Children's Tumor Foundation™
Ending Neurofibromatosis Through Research

Information For Patients & Families

INTRODUCTION

Neurofibromatosis (NF) is a genetically determined disorder, which affects 100,000 Americans. One baby in every 4,000 is born with NF. NF is worldwide in distribution; it affects both sexes equally and has no particular racial, geographic or ethnic distribution.

A variety of terms are used to refer to NF. **Von Recklinghausen's Disease** is commonly used, after the German physician who recognized the neurological component of the disorder in 1882. **Phakomatosis**, derived from the Greek word "phakos", meaning birthmark, refers to a number of disorders, including NF, which are characterized by birthmarks. **Neurocutaneous** disorder refers to any one of several disorders, of which NF is the most common, which affect the skin and the nervous system. NF1, formerly called Von Recklinghausen NF, refers to the common form of NF with skin lesions. NF2, also called bilateral acoustic NF, refers to a rare form of NF with bilateral acoustic neuromas and few skin lesions.

COMMON SIGNS OF NF

NEUROFIBROMAS, the most common tumors in NF, are benign growths which typically develop on or just underneath the surface of the skin but may also occur in deeper areas of the body. Nodule-like surface tumors are known as **dermal neurofibromas. Plexiform neurofibromas** grow diffusely under the skin surface or in deeper areas of the body. Neurofibromas, which are composed of tissue from the nervous system (neuro) and fibrous tissue (fibroma), usually develop around puberty although they may appear at any age. The tumors are not contagious.

The presence of **multiple** neurofibromas is an important diagnostic sign of NF. (A single neurofibroma may occasionally occur in a person who does not have NF). The number of neurofibromas varies widely among affected individuals from only a few to thousands. There is no way at present to predict how many neurofibromas a person will develop. Dermal neurofibromas rarely, if ever, become cancerous. Such a change, called a **malignant transformation**, may occur, although very rarely, in plexiform tumors.

Some neurofibromas, depending on their location and size, can be removed surgically if they become painful or infected, or cosmetically troublesome. A new tumor sometimes appears where one has been removed, particularly if that tumor was not removed completely. There is **no evidence** that removal of growths will increase the rate of appearance of new growths, or can cause incompletely removed tumors to change from benign to cancerous.

CAFE-AU-LAIT SPOTS, the most common sign of NF, are flat, pigmented spots on the skin, which are called by the French term for coffee (cafe) with milk (lait) because of their light tan color. In darker-skinned people, cafe-au-lait spots appear darker in color than surrounding skin.

People with NF almost always have six or more cafe-au-lair spots. (Fewer cafe-au-lait spots may occur in people who do not have NF; in fact, about 10% of the general population has one or two cafe-au-lait spots). The size of the spots that identify NF varies from 1/4 inch (5 mm) in children and 3/4 inch (15 mm) in adults to several inches in diameter or larger. In general, with few exceptions, tumors are not more likely to appear where there are spots.

Cafe-au-lait spots are usually present at birth in children who have NF or, generally, appear by two years of age. The number of spots may increase in childhood and occasionally later in life. The spots may be very light in color in infants and usually darken as the child gets older.

Smaller pigmented spots, which may be difficult to distinguish from ordinary freckles, may also be present in people with NF. In those who do not have NF, freckling usually occurs in areas of skin exposed to sun; with NF, cafe-au-lait spots and freckling are present in other areas as well, including the armpit (axilla), where small spots are called **axillary freckling**, and the groin. Axillary freckling is not seen in every person with NF, but when present it is considered strong evidence of NF.

IRIS NEVI (also called **Lisch nodules)** are clumps of pigment in the pigmented part of the eye (iris). Iris nevi, which usually appear around puberty, can be distinguished from iris freckles (commonly seen in people without NF) by a simple procedure called a slit-lamp examination, which is typically performed by an ophthalmologist. Iris nevi do not cause medical problems and do not affect vision. The presence of iris nevi can occasionally be helpful in confirming the diagnosis of NF.

HOW DO I KNOW IF I HAVE NF?
Only a knowledgeable physician can answer that question. In the language of the experts, the tentative diagnostic criteria for the two major forms of NF are:

I. NF1, formerly known as Von Recklinghausen neurofibromatosis is present in an individual with two of the following criteria, provided that no other disease accounts for the findings.

