moreover, some diseases with proper treatment have been virtually annihilated, such as polio, rheumatic fever, smallpox, and, to some extent, tuberculosis. Other diseases seem to target one organ, such as the heart, and there has been great progress in either fixing defects, adding blood flow, or giving medications to strengthen the diseased pump. Cancer, however, continues to frustrate even the cleverest of doctors or the most fastidious of health-conscious individuals. Why?

By its very nature, cancer is a survivor. It has only one purpose: to proliferate. After all, that is the definition of cancer: unregulated growth of cells that fail to heed the message to stop growing. Normal cells go through a cycle of division, aging, and then selection for death. Cancer cells are able to circumvent this normal cycle and escape recognition to be eliminated.

There are many mechanisms that can contribute to this unregulated cell growth. One of these mechanisms is inheritance. Some individuals can be programmed for cancer due to inherited disorders in their genetic makeup. In its simplest terms, a person can inherit a faulty gene or a missing gene whose role is to eliminate damaged cells or to prevent imperfect cells from growing. Without this natural braking system, the damaged cells can divide and lead to more damaged cells with the same abnormal genetic makeup as the parent cells. Given enough time, and our inability to detect them, these groups of cells can grow to a size that will cause discomfort or other symptoms.

Inherited genetics are obviously not the only source of abnormalities in cells. Humans do not live in a sterile world devoid of environmental attacks or pathogens. Humans must work, and working environments can be dangerous. Danger can come in the form of radiation, chemicals, or fibers to which we may be chronically exposed with or without our knowledge. Moreover, humans must eat, and if our food is contaminated with these environmental hazards, or if we prepare our food in a way that may change the chemical nature of the food to hazardous molecules, then chronic exposure to these toxins could damage cells. Finally, humans are social. They have found certain habits that are pleasing because they are relaxing or help release inhibitions. Such habits, including smoking and alcohol consumption, can have a myriad of influences on the genetic makeup of cells.

Why the emphasis on genes in the new century? Because they are potentially the reason as well as the answer for cancer. Genes regulate our micro- and macrosopic events by eventually coding for proteins that control our structure and function. If environmental events cause errors in those genes that control growth, then imperfect cells can start to take root. For the majority of cases, a whole cascade of genetic events must occur before a cell is able to outlive its normal predecessors. This cascade of events could take years to occur, in a silent, undetected manner until the telltale signs and symptoms of advanced cancer are seen, including pain, lack of appetite, cough, loss of blood, or the detection of a lump. How did these cells get to this state where they are now dictating the everyday physical, psychological, and economic events for the person afflicted?

At this time, the sequence of genetic catastrophes is much too complex to comprehend or summarize, because it is only in the past decade that we have even been able to map what genes we have and where they are located in our chromosomes. We have learned, however, that cancer cells are equipped with a series of self-protection mechanisms. Some of the altered genes are actually able to express themselves more than in the normal situation. These genes could then code for more growth factors for the transforming cell, or they could make proteins that could keep our own immune system from eliminating these interlopers. Finally, these cells are chameleons: if we treat them with drugs to try to kill them, they can "change their colors" by mutation, and then be resistant to the drugs that may have harmed them before.

Then what do we do for treatment? Humans have always had a fascination with grooming, and grooming

involves removal—dirt, hair, waste. The ultimate removal involves cutting away the spoiled or imperfect portion. An abnormal growth? Remove it by surgery . . . make sure the edges are clean. Unfortunately, the painful reality of cancer surgery is that it is most effective when performed in the early stages of the disease. "Early stages of the disease" implies that there is no spread, or, hopefully, before there are symptoms. In the majority of cases, however, surgery cannot eradicate all the disease because the cancer is not only at the primary site of the lump, but also has spread to other organs. Cancer is not just a process of growth, but also a metastasizing process that allows for invasion and spread. The growing cells need nourishment so they secrete proteins that allow for the growth of blood vessels (angiogenesis); once the blood vessels are established from other blood vessels, the tumor cells can make proteins that will dissolve the imprisoning matrix surrounding them. Once this matrix is dissolved, it is only a matter of time before the cancer cells will migrate to other places, making the use of surgery fruitless.

Since cancer cells have a propensity to spread to other organs, therapies must be geared to treat the whole body and not just the site of origin. The problem with these chemotherapies is that they are not selective and wreak havoc on tissues that are not affected by the cancer. These therapies are not natural to the human host, and result in nausea, loss of appetite, fatigue, and a depletion in the cells that protect us from infection and those that carry oxygen. Doctors who prescribe such medications must walk a fine line between helping the patient (causing a "response" in the cancer by making it smaller) or causing "toxicity," which, due to effects on normal organs, causes the patient problems. Although these drugs are far from perfect, we are fortunate to have them because when they work, their results can be remarkable.

But that's the problem—"when they work." We cannot predict who is going to benefit from our therapies, and doctors must inform the patient and his/her family about countless studies that have been done to validate the use of these potentially beneficial/potentially harmful agents. Patients must suffer the frustration that oncologists have because each individual afflicted with cancer is different, and each cancer is different. This makes it virtually impossible to personalize an individual's treatment expectations and life expectancy. Cancer, after all, is a very impersonal disease, with little regard to sex, race, age, or any other "human" characteristics.

Cancer treatment is in search of "smart" options. Like modern-day instruments of war, successful cancer treatment necessitates the construction of therapies that can do three basic tasks: search out the enemy, recognize the enemy, and kill the enemy without causing "friendly fire." The successful therapies of the future will involve the use of "living components," "manufactured components," or a combination of both. Living components, white blood cells, will be educated to recognize where the cancer is, and help our own immune system fight the foreign cells. These lymphocytes can be educated to recognize signals on the cancer cell that make them unique. Therapies in the future will be able to manufacture molecules with these signature, unique signals that are linked to other molecules specifically for killing the cells. Only the cancer cells are eliminated in this way, hopefully sparing the individual from toxicity.

Why use these unique signals as delivery mechanisms? If they are unique and are important for growth of the cancer cell, why not target them directly? This describes the ambitious mission of gene therapy, whose goal is to supplement a deficient, necessary genetic pool or diminish the number of abnormally expressed genes fortifying the cancer cells. If a protein is not being made that slows the growth of cells, gene therapy would theoretically supply the gene for this protein to replenish it and cause the cells to slow down. If the cells can make their own growth factors that sustain them selectively over normal cells, then the goal is to block the production of this growth factor. There is no doubt that gene therapy is the wave of the future, and it is under intense investigation and scrutiny. The problem, however, is that there is no way to tell when this future promise will be fulfilled.

No book can fully describe the medical, psychological, social, and economic burden of cancer, and if this is your first confrontation with the enemy, you may find yourself overwhelmed with its magnitude. Books are only part of the solution. Newly enlisted participants in this war must seek proper counsel from educated physicians who will inform the family and the patient of the risks and benefits of a treatment course in a way that can be understood. Advocacy groups of dedicated volunteers, many of whom are cancer survivors, can guide and advise. The most important component, however, is an intensely personal one. The afflicted individual must realize that he/she is responsible for charting the course of his/her disease, and this requires the above described knowledge as well as great personal intuition. Cancer comes as a series of shocks: the symptoms, the diagnosis, and the treatment. These shocks can be followed by cautious optimism or profound disappointment. Each one of these shocks either reinforces or chips away at one's resolve, and how an individual reacts to these issues is as unique as the cancer that is being dealt with.

While cancer is still life-threatening, strides have been made in the fight against the disease. Thirty years ago, a young adult diagnosed with testicular cancer had

few options for treatment that could result in cure. Now, chemotherapy for good-risk stage II and III testicular cancer can result in a complete response of the tumor in 98% of the cases and a durable response in 92%. Sixty years ago, there were no regimens that could cause a complete remission for a child diagnosed with leukemia, but now, using combination chemotherapy, complete remissions are possible in 96% of these cases. Progress has been made, but more progress is needed. The first real triumph in cancer care will be when cancer is no longer thought of as a life-ending disease, but as a chronic disease whose symptoms can be managed. Anyone who has been touched by cancer or who has been involved in the fight against it lives in hope that that day will arrive.

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INTRODUCTION

The *Gale Encyclopedia of Cancer: A Guide to Cancer and Its Treatments* is a unique and invaluable source of information for anyone touched by cancer. This collection of more than 600 entries provides in-depth coverage of specific cancer types, diagnostic procedures, treatments, cancer side effects, and cancer drugs. In addition, entries have been included to facilitate understanding of related concepts, such as cancer biology, carcinogenesis, and cancer genetics, as well as cancer issues such as clinical trials, home health care, fertility issues, and cancer prevention. This easy-to-read encyclopedia defines medical concepts and terminology in language that general readers can understand while still providing thorough coverage.

SCOPE

Entries follow a standardized format to help users find information quickly. Rubrics include the following headings (as applicable):

Cancer types

- Definition
- Description
- Demographics
- Causes and symptoms
- Diagnosis
- Treatment team
- Clincial staging
- Treatment
- Prognosis
- Coping with cancer treatment
- Clinical trials
- Prevention
- Special concerns
- Resources

Drugs, herbs, and supplements

- Definition
- Description
- Recommended dosage
- Precautions
- Side effects
- Interactions
- Resources

Tests, treatments, and other procedures

- Definition
- Purpose
- Description
- Benefits
- Precautions
- Preparation
- Aftercare
- Risks
- Results
- Alternatives
- Health care team roles
- Research and general acceptance
- Caregiver concerns
- Training and certification

INCLUSION CRITERIA

A preliminary list of cancers and related topics was compiled from a wide variety of sources, including professional medical guides and textbooks as well as consumer guides and encyclopedias. The advisory board, made up of medical doctors and oncology pharmacists, evaluated the topics and made suggestions for inclusion. Final selection of topics to include was made by the advisory board in conjunction with the editor.

ABOUT THE CONTRIBUTORS

The essays were compiled by experienced medical writers, including physicians, pharmacists, nurses, and

other healthcare professionals. Medical advisors reviewed the completed essays to ensure that they are appropriate, up to date, and accurate.

HOW TO USE THIS BOOK

The *Gale Encyclopedia of Cancer* has been designed with ready reference in mind.

- Straight **alphabetical arrangement** of topics allows users to locate information quickly.
- **Bold-faced terms** within entries indicate that full-length articles exist for those topics.
- **Cross-references** placed throughout the encyclopedia direct readers from alternate names and related topics to their intended entries.
- A list of **key terms** is provided in most entries to define unfamiliar or complicated terms or concepts.
- A **glossary**, located at the end of volume 3, contains a list of all key terms, arranged alphabetically.
- **Questions to Ask Your Doctor** sidebars are provided when appropriate to help facilitate patient discussions with physicians and other healthcare providers.
- **See also** suggestions at the end of some entries point readers toward similar or related topics.
- **Resources** sections at the end of entries direct readers to additional sources of information on a topic.
- Valuable **contact information** for organizations and support groups is included with most entries. All of the contact information is compiled in an appendix in the back of volume 3, arranged alphabetically.
- A comprehensive **general index** guides readers to all topics mentioned in the text.
- **Author and advisor bylines** provide information on who updated and reviewed the entries, including their credentials. Advisor bylines are new to this edition and are not yet present in every article, but the absence of an advisor byline does not mean that the entry was never reviewed.

A note about **drug entries**: Drug entries are listed in alphabetical order by common **generic names**. However, because many oncology drugs have more than one common generic name, and because the brand name may be used interchangeably with a generic name, drug entries may be located in three ways: The reader may find the intended entry under the generic drug name in alphabetical order; may be directed to the entry from an alternate name cross-reference; or may use the **index** to look up a **brand name**, which will direct the reader to the appropriate entry.