1. On examination in room light, at least 6 major cafe-au-lait macules over 5 mm in greatest diameter, if pre-pubertal; 6 cafe-au-lait macules over 15 mm in greatest diameter, if postpubertal.
2. Based on clinical, or histological background, two or more neurofibromas of any type, or one plexiform neurofibroma.
3. Multiple freckles in the axillary (armpit) or inguinal (groin) regions.
4. A distinctive osseous lesion such as sphenoid dyspla-sia, or thinning of long bone cortex with or without pseudarthrosis.
5. Optic glioma.
6. Two or more iris Lisch nodules on slit-lamp examination.
7. A first-degree relative (parent, sibling, or offspring) with NF1 by the above criterial observations.

II. NF2, also known as bilateral acoustic neurofibromatosis, is present in an individual with either criterion:

1. CT or magnetic resonance imaging evidence of bilateral internal auditory canal masses, consistent with acoustic neuroma: or,
2. A first-degree relative with NF2 and either:
   a. A unilateral eighth nerve mass, or
   b. Two of the following:
      - neurofibroma
      - meningioma
      - glioma
      - schwannoma
      - juvenile posterior subcapsular lenticular opacity

Laboratory tests are now available in most cases to determine whether a person has NF 1 and 2. Gene linkage testing is available for families with NF1 and NF2. Direct gene testing is currently available for NF1 and may be available in the near future for NF2. These tests may be used for presymptomatic or prenatal diagnosis. To find out whether you qualify for such tests, consult your nearest NF clinic or center.

Occasionally, the signs of NF are not easy to identify. For example, cafe-au-lait spots may be so pale that they are not noticeable in ordinary light. For this reason, members of families in which NF has occurred are often concerned about whether they may have the NF gene, even if they have no obvious signs of the disorder. An examination by a physician familiar with the signs of NF is the best way now available to determine whether NF is present. Examination of the skin may be helped by use of an ultraviolet light (Wood's lamp) which can occasionally identify very light cafe-au-lait spot pigmentation and can also help to differentiate this from pigmentation due to fungal infections of the skin. An examination that reveals no signs of NF can be considered reassuring since it is extremely rare for an individual to inherit the gene and to show no detectable sign of the disorder.

VARIABILITY OF NF

NF is an extremely variable disorder. The severity of NF ranges from extremely mild cases in which the only signs of the disorder in adulthood may be multiple cafe-au-lait spots and a few dermal neurofibromas, to more severe cases in which one or more serious complications may develop. The complications of NF are discussed in the next section of this booklet. There is no way to predict who will have a mild case and who will develop serious complications. The majority of people with NF (probably 60%) have mild forms of the disorder and lead healthy and productive lives. Another 20% have correctable problems and another 20% have serious and persistent problems.

NF is a developmental disorder, that is, it has its origins as the child develops before birth. Many of the serious problems in NF mentioned below are evident at birth or develop prior to adolescence. These include congenital defects of the bone, scoliosis, optic glioma and neurological impairment leading to mental retardation or learning disability. People with NF who have reached adulthood without having these problems are unlikely to develop them.

COMPLICATIONS OF NF1

1. Disfigurement

NF1 can result in disfigurement in a number of ways. Skin neurofibromas may develop on the face or on exposed areas of the arms or legs. The generally larger and deeper plexiform neurofibromas may grow around the eye or eyelid, or affect growth of one side of the face. Scoliosis, or curvature of the spine (see below), can affect appearance when it is severe. Growths can occur around the nipple (periareolar neurofibromas), which may be distressing. Rarely, an over-growth of skin or bone causes enlargement of an arm or leg.

In some people, the size or number of neurofibromas increases during puberty and pregnancy, reflecting a possible hormonal effect.

There is no evidence that diet, exercise or vitamins affect the growth of neurofibromas.

While disfigurement, and fear of disfigurement, are often major concerns for those with NF1, not everyone reacts the same way to complications that affect appearance. Some people find that cafe-au-lait spots or a minimum number of skin neurofibromas are hard to live with, while others are able to tolerate more severe involvement. Those who are upset by the problems of disfigurement often find support and discussion groups to be helpful. If surgery is desired primarily to improve appearance, a plastic surgeon may be consulted to determine whether a particular tumor can be removed. Plexiform neurofibromas around the eye are often managed jointly by an eye (ophthalmic) surgeon and a plastic surgeon.