GRAPHICS

The *Gale Encyclopedia of Cancer* is enhanced by 275 color photographs, illustrations, and tables.

ALPHABETICAL LIST OF ENTRIES

D

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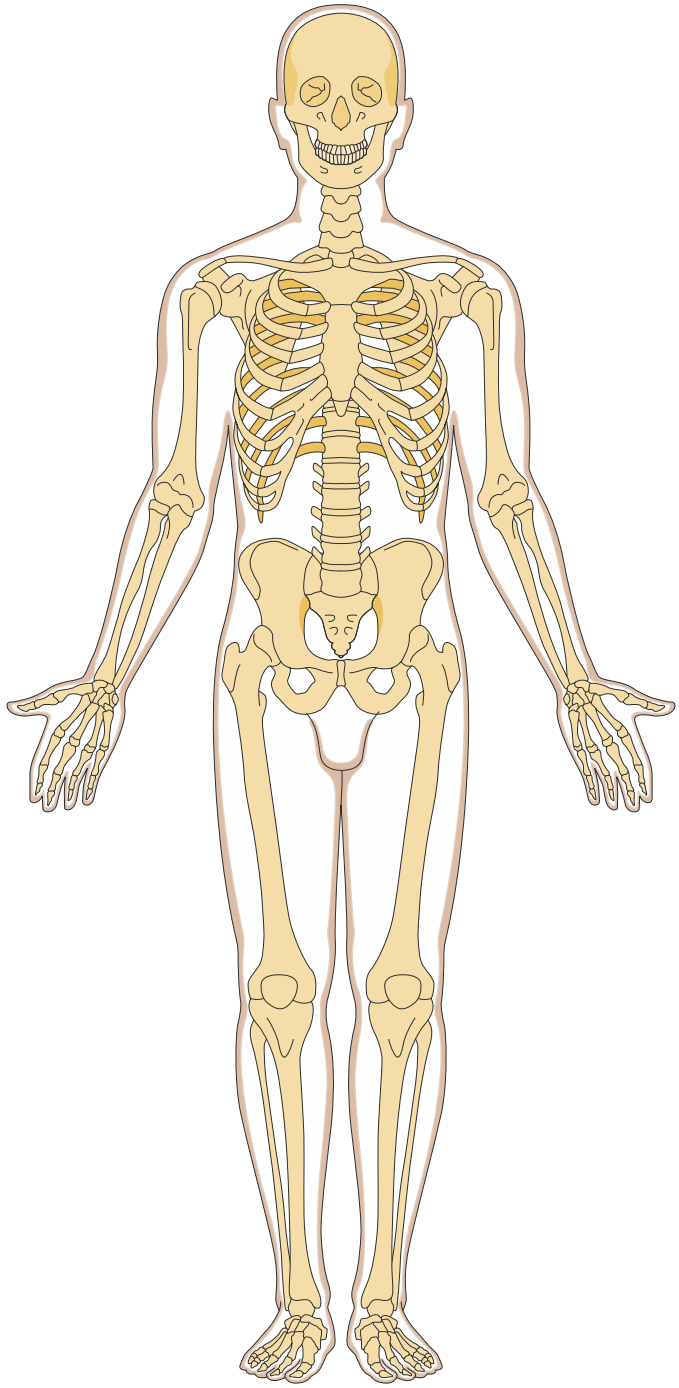
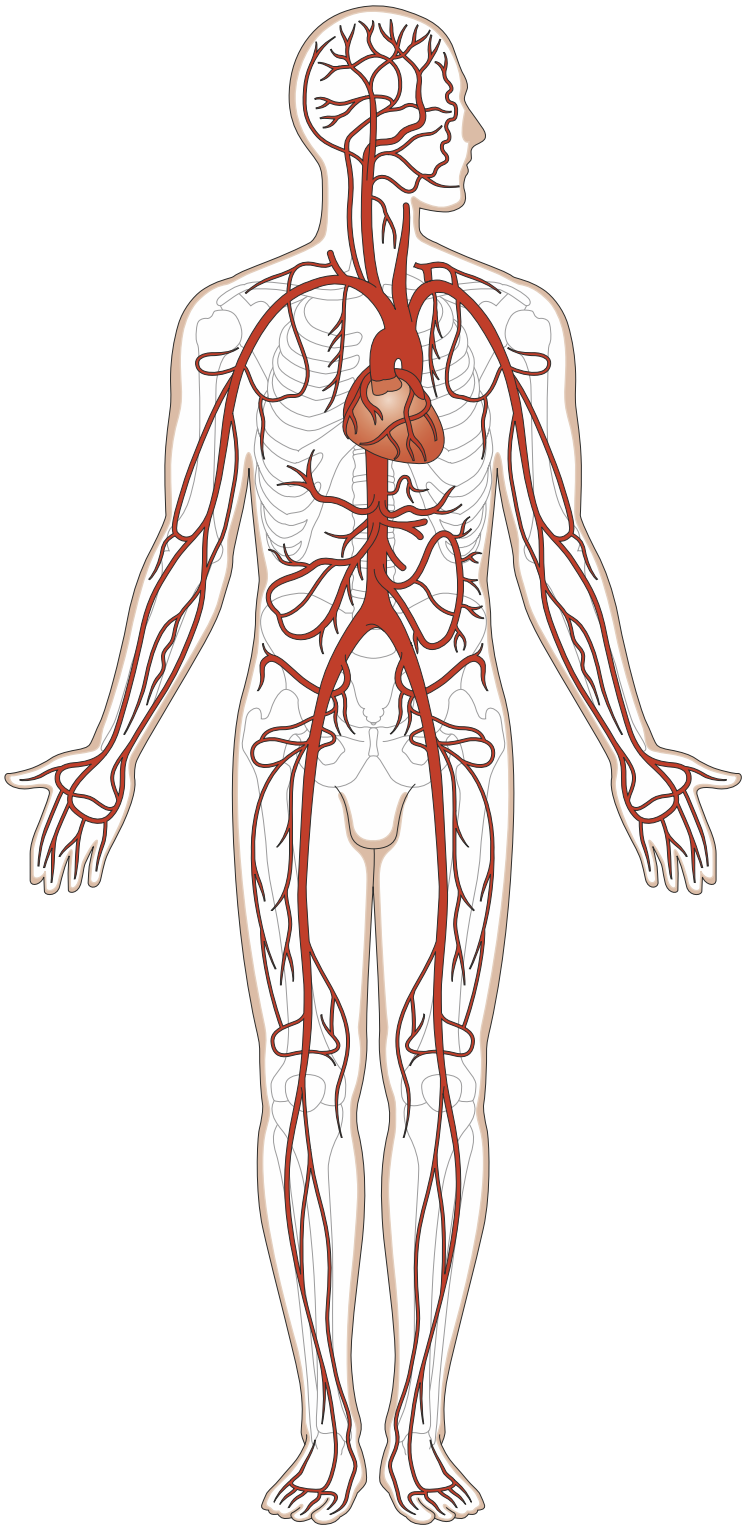
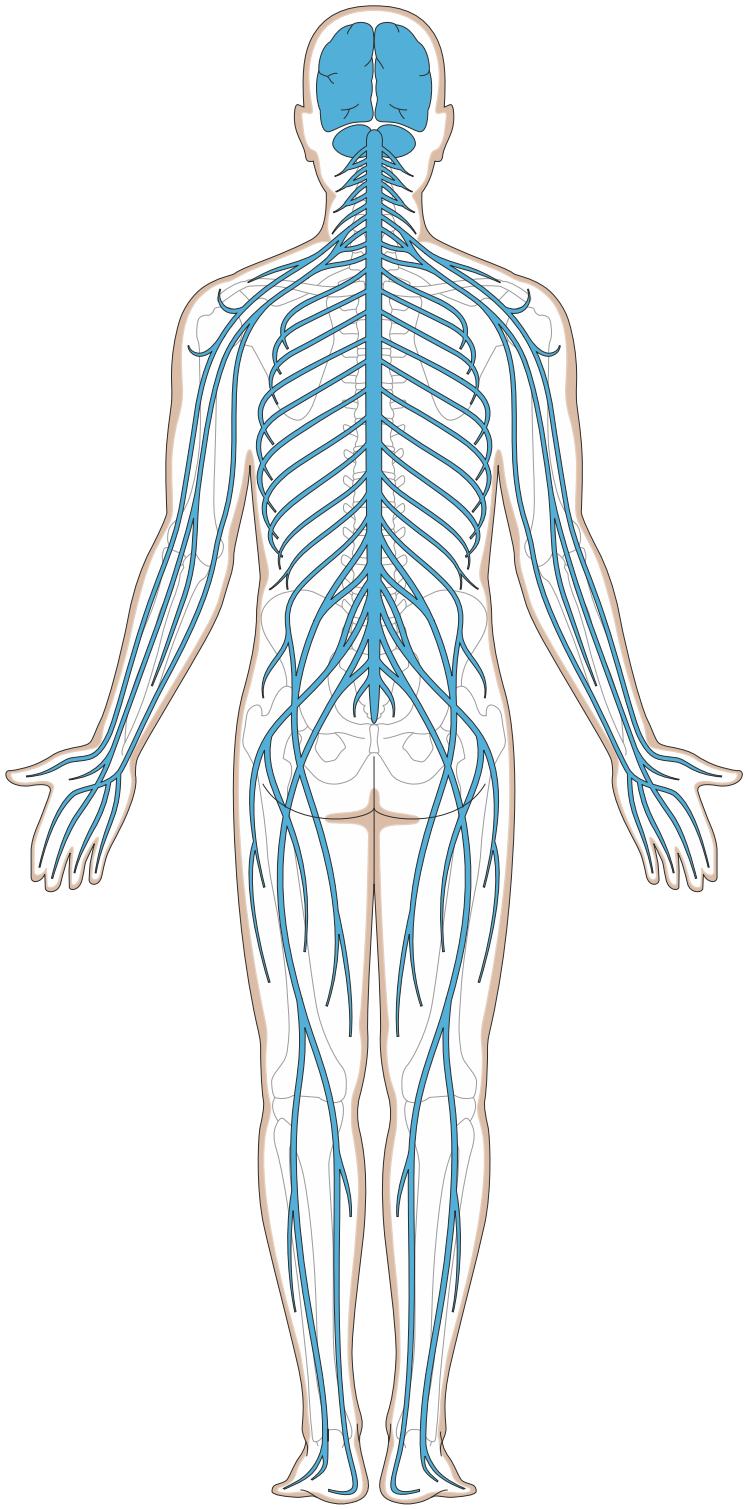
ILLUSTRATIONS OF BODY SYSTEMS