2. Scoliosis.
Lateral curvature of the spine, known as scoliosis, is common in NF1. In most cases it is mild. Scoliosis usually appears in early childhood. A child with scoliosis will need periodic spine X-rays and physical examinations to determine whether corrective measures are needed. In some cases, a brace may be used to prevent progression of the problem. More serious cases may require corrective surgery.

3. Learning Disabilities.
Learning disabilities, often first noticed when the child starts school, are specific problems with reading, writing and the use of numbers which occur in children who have normal intelligence. Learning disabilities are probably more common in children with NF1 than in other children, and may be associated with hyperactivity. A child suspected of having a learning disability can be evaluated by a psychologist, child neurologist or professional with special knowledge of this problem. Many school systems provide referrals to specialists in these fields.

4. Large Heads
Children and adults with NF1 often have large head circumference, which usually does not indicate any significant medical problem. Very rarely, large head circumference results from hydrocephalus, a serious problem which may require surgery. Imaging of the brain with CT scan or MRI can help determine if head enlargement is serious or not. Head circumference in children with NFI should be periodically measured.

5. Optic Gliomas
An optic glioma is a tumor of the optic nerve (the nerve which controls vision). This tumor, which fortunately is uncommon, usually appears in childhood and is first noticed because of poor or failing vision or bulging of the eye. Children with NF1 should have routine eye examinations by an ophthalmologist, neurologist or

physician familiar with this problem. Treatment for this condition includes surgery and radiation therapy.

6. Congenial Defects of Bone

The variety of bone defects seen in NF1 are usually evident at birth. Most are uncommon. Defects can occur in almost any bone, but are seen most often in the skull and limbs. They include:

a. Congenital absence of the orbital wall, the bone normally surrounding the eye. Its absence may cause slight bulging of the skin around the eye.
b. Congenital bowing of the leg bones below the knee (tibia or fibula). These bones may be thinner than normal and bowed. If a fracture occurs, healing may be slow or incomplete. Incomplete healing, called **pseudarthrosis,** may also affect the bones in the forearm (radius or ulna), but this occurs very rarely. This is a difficult problem, which requires the supervision of an orthopedic surgeon.

7. High Blood Pressure (Hypertension).

People with NF1 can have hypertension for reasons completely unrelated to NF1. However, two rare problems associated with NF1 may result in hypertension: renal artery stenosis (blocking of the artery to the kidney), and pheochromocytoma, a rare and usually benign tumor of the adrenal gland. Both of these problems are treatable. Because of these possible problems, it is important that routine physical exams for children and adults with NF1 include blood pressure checks.

RARE COMPLICATIONS OF NF1

The complications mentioned below occur in 1%, or less, or people with NF1. The listing is intended to inform you of the tare complications possible in NF1, but it should be emphasized that very few people with NF1 will experience any of these symptoms.

1. Early or late onset of puberty.
2. Problems with growth (too short or too tall).
3. Mental retardation.
4. Epilepsy (seizure disorder).
5. People with NF1 may have a somewhat higher risk for certain rare malignant tumors that occur in the brain, nerves or spinal cord, but probably have the same risk for "common" cancers (such as lung, breast, stomach, etc.) as the general population.
6. Brain tumors (other than acoustic neuroma and optic glioma).
7. Cerebrovascular occlusion (stroke). This refers to blockage of the blood vessels supplying the brain.
8. Itching of the skin (pruritis). This can be treated with antihistamine medication.

COMPLICATIONS OF NF2

A Vestibular Schwannoma (Acoustic Neuroma) is a tumor of the nerve which controls hearing. Early signs include progressive hearing loss, ringing in the ears (tinnitus) and dizziness. Bilateral acoustic neuromas are tumors of the nerves of both ears and occur in NF2. Unilateral acoustic neuroma, a tumor occurring in the nerve of one ear only, also occurs in people who do not have NF. People with NF2 generally have a few of the dermal neurofibromas and cafe-au-lait spots seen in NF1. NF2 is much less common than NF1, and does not usually appear before young adulthood. It is caused by a different gene than the one which causes NF1. The management and possible surgery for bilateral acoustic neuromas require careful individual

consideration with special attention to timing. Those whose family history suggests they may have a risk to develop this form of NF should swim with a companion because loss of direction can occur while swimming underwater.