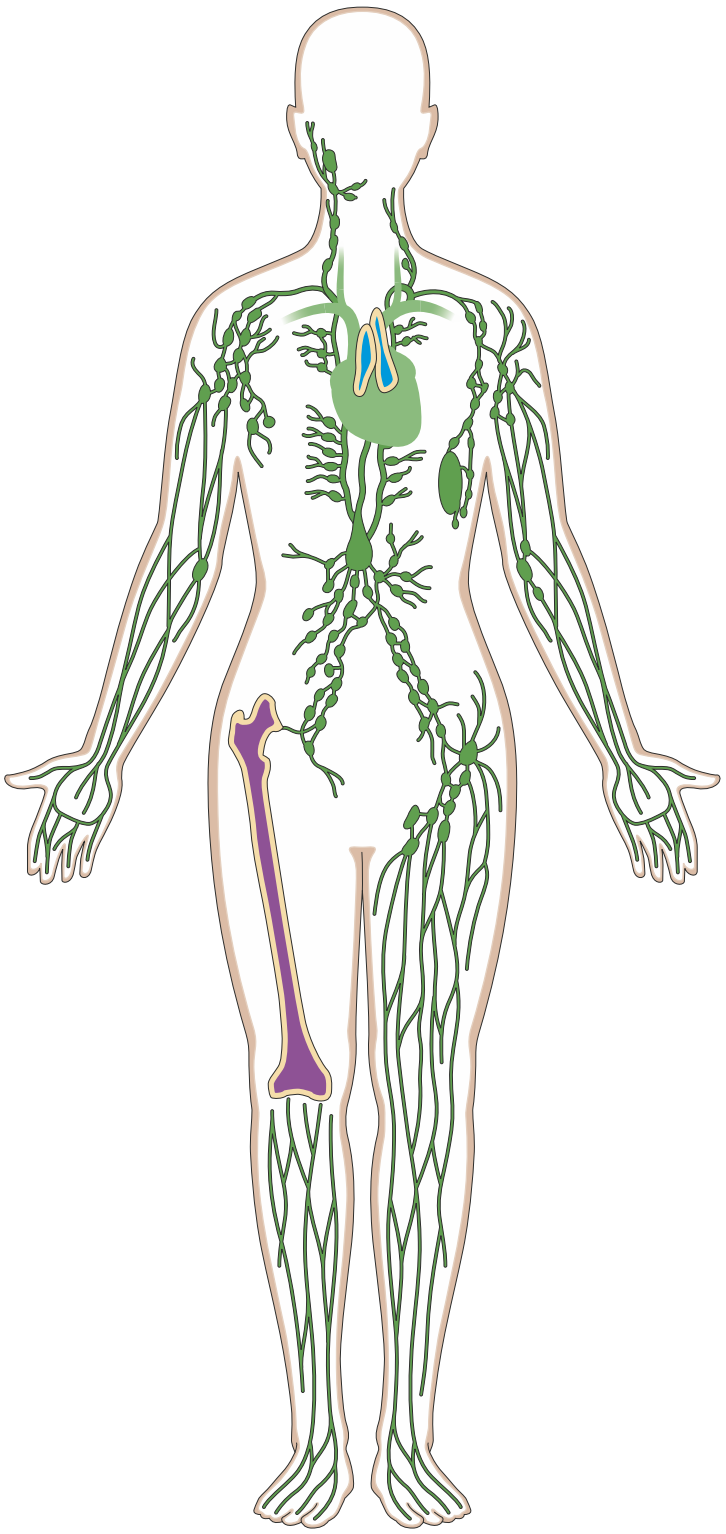
HUMAN SKELETON and SKIN. Some cancers that affect the skeleton are: Osteosarcoma; Ewing sarcoma; Fibrosarcoma (can also be found in soft tissues like muscle, fat, connective tissues, etc.). Some cancers that affect tissue near bones: Chondrosarcoma (affects joints near bones); Rhabdomyosarcoma (formed from cells of muscles attached to bones); Malignant fibrous histiocytoma (common in soft tissues, rare in bones). SKIN CANCERS: Basal cell carcinoma; Melanoma; Merkel cell carcinoma; Squamous cell carcinoma of the skin; and Trichilemmal carcinoma. Precancerous skin condition: Bowen disease. Lymphomas that affect the skin: Mycosis fungoides; Sézary syndrome. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



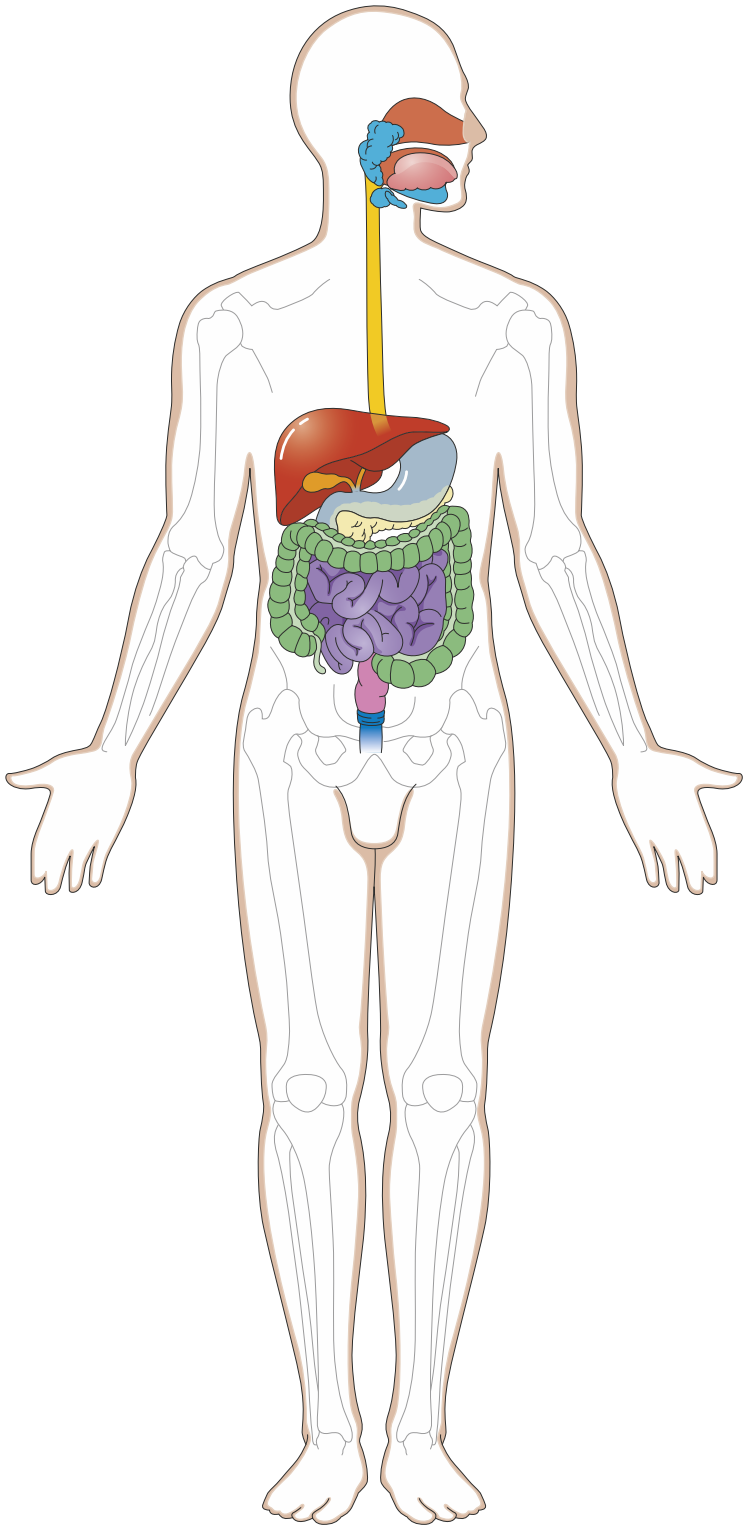
HUMAN CIRCULATORY SYSTEM. Some cancers of the blood cells are: Acute erythroblastic leukemia; Acute lymphocytic leukemia; Acute myelocytic leukemia; Chronic lymphocytic leukemia; Chronic myelocytic leukemia; Hairy cell leukemia; and Multiple myeloma. One condition associated with various cancers that affects blood is called Myelofibrosis. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



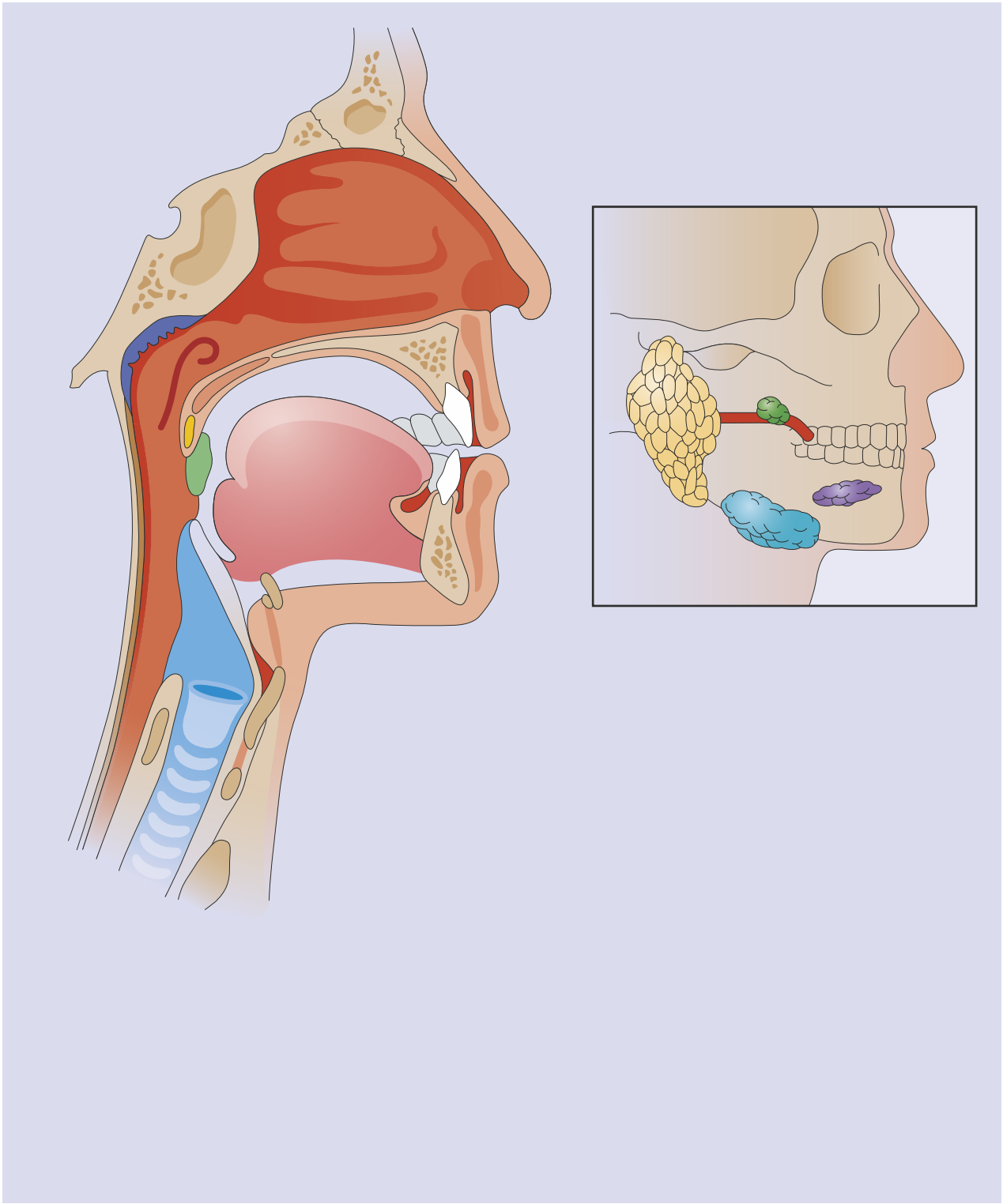
HUMAN NERVOUS SYSTEM. Some brain and central nervous system tumors are: Astrocytoma; Carcinomatous meningitis; Central nervous system carcinoma; Central nervous system lymphoma; Chordoma; Choroid plexus tumors; Craniopharyngioma; Ependymoma; Medulloblastoma; Meningioma; Oligodendroglioma; and Spinal axis tumors. One kind of noncancerous growth in the brain: Acoustic neuroma. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



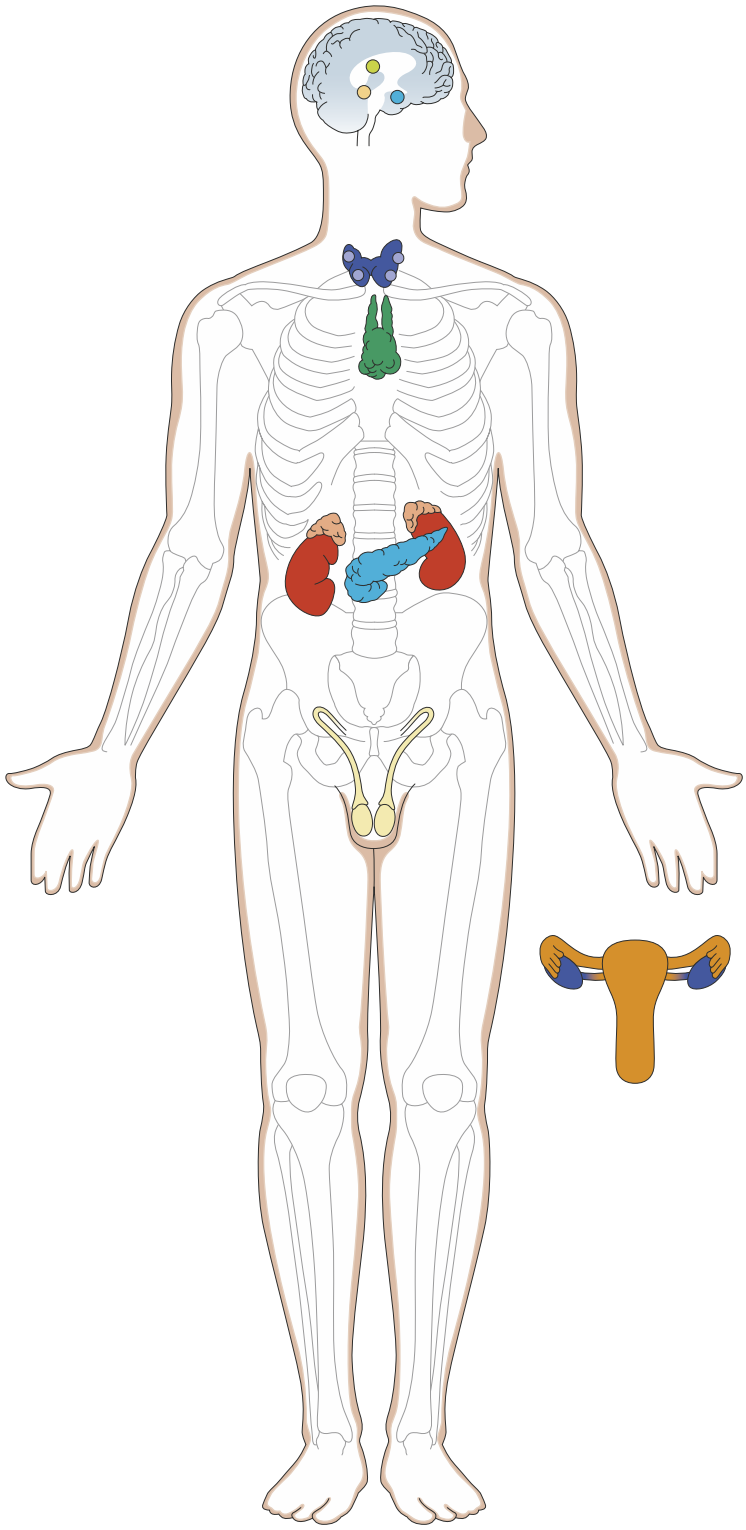
HUMAN LYMPHATIC SYSTEM. The lymphatic system and lymph nodes are shown here in pale green, the thymus in deep blue, and one of the bones rich in bone marrow (the femur) is shown here in purple. Some cancers of the lymphatic system are: Burkitt lymphoma; Cutaneous T-cell lymphoma; Hodgkin lymphoma; MALT lymphoma; Mantle cell lymphoma; Sézary syndrome; and Waldenström macroglobulinemia. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



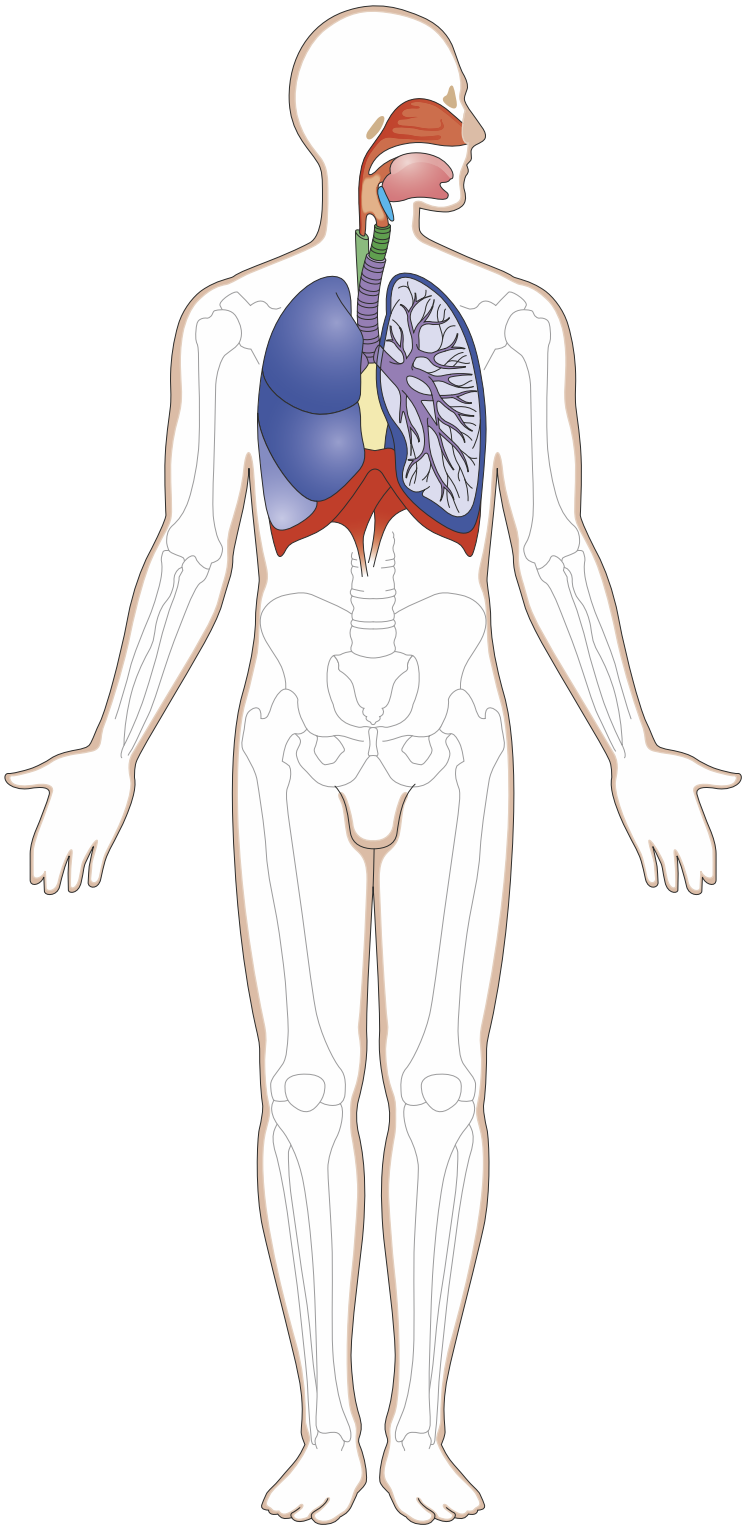
HUMAN DIGESTIVE SYSTEM. Organs and cancers of the digestive system include: Salivary glands (shown in turquoise): Salivary gland tumors. Esophagus (shown in bright yellow): Esophageal cancer. Liver (shown in bright red): Bile duct cancer; Liver cancer. Stomach (pale gray-blue): Stomach cancer. Gallbladder (bright orange against the red liver): Gallbladder cancer. Colon (green): Colon cancer. Small intestine (purple): Small intestine cancer; can have malignant tumors associated with Zollinger-Ellison syndrome. Rectum (shown in pink, continuing the colon): Rectal cancer. Anus (dark blue): Anal cancer. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



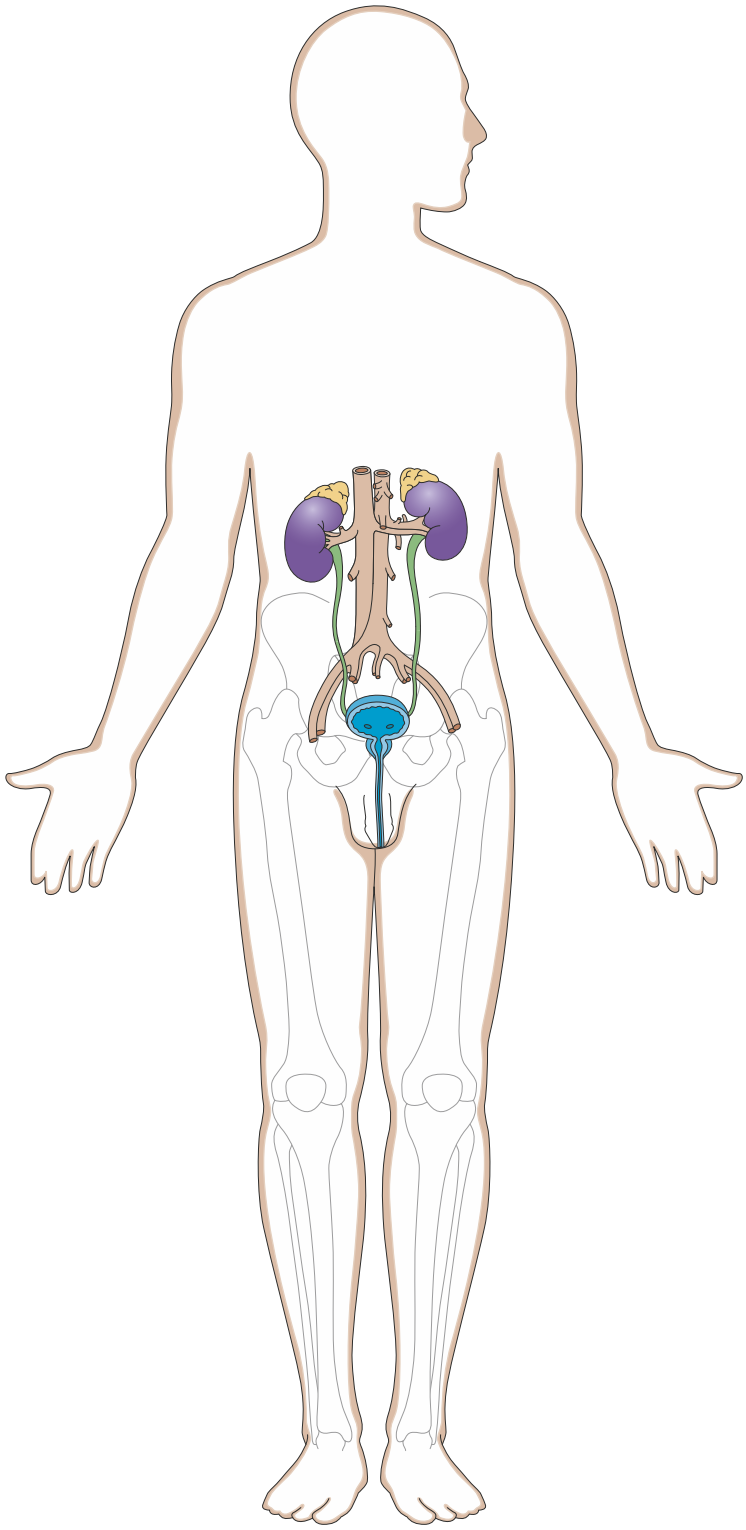
HEAD AND NECK. The pharynx, the passage that leads from the nostrils down through the neck, is shown in orange. This passage is broken into several divisions. The area behind the nose is the nasopharynx. The area behind the mouth is the oropharynx. The oropharynx leads into the laryngopharynx, which opens into the esophagus (still in orange) and the larynx (shown in the large image in medium blue). The cancers that affect these regions include: Nasopharyngeal cancer; Oropharyngeal cancer; Esophageal cancer; and Laryngeal cancer. Oral cancers can affect the lips, gums, and tongue (pink). Referring to the inset picture of the salivary glands, salivary gland tumors can affect the parotid glands (shown in yellow), the submandibular glands (turquoise), and the sublingual glands (purple). *(Illustration by Argosy Publishing. © Cengage Learning®.)*



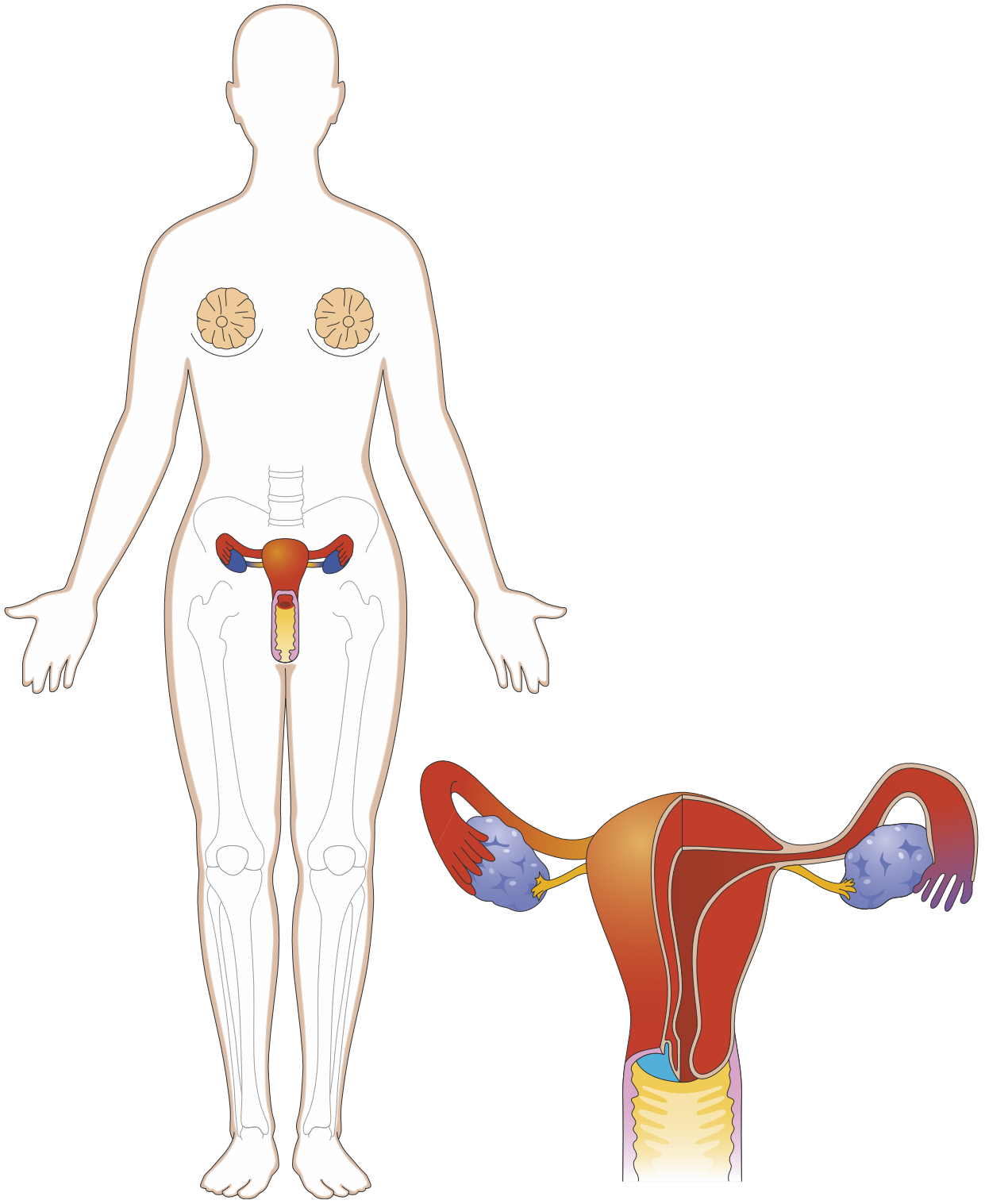
HUMAN ENDOCRINE SYSTEM. The glands and cancers of the endocrine system include (in the brain): the pituitary gland shown in blue (pituitary tumors), the hypothalamus in pale green, and the pineal gland in bright yellow. Throughout the rest of the body: Thyroid (shown in dark blue): Thyroid cancer. Parathyroid glands, adjacent to the thyroid: Parathyroid cancer. Thymus (green): Thymic cancer; Thymoma. Pancreas (turquoise): Pancreatic cancer; Zollinger-Ellison syndrome tumors can also be found in the pancreas. Adrenal glands (shown in apricot, above the kidneys): Neuroblastoma; Pheochromocytoma. Testes (in males, shown in yellow): Testicular cancer. Ovaries (in females, shown in dark blue in inset image): Ovarian cancer. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



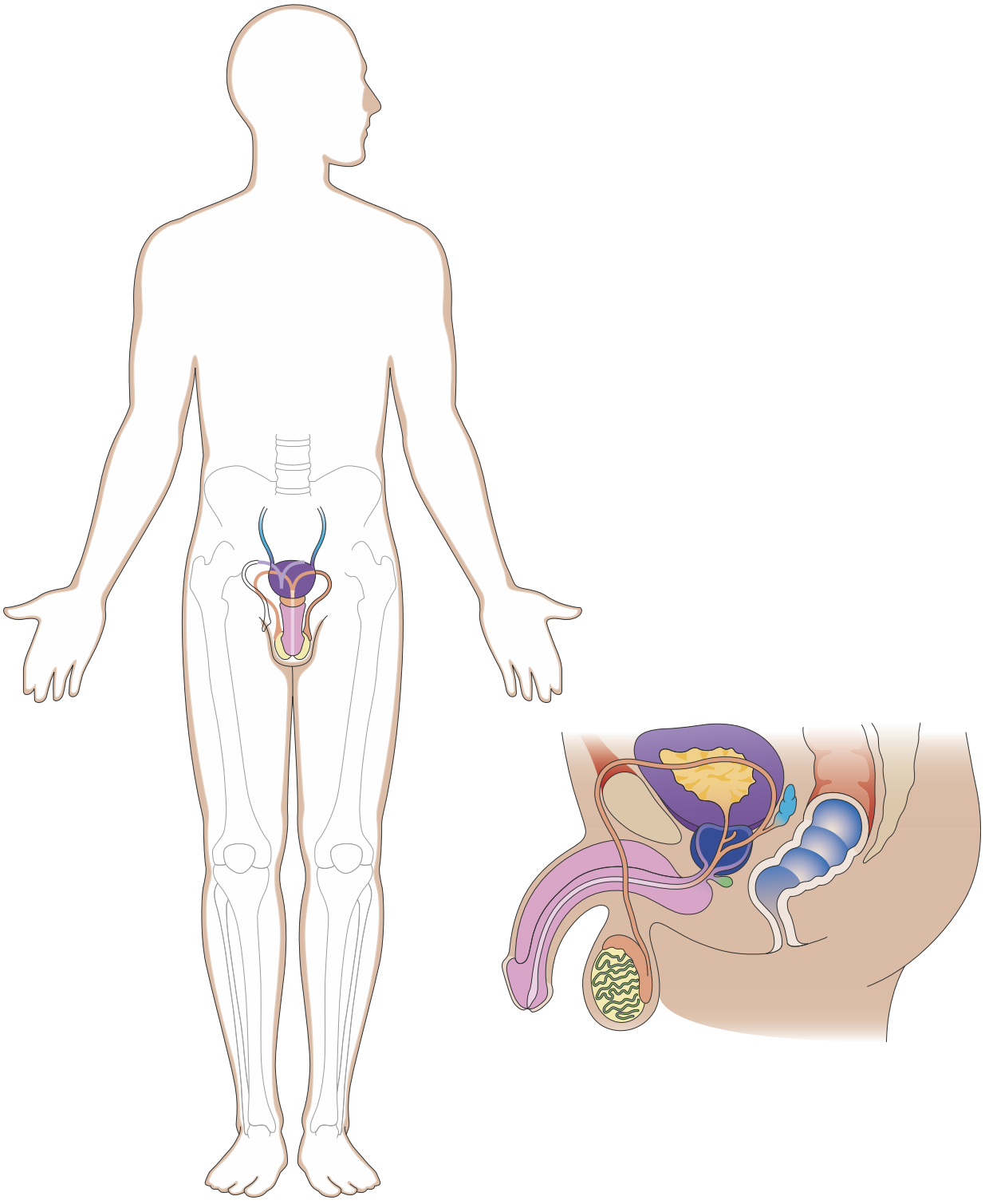
HUMAN RESPIRATORY SYSTEM. Air is breathed in through the nose or mouth, enters the pharynx (shown in orange), and passes through the larynx (shown as the green tube with a ridged texture; the smooth green tube is the esophagus, which is posterior to the larynx but is involved in digestion instead of breathing). The air then passes into the trachea (purple), which divides into two tubes called bronchi. One bronchus passes into each lung and continues to branch within the lung. These branches are called bronchioles, and each bronchiole leads to a tiny cluster of air sacs called alveoli. This is where the air and gases breathed in get diffused to the blood. The lungs (deep blue) are spongy and can be affected by Lung cancer, both the non-small cell and small-cell types. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



HUMAN URINARY SYSTEM. Organs and cancers of the urinary system include: Kidneys (shown in purple): Kidney cancer; Renal pelvis tumors; Wilms tumor. Ureters are shown in green. Bladder (blue-green): Bladder cancer. The kidneys, bladder, or ureters can be affected by Transitional cell carcinoma. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



FEMALE REPRODUCTIVE SYSTEM. Organs and cancers of the female reproductive system include: Uterus, shown in red with the uterine or Fallopian tubes: Endometrial cancer. Ovaries (blue): Ovarian cancer. Vagina (shown in pink with a yellow interior or lining): Vaginal cancer. Breasts: Breast cancer; Paget disease of the breast. Shown in detailed inset only (in turquoise), Cervix: Cervical cancer. *(Illustration by Argosy Publishing. © Cengage Learning®.)*



MALE REPRODCTIVE SYSTEM. Organs, glands, and cancers of the male reproductive system include: Penis (shown in pink): Penile cancer. Testes (shown in yellow): Testicular cancer. Prostate gland (shown in full-body illustration in a peach/apricot color, and in the inset as the dark blue gland between the bladder and the penis): Prostate cancer. *(Illustration by Argosy Publishing. © Cengage Learning®.)*

A

2-CdA *see* **Cladribine**

5-Azacitidine *see* **Azacitidine**

5-Fluorouracil *see* **Fluorouracil**

6-Mercaptopurine *see* **Mercaptopurine**

6-Thioguanine *see* **Thioguanine**

Abarelix

Definition

Abarelix is an injectable gonadotropin-releasing hormone (GnRH) antagonist that is used to decrease the production of the male hormone **testosterone**. It was withdrawn from the U.S. market in 2005.

Purpose

Abarelix was used in men to treat advanced **prostate cancer** that had not responded to other treatments. The prostate gland lies under the bladder and surrounds the urethra. Its main function is to produce seminal fluid that mixes with sperm prior to ejaculation. Prostate **cancer** is the most common cancer in men over the age of 50.

Abarelix was associated with serious side effects, and was considered appropriate for use only in the following situations:

- The cancer had spread (metastasized) and was close to the spinal column, so there was a risk that pressure from the tumor would damage the spinal nerves.
- The urethra or bladder was blocked because of malignant tissue growth, making urination difficult or impossible.
- The cancer caused severe pain in the bones that narcotic pain medication could not control.

Description

Abarelix worked by blocking gonadotropin-releasing hormone (GnRH), a hormone released from the anterior pituitary gland that stimulates the production of testosterone. When this messenger hormone is blocked, the level of testosterone in the blood decreases. Prostate cancer cells grow best in the presence of testosterone, so by decreasing the amount available, growth of the tumor is slowed or stopped. Other drugs, such as **leuprolide acetate** (Lupron) and **goserelin acetate** (Zoladex), are available that also decrease testosterone production. One advantage of abarelix over these other drugs was that the other drugs first stimulate the production of testosterone, then decrease it. With abarelix, there was no initial increase in testosterone production—the decline in production of the hormone began immediately. However, abarelix stopped working in some men after an initial period of effectiveness.

Abarelix was manufactured in the United States by Praecis Pharmaceuticals and sold under the brand name Plenaxis. Abarelix was originally approved for use only with specific restrictions. The drug could only be administered by doctors who were registered in the Plenaxis PLUS Program (Plenaxis User Safety Program) because of its potentially life-threatening side effects.

Recommended dosage

Abarelix was an injectable liquid. It was supplied as powder in a single-dose vial to be mixed with saline (salt water) before use. The resulting liquid was injected into the buttocks muscle. The treatment cycle called for an initial injection on days 1, 15, and 29 of the first month, followed by injections every 28 days. The testosterone level of the blood was checked after the first month and then about every eight weeks to assure that the drug was continuing to work. Liver function tests were also to be done regularly.

KEY TERMS

Antagonist—A drug or chemical that works against or blocks another chemical.

Pituitary gland—A tissue located at the base of the brain that is divided into two parts (anterior and posterior). The pituitary gland produces many different hormones that regulate body metabolism or control the production of other hormones.

Testes—Male reproductive organs that produce sperm and the hormone testosterone.

Urethra—The tube that drains urine from the bladder.

Precautions

Certain individuals could not use abarelix, including women, children under age 18, and men with a rare heart condition called prolongation of the QTc interval.

Side effects

Abarelix caused serious and life-threatening reactions, so the drug could only be administered by a physician registered in the Plenaxis PLUS safety program. The likelihood of life-threatening reactions increased with each injection of abarelix.

Symptoms of rare but life-threatening reactions included:

- low blood pressure
- fainting
- shock
- swelling of the face, eyelids, tongue, or throat
- wheezing, asthma, tightness in the chest, difficulty breathing

More common but less serious side effects included:

- hot flashes
- rapid heartbeat (tachycardia)
- rash, hives, itching, skin redness
- vomiting
- jaundice (yellowing of the whites of the eyes or skin)
- stomach pain
- breast enlargement
- problems sleeping
- breast, back, or other pain
- constipation
- changes in the electrical profile of the heart

Resources

WEBSITES

A.D.A.M. "Abarelix (Injection)." University of Maryland Medical Center. http://umm.edu/health/medical/drug-notes/notes/abarelix-injection (accessed September 25, 2014).

Tish Davidson, A. M.

Accelerated partial breast irradiation

Definition

Accelerated partial breast irradiation (APBI), also referred to as high-dose rate breast brachytherapy, is a shortened course of high-dose **radiation therapy** given to **breast cancer** patients. It targets the area of the breast where the **cancer** is most likely to recur.

Purpose

One purpose of APBI is to reduce the radiation treatment time from seven or eight weeks, which is generally required with conventional whole breast irradiation, to four or five days. Planning for seven or eight weeks of radiation treatment is difficult for many women, especially women who work outside the home, are single parents, and/or live in rural areas. Reducing the treatment time to one week is not only more convenient for many patients but also helps them with emotional closure. In other words, the sooner they are done with the treatments, the sooner they can put the cancer behind them.

Another purpose of APBI is to save the breast while still preventing recurrence of the cancer. Many women are good candidates for breast conserving therapy, in which the lump is surgically removed (**lumpectomy**), and then radiation or **chemotherapy** is used to destroy any remaining cancer cells. Although this treatment leaves the breast intact, many women still choose to have full removal of the breast (**mastectomy**). There are many reasons women may make this choice, including the long treatment regimen being too difficult or costly to arrange and concerns about exposing surrounding tissue and organs to radiation. Arranging for seven or eight weeks of treatment can be especially burdensome for individuals living far from their treatment center, or who have

to juggle multiple obligations to family and work. Because APBI is of shorter duration than traditional breast saving treatment, it may be a more viable option for many women. It also targets a smaller area for treatment, meaning that fewer healthy tissues and organs are exposed to the radiation.

In 2009, the American Society for Radiation Oncology issued a consensus statement on accelerated partial breast irradiation. In it, the society made recommendations based on a wide range of clinical trial outcomes. The oncologists established guidelines for which women are good candidates for APBI instead of the traditional whole breast irradiation.

Demographics

Patients over 60 years of age are considered "suitable" candidates for APBI. Patients from 50 to 59 years of age are considered "cautionary," meaning in some cases the treatment may be appropriate, and patients under age 50 are considered "unsuitable." Guidelines also define which women are suitable candidates based on a variety of other factors, including tumor size (less than or equal to 2 cm), cancer stage (T1), and other factors.

Description

High-dose rate breast brachytherapy

There are two ways to administer APBI, both of which can be done on an outpatient basis. One way, called high does rate breast brachytherapy, involves inserting multiple plastic tubes (catheters) in the breast area surrounding the lumpectomy cavity. A tiny radioactive seed, which delivers the correct amount of radiation, is inserted in the catheters. Generally, the treatment is given twice a day for five days, although some treatment regimens vary according to the individual patient's needs. Treatment sessions usually take no longer than 20 minutes. At the end of the five-day treatment, the catheters are removed.

MammoSite breast brachytherapy

Another way to administer APBI is called MammoSite breast brachytherapy, which is also known as balloon catheter brachytherapy. In this case, a small balloon is attached to a single catheter, which is inserted into the lumpectomy cavity. Then the balloon is inflated and a computer-controlled machine places the high-dose radioactive seed inside the balloon. This therapy requires a fairly narrow range of cavity location and size, so it is not an appropriate treatment for all women.

QUESTIONS TO ASK YOUR DOCTOR

- Am I a good candidate for APBI?
- Are there any clinical trials for which I may qualify?
- What are the costs and benefits of having APBI instead of whole-breast irradiation?
- Is this treatment covered by my insurance?
- How often have you performed this procedure?
- Do many of your patients express regret over choosing APBI over external beam radiation therapy?

Precautions

Accelerated partial breast irradiation is a relatively new treatment method. Long-term studies of its effectiveness and safety are still being carried out. For many women it may not be as effective as traditional whole-breast irradiation. **Clinical trials** are under way to determine its long-term effectiveness and for which patient populations it is most appropriate. Until more is known about this treatment, the American Society for Radiation Oncology recommends that conservative guidelines be used.

Preparation

Preparation requirements differ according to the type of procedure being performed, and the specifics of the patient's breast and previous history. Making plans in advance with family and friends to help in providing transportation, caring for children, preparing meals, or doing housework can provide much-needed support during treatment.

Aftercare

Good nutrition, regular light exercise, and plenty of rest are important after any radiation therapy. Additional aftercare information is provided by treatment staff on a case-by-case basis.

Risks

Possible side effects include discomfort due to the insertion and removal of the catheters and pain or soreness around the insertion sites. Other possible side effects include swelling around the irradiated area, soreness, changes in skin coloration, and **fatigue**.

Results

Preliminary evidence suggests that for many women APBI is as effective as traditional whole-breast irradiation. However, clinical trials are still under way to determine the long-term effectiveness of the treatment. Patients should ask their physician for the most up-to-date information on recommendations for treatment and outcome statistics.

Resources

BOOKS

Kneece, Judy C. *Breast Cancer Treatment Handbook: Understanding the Disease, Treatments, Emotions, and Recovery from Breast Cancer*. 8th ed. North Charleston, SC: EduCare, 2012.

Miller, Kenneth D. *Choices in Breast Cancer Treatment: Medical Specialists and Cancer Survivors Tell You What You Need to Know*. Baltimore: Johns Hopkins University Press, 2008.

Wazer, David E. *Accelerated Partial Breast Irradiation*. New York: Springer, 2009.

PERIODICALS

Bauer, Elfrida, and Joanne Lester. "Accelerated Partial Breast Irradiation." *Oncology Nursing Society* 18, no. 5 (2014): 556–66. http://dx.doi.org/10.1188/14.CJON.556-566 (accessed October 28, 2014).

Dirbas, Frederick M. "Accelerated Partial Breast Irradiation: Where Do We Stand?" *Journal of the National Comprehensive Cancer Network* (February 2009): 215–25.

He, Z., et al. "Accelerated Partial Breast Irradiation with Intensity-Modulated Radiotherapy Is Feasible for Chinese Breast Cancer Patients." *Journal of Breast Cancer* 17, no. 3 (2014): 256–64. http://dx.doi.org/10.4048/jbc.2014.17.3.256 (accessed October 28, 2014).

Smith, Benjamin D., et al. "Accelerated Partial Breast Irradiation Consensus Statement from the American Society for Radiation Oncology." *Journal of the American College of Surgeons* (August 2009): 269–77.

WEBSITES

MD Anderson Cancer Center. "Accelerated Partial Breast Irradiation." http://www.mdanderson.org/patient-and-cancer-information/cancer-information/cancer-topics/cancer-treatment/radiation/partial-breast-irradiation/index.html (accessed October 13, 2014).

ORGANIZATIONS

American Cancer Society, 250 Williams St. NW, Atlanta, GA 30303, (800) 227-2345, http://www.cancer.org.

National Cancer Institute, 9609 Medical Center Dr., BG 9609 MSC 9760, Bethesda, MD 20892-9760, (800) 4-CANCER (422-6237), http://www.cancer.gov.

Susan G. Komen Foundation, 5005 LBJ Freeway, Suite 250, Dallas, TX 75244, (877) GO-KOMEN, http://www.komen.org.

Lee Ann Paradise

REVISED BY TISH DAVIDSON, AM

Acoustic neuroma

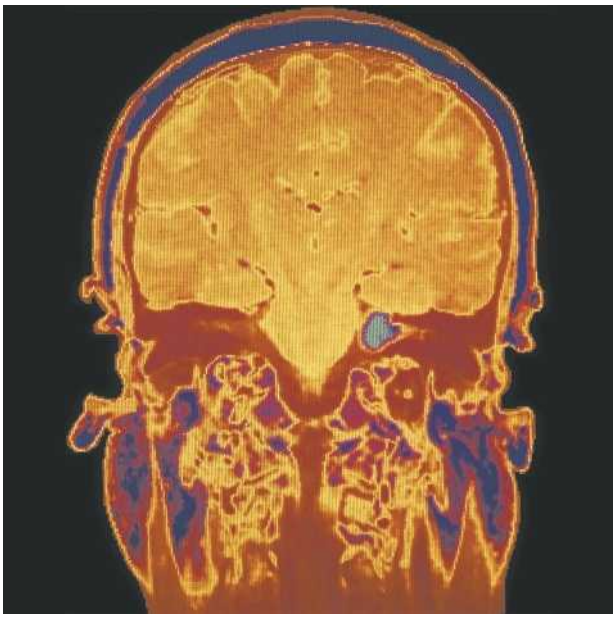
Definition

An acoustic neuroma is a benign tumor involving cells of the myelin sheath that surrounds the vestibulocochlear nerve (eighth cranial nerve).

Description

The vestibulocochlear nerve extends from the inner ear to the brain and is made up of a vestibular branch, often called the vestibular nerve, and a cochlear branch, called the cochlear nerve. The vestibular and cochlear nerves lie next to one another. They also run alongside other cranial nerves. People possess two of each type of vestibulocochlear nerve, one that extends from the left ear and one from the right ear.

The vestibular nerve transmits information concerning balance from the inner ear to the brain, and the cochlear nerve transmits information about hearing. The vestibular nerve, like many nerves, is surrounded by a cover called a myelin sheath. A tumor called a schwannoma can sometimes develop from the cells of the myelin sheath. A tumor is an abnormal growth of tissue that results from the uncontrolled reproduction of cells. Acoustic neuromas are often called vestibular schwannomas because they are tumors that arise from the myelin sheath that surrounds the vestibular nerve.



False-color magnetic resonance imaging (MRI) scan of a coronal section of the head and brain of a patient with an acoustic neuroma (green/gray circular area near the center). *(MEHAU KULYK/Science Source)*

Acoustic neuromas are considered benign (noncancerous) tumors since they do not spread to other parts of the body. They can occur anywhere along the vestibular nerve but are most likely to occur where the vestibulocochlear nerve passes through the tiny bony canal that connects the brain and the inner ear.

An acoustic neuroma can arise from the left vestibular nerve or the right vestibular nerve. A unilateral tumor is a tumor arising from one nerve; a bilateral tumor arises from both vestibular nerves. Unilateral acoustic neuromas usually occur spontaneously (by chance). Bilateral acoustic neuromas occur as part of a hereditary condition called neurofibromatosis type 2 (NF2). A person with NF2 has inherited a predisposition to develop acoustic neuromas and other tumors of the nerve cells.

Acoustic neuromas usually grow slowly and can take years to develop. Some acoustic neuromas remain so small that they do not cause any symptoms. As the acoustic neuroma grows, it can interfere with the functioning of the vestibular nerve and cause vertigo and balance difficulties. If the acoustic nerve grows large enough to press against the cochlear nerve, then hearing loss and a ringing (tinnitus) in the affected ear will usually occur. If left untreated and the acoustic neuroma continues to grow, it can press against other nerves in the region and cause other symptoms. This tumor can be life-threatening if it becomes large enough to press against and interfere with the functioning of the brain.

Causes and symptoms

Causes

An acoustic neuroma is caused by a change in or absence of both of the *NF2* tumor suppressor genes in a nerve cell. Every person possesses a pair of *NF2* genes in every cell of their body, including their nerve cells. One *NF2* gene is inherited from the egg cell of the mother and the other *NF2* gene is inherited from the sperm cell of the father. The *NF2* gene is responsible for helping to prevent the formation of tumors in the nerve cells. In particular, the *NF2* gene helps to prevent acoustic neuromas.

Only one unchanged and functioning *NF2* gene is necessary to prevent the formation of an acoustic neuroma. If both *NF2* genes become changed or are missing in one of the myelin sheath cells of the vestibular nerve, an acoustic neuroma will usually develop. Most unilateral acoustic neuromas result when the *NF2* genes become spontaneously changed or are missing. Someone with a unilateral acoustic neuroma that has developed spontaneously is not at increased risk of having children with an acoustic neuroma. Some unilateral acoustic neuromas result from NF2. It is also possible that some unilateral acoustic neuromas may be caused by changes in other genes responsible for preventing the formation of tumors.

Bilateral acoustic neuromas result when someone is affected with the hereditary condition NF2. A person with NF2 is typically born with one unchanged and one changed or missing *NF2* gene in every cell of their body. Sometimes they inherit this change from their mother or father. Sometimes the change occurs spontaneously when the egg and sperm come together to form the first cell of

KEY TERMS

Benign—Noncancerous.

Cranial nerves—The set of twelve nerves found on each side of the head and neck that control the sensory and muscle functions of a number of organs, including the eyes, nose, tongue, face, and throat.

Computed tomography (CT)—An imaging technique that uses x-rays to produce detailed pictures (scans) of anatomical structures inside the body.

DNA testing—Testing for a change or changes in a gene or genes.

Gene—A building block of inheritance, made up of a compound called DNA (deoxyribonucleic acid) and containing the instructions for the production of a particular protein. Each gene is found in a specific location on a chromosome.

Magnetic resonance imaging (MRI)—An imaging technique that uses magnetic fields and radio waves to create detailed images of internal body organs and structures.

Myelin sheath—The cover that surrounds many nerve cells and helps to increase the speed by which information travels along the nerve.

Neurofibromatosis type 2 (NF2)—A hereditary condition associated with an increased risk of bilateral acoustic neuromas, other nerve cell tumors, and cataracts.

Schwannoma—A tumor derived from the cells of the myelin sheath.

Tinnitus—A ringing sound or other noise in the ear.

Vertigo—A feeling of spinning or whirling.

Vestibulocochlear nerve (eighth cranial nerve)—Nerve that transmits information about hearing and balance from the ear to the brain.

the baby. Children of a person with NF2 have a 50% chance of inheriting the changed or missing *NF2* gene.

A person with NF2 will develop an acoustic neuroma if the remaining unchanged *NF2* gene becomes spontaneously changed or missing in one of the myelin sheath cells of their vestibular nerve. People with NF2 often develop acoustic neuromas at a younger age. The mean age at onset of acoustic neuroma in NF2 is 31 years versus 50 years for sporadic acoustic neuromas. Not all people with NF2, however, develop acoustic neuromas. People with NF2 are at increased risk of developing cataracts and tumors in other nerve cells.

Most people with a unilateral acoustic neuroma are not affected with NF2. Some people with NF2, however, develop a tumor in only one of the vestibulocochlear nerves. Others may initially be diagnosed with a unilateral tumor but may develop a tumor in the other nerve a number of years later. A diagnosis of NF2 should be considered in someone under the age of 40 who has a unilateral acoustic neuroma. Someone with a unilateral acoustic neuroma and other family members diagnosed with NF2 probably is affected with NF2. Someone with a unilateral acoustic neuroma and other symptoms of NF2 such as cataracts and other tumors may also be affected with NF2. On the other hand, someone over the age of 50 with a unilateral acoustic neuroma, no other tumors, and no family history of NF2 is very unlikely to be affected with NF2.

Symptoms

Small acoustic neuromas usually only interfere with the functioning of the vestibulocochlear nerve. The most common first symptom of an acoustic neuroma is hearing loss, which is often accompanied by a ringing sound (tinnitus). People with acoustic neuromas sometimes report difficulties in using the phone and difficulties in perceiving the tone of a musical instrument or sound even when their hearing appears to be otherwise normal. In most cases, the hearing loss is initially subtle and worsens gradually over time until deafness occurs in the affected ear. In approximately 10% of cases, the hearing loss is sudden and severe.

Acoustic neuromas can also affect the functioning of the vestibular branch of the vestibulocochlear nerve and cause vertigo and disequilibrium. Twenty percent of small tumors are associated with periodic vertigo, which is characterized by dizziness or a whirling sensation. Larger acoustic neuromas are less likely to cause vertigo but more likely to cause disequilibrium. Disequilibrium, which is characterized by minor clumsiness and a general feeling of instability, occurs in nearly 50% of people with an acoustic neuroma.

As the tumor grows larger, it can press on the surrounding cranial nerves. Compression of the fifth cranial nerve can result in facial pain and or numbness. Compression of the seventh cranial nerve can cause spasms, weakness, or paralysis of the facial muscles. Double vision is a rare symptom but can result when the sixth cranial nerve is affected. Swallowing and/or speaking difficulties can occur if the tumor presses against the ninth, tenth, or twelfth cranial nerves.

If left untreated, the tumor can become large enough to press against and affect the functioning of the brain stem. The brain stem is the stalk-like portion of the brain that joins the spinal cord to the cerebrum, the thinking and reasoning part of the brain. Different parts of the brain stem have different functions, such as the control of breathing and muscle coordination. Large tumors that affect the brain stem can result in headaches, walking difficulties (gait ataxia), and involuntary shaking movements of the muscles (tremor). In rare cases when an acoustic neuroma remains undiagnosed and untreated, it can cause nausea, vomiting, lethargy, and eventually coma, respiratory difficulties, and death. In the vast majority of cases, however, the tumor is discovered and treated long before it is large enough to cause such serious manifestations.

Diagnosis

Anyone with symptoms of hearing loss should undergo hearing evaluations. Pure tone and speech audiometry are two screening tests that are often used to evaluate hearing. Pure tone audiometry tests how well someone can hear tones of different volume and pitch, while speech audiometry tests how well someone can hear and recognize speech. An acoustic neuroma is suspected in someone with unilateral hearing loss, or hearing loss that is less severe in one ear than the other (asymmetrical).

Sometimes an auditory brainstem response (ABR, BAER) test is performed to help establish whether someone is likely to have an acoustic neuroma. During the ABR examination, a harmless electrical impulse is passed from the inner ear to the brainstem. An acoustic neuroma can interfere with the passage of this electrical impulse and can sometimes be identified through the ABR evaluation. An abnormal ABR examination increases the likelihood that an acoustic neuroma is present, but other tests are necessary to confirm the presence of a tumor.

If an acoustic neuroma is strongly suspected, **magnetic resonance imaging** (MRI) is usually performed. The MRI is a very accurate evaluation that is able to detect nearly 100% of acoustic neuromas. **Computed tomography** (CT scan) is unable to identify smaller tumors but may be used when an acoustic

neuroma is suspected and an MRI evaluation cannot be performed.

Once an acoustic neuroma is diagnosed, an evaluation by genetic specialists such as a geneticist and genetic counselor may be recommended. The purpose of this evaluation is to obtain a detailed family history and check for signs of NF2. If NF2 is strongly suspected, then DNA testing may be recommended. DNA testing involves checking the blood cells obtained from a routine blood draw for the common gene changes associated with NF2.

Treatment

The three treatment options for acoustic neuroma are surgery, radiation, and observation. The physician and patient should discuss the pros and cons of the different options prior to making a decision about treatment. The patient's physical health, age, symptoms, tumor size, and tumor location should be considered.

Microsurgery

The surgical removal of the tumor or tumors is the most common treatment for acoustic neuroma. In most cases, the entire tumor is removed during the surgery. If the tumor is large and causing significant symptoms, yet there is a need to preserve hearing in that ear, then only part of the tumor may be removed. During the procedure the tumor is removed under microscopic guidance and general anesthetic. Monitoring of the neighboring cranial nerves is done during the procedure so that damage to these nerves can be prevented. If preservation of hearing is a possibility, then monitoring of hearing will also take place during the surgery.

Most people stay in the hospital four to seven days following the surgery. Total recovery usually takes four to six weeks. Most people experience **fatigue** and head discomfort following the surgery. Problems with balance and head and neck stiffness are also common. The mortality rate of this type of surgery is less than 2% at most major centers, but approximately 20% of patients experience some type of postsurgical complication. In most cases these complications can be managed successfully and do not result in long-term medical problems. Surgery brings with it a risk of stroke, damage to the brain stem, infection, leakage of spinal fluid, and damage to the cranial nerves. Hearing loss and/or tinnitus often result from the surgery. A follow-up MRI is recommended one to five years following the surgery because of possible regrowth of the tumor.

Stereotactic radiation therapy

During stereotactic **radiation therapy**, also called radiosurgery or radiotherapy, many small beams of radiation are aimed directly at the acoustic neuroma. The radiation is administered in a single large dose under local anesthetic and is performed on an outpatient basis. This results in a high dose of radiation to the tumor but little radiation exposure to the surrounding area. This treatment approach is limited to small or medium tumors. The goal of the therapy is to cause tumor shrinkage or at least limit the growth of the tumor. Periodic MRI monitoring throughout the life of the patient is therefore recommended.

Radiation therapy does still result in hearing loss in most cases, but the loss seems to be delayed. Radiation therapy can also cause damage to neighboring cranial nerves, which can result in symptoms such as numbness, pain, or paralysis of the facial muscles. In many cases, these symptoms are temporary. Radiation treatment can also induce the formation of other benign or malignant schwannomas. This type of treatment may therefore be contraindicated in the treatment of acoustic neuromas in those with NF2 who are predisposed to developing schwannomas and other tumors.

Observation

Acoustic neuromas are usually slow-growing; in some cases they will stop growing and even become smaller or disappear entirely. It may therefore be appropriate in some cases to hold off on treatment and to monitor the tumor periodically through MRI evaluations. Long-term observation may be appropriate, for example, in an elderly person with a small acoustic neuroma and few symptoms, or for someone with a small and asymptomatic acoustic neuroma that was detected through an evaluation for another medical problem. Observation may also be suggested for someone with an acoustic neuroma in the only hearing ear or in the ear that has better hearing. The primary risk of an observational approach is that as the tumor grows larger, it can become more difficult to treat.

Prognosis

The prognosis for someone with a unilateral acoustic neuroma is usually quite good provided the tumor is diagnosed early and appropriate treatment is instituted. Long-term hearing loss and tinnitus in the affected ear are common even when appropriate treatment is provided. Many patients also experience facial weakness, balance problems, and headaches. Regrowth of the tumor is also a possibility following surgery or radiation therapy and repeat treatment may be necessary. The prognosis can be poorer for those with NF2 who have an increased risk of bilateral acoustic neuromas and other tumors.

Resources

PERIODICALS

Kano, H., et al. "Predictors of Hearing Preservation after Stereotactic Radiosurgery for Acoustic Neuroma: Clinical Article." *Journal of Neurosurgery* 119 suppl. (December 2013): 863–73.

Leong, Samuel C., and Tristram H. Lesser. "A United Kingdom Survey of Concerns, Needs, and Priorities Reported by Patients Diagnosed With Acoustic Neuroma." *Otology & Neurotology* (August 12, 2014): e-pub ahead of print. http://dx.doi.org/10.1097/MAO.0000000000000556 (accessed August 20, 2014).

Wang, Wei, et al. "Masseter-to-Facial Nerve Transfer: A Highly Effective Technique for Facial Reanimation After Acoustic Neuroma Resection." *Annals of Plastic Surgery* 73 (September 2014): S63–69. http://dx.doi.org/10.1097/SAP.0000000000000246 (accessed August 20, 2014).

WEBSITES

Acoustic Neuroma Association. "Treatment Options Summary." https://www.anausa.org/pretreatment/treatment-options-summary (accessed August 20, 2014).

Acoustic Neuroma Association. "What is an Acoustic Neuroma?" https://www.anausa.org/overview/what-is-acoustic-neuroma (accessed August 20, 2014).

Mayo Clinic staff. "Acoustic Neuroma." http://www.mayoclinic.org/diseases-conditions/acoustic-neuroma/basics/definition/con-20023851 (accessed August 20, 2014).

ORGANIZATIONS

Acoustic Neuroma Association, 600 Peachtree Pkwy., Ste. 108, Cumming, GA 30041-6899, (770) 205-8211, (877) 200-8211, Fax: (770) 205-0239, info@anausa.org, https://www.anausa.org.

Acoustic Neuroma Association of Canada, PO Box 193, Buckhorn, Ontario, Canada K0L 1J0, (800) 561-2622, http://www.anac.ca.

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REVISED BY REBECCA J. FREY, PHD

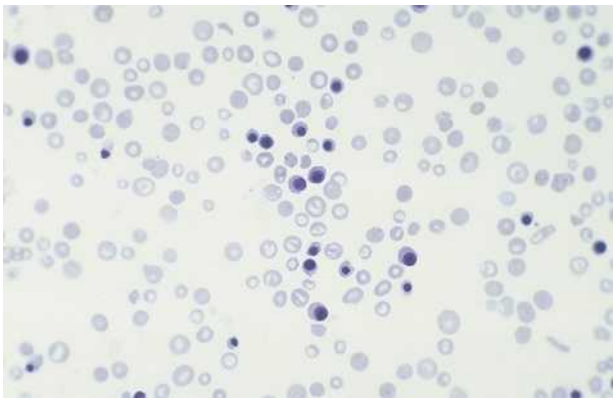
Acquired immune deficiency syndrome (AIDS) *see* **AIDS-related cancers**

Actinomycin-D *see* **Dactinomycin**

Acute erythroblastic leukemia

Definition

Acute erythroblastic leukemia is a subtype (M6) of acute myelogenous leukemia (AML). It is also called erythroid leukemia, Di Guglielmo syndrome, or erythroleukemia and results from uncontrolled proliferation of immature erythrocytes in the bone marrow.



Erythroblastic leukemia cells. In erythroblastic leukemia, immature red blood cells (erythrocytes) multiply rapidly. *(Richard J. Green/Science Source)*

Description

Acute erythroblastic leukemia, a variant of AML, originates in the blood and in the bone marrow. In this form of leukemia, a large number of abnormal immature red blood cells are produced. The World Health Organization (WHO) classifies acute erythroid leukemia into two subtypes: erythroleukemia, which includes erythroblastic and myeloblastic components (blast cells are immature cells), and pure erythroid leukemia, in which the erythroid component constitutes 80% or more of the bone marrow.

Demographics

According to the American Cancer Society, in 2014 approximately 18,860 people were newly diagnosed with all types of AML. In the same year, 10,460 deaths were predicted to occur from all AMLs. Acute erythroid leukemia accounts for about 3–5% of all new cases of AML and constitutes 20–30% of cases of secondary leukemia (leukemia that develops after treatment for another cancer).

Erythroid leukemia is rare in children, although occasional cases have been reported in children from newborn through age 7. Males are affected slightly more often than females. The disease is more common after age 50 and especially after age 70.

Causes and symptoms

The causes of acute erythroblastic leukemia are largely unknown. However, acute erythroblastic leukemia constitutes 10–20% of leukemias that develop secondary to previous exposures to ionizing radiation; previous treatment with **chemotherapy** agents known as alkylating agents, which may have been used to treat **Hodgkin lymphoma**, **multiple myeloma**, **ovarian**

KEY TERMS

Anemia—A condition in which there are too few red blood cells, too many abnormal red blood cells, or too little iron-containing hemoglobin for normal oxygen transport in the body.

Blast cells—Immature cells of the bone marrow that normally develop into various types of blood cells.

Chemotherapy—The treatment of disease by means of chemicals. In cancer, the chemicals selectively destroy cancerous tissue. When cancer remission occurs, a course of maintenance chemotherapy is often prescribed to prevent recurrence.

Erythrocyte—Red blood cell.

Leukemia—Cancer of the blood-forming tissues.

Myeloid blast cell—Type of cancer cell originating in the bone marrow.

Platelet—A type of blood cell responsible for blood coagulation and for the repair of damaged blood vessels.

Proliferation—Rapid reproduction of tissue.

cancer, **breast cancer** and some other noncancerous diseases and disorders; or as a result of overexposure to **benzene**.

Inheritance

A rare type of inherited erythroid leukemia is known as familial erythroleukemia. This familial disorder typically occurs in people in their sixties.

Diagnosis

Physical exam

Patients seeking treatment usually report a vague history of ongoing general **fatigue**. Patients diagnosed with erythroid leukemia have fewer than normal healthy red blood cells and platelets, which results in insufficient oxygen carried to body tissues. This condition is called **anemia**, which causes severe weakness and fatigue. Patients may have fewer than the normal number of white blood cells, as well. Other symptoms include **fever**, chills, loss of appetite and weight, easy bleeding or bruising (due to lower than normal platelet levels), bone or joint pain, headaches, vomiting, and confusion. In addition, patients with leukemia may have hepatosplenomegaly, an enlargement of the liver and spleen. Enlargement of these organs creates the sensation of fullness or swelling in the abdomen and can be detected by a doctor during a physical examination. The occurrence of Sweet's syndrome, a rare skin disorder accompanied by fever, inflammation of the joints (arthritis), and the sudden onset of a rash, has also been associated with acute erythroblastic leukemia.

Tests

The diagnosis is established by blood tests. A sample of blood is examined under a microscope to identify abnormal red cells—which are larger than healthy cells—and to count the number of mature cells and blasts present. Cancer red cell precursors predominate, myeloid blasts may also be apparent, and multinucleated red cell precursors are common. However, blasts may not be present at diagnosis in as many as half of the cases.

Other laboratory studies that help to establish the diagnosis include a blood chemistry profile, liver function tests, and serum electrolytes. Blood and urine cultures may be obtained in patients with fever or other signs of infection. Vitamin B_{12} and folate levels should be measured to rule out severe pernicious anemia, the signs and symptoms of which mimic erythroleukemia. **Flow cytometry** is conducted to determine myeloid markers for the disease, and cytogenetics studies assess for chromosomal abnormalities. Cytogenetics studies are important in diagnosis and prognosis of the disease. However, no specific chromosomal abnormalities have yet been identified for the M6 subtype of AML.

Imaging studies will also be performed at the time of diagnosis. These studies include echocardiogram or multiple-gated acquisition (MUGA) scans, which may be used to evaluate the status of the cardiac system prior to chemotherapy administration. Some chemotherapy medications used to treat this subtype of AML may be toxic to the cardiac system. A chest x-ray helps to evaluate for pulmonary infections, enlargement of the heart, and other heart and lung problems, and a **computed tomography** (CT) or **magnetic resonance imaging** (MRI) scan will be performed if the doctor suspects neurologic involvement. **Bone marrow aspiration** or **biopsy** is done to further examine the cell types. The results of these examinations are critical to an accurate diagnosis of erythroleukemia.

A **lumbar puncture** may be performed when neurologic involvement is suspected or present; this procedure is also recommended in patients whose circulating leukemic cell counts are very elevated (higher than 50,000/mm^3) and for those patients with elevated liver enzyme (LDH) levels.