CT scan, audiometrics and auditory-evoked potentials are useful for diagnosis. The latter two are specialized heating tests which can be used for periodic screening for those whose family history indicates they may have a high risk for NF2.

MEDICAL EVALUATION AND FOLLOW-UP

A person with NF should see a physician for evaluation and follow-up care who is knowledgeable about the disorder and its complications or is willing to learn about it. Specialists from many disciplines may be knowledgeable about specific aspects of NF; those most likely to be familiar with the disorder as a whole include geneticists, neurologists and pediatric neurologists. NF clinics which cooperate with the Children's Tumor Foundation have been established in a number of major medical centers in the U.S. For more information about NF clinics and where to get help, contact the national headquarters or your local chapter or affiliate.

It is suggested that a medical evaluation for anyone with NF include a family history and family tree. The role of the knowledgeable pediatrician who follows a child with NF1 is to monitor the child's growth and development much as is ordinarily done for any other child. The physician ideally will be able to accomplish this without unduly emphasizing potential difficulties, which may, or may not, become problems for any given child. Children with NF1 are usually checked for height, weight, head circumference, blood pressure, vision and hearing, evidence of normal sexual development, signs of learning disability and hyperactivity, and evidence or scoliosis, in addition to examination of the skin for cafe-au-lait spots and neurofibromas. The causes of any unusual growth pattern are generally investigated. Early or late onset of puberty also suggests further study. Further diagnostic evaluations, including blood tests and X-rays, are usually needed only to investigate suspected problems. Healthy children with NF1 are usually examined at 6 or 12-month intervals.

Routine check-ups for adults with NF1 generally include, in addition to standard physical evaluation, an examination of the skin, blood pressure, vision and hearing, and examination of the spine for scoliosis. Attention is given to any mass that is rapidly enlarging or causing new pain. Other tests can be performed if a medical problem develops. Adults with NF1 who are otherwise healthy usually have periodic check-ups at 12-month intervals.

PSYCHOLOGICAL & SOCIAL ISSUES

Neurofibromatosis can be stressful for many affected individuals. Some may experience social isolation and loneliness. Uncertainty about possible future complications of the disorder, and decisions about whether to tell friends and whether to have children are concerns expressed by many. Anxiety about the need for medical treatments, a sense of losing control and the feeling of being different from others are often experienced. The general public's reaction to disfigurement and the unfounded fear that NF is contagious can provoke unpleasant situations.

To help ease these difficulties, the Children's Tumor Foundation and its Chapters and Affiliates have organized groups for discussion and mutual support. Such groups, led by qualified professionals, can help those with NF overcome their sense of isolation, and offer an opportunity to share feelings and to learn more about the disorder in an atmosphere of mutual support and understanding,

NF can place emotional burdens not only on the individual affected, but on parents and unaffected siblings as well. The concerns of all family members need to be considered.

Individual or family counseling by a social worker or psychotherapist is often helpful.

GENETICS OF NF

Neurofibromatosis is caused by a single, "dominant" gene. This gene may be inherited from an affected parent, or it may occur by chance in an individual with no family history of NF1 as a result of a gene change called a **spontaneous mutation**.

About half of those with NF1 have inherited it from a parent; the other half are affected because of a spontaneous mutation, and have no affected parent. It is believed that NF has an unusually high spontaneous mutation rate, which means that **NF1 can appear in any family**.

Once an individual has the NF1 gene, whether by inheritance or because of a spontaneous mutation, there is a 50-50 chance, each time he or she has a child that the gene will be passed on. There is also a 50-50 chance each time that the gene will not be passed on. In this case, the child will be completely free of neurofibromatosis and will never develop signs of the disease. This is just like flipping a coin: the odds are 50-50 every time. Almost every individual who has the gene either by inheritance or because of a spontaneous mutation will show some signs of NF1.

NF1's extreme variability is seen even within families. The same gene present in different members of the same family - brothers and sisters, grandparents, parents and children -can result in NF1 cases of widely varying degrees of severity and with very different NF1 symptoms. For example, a parent who has mild NF1 (few cafe-au-lait spots or neurofibromas) may have a very severely affected child. The reverse situation can also occur: a severely affected parent may have a child with very mild NF1. At present, there is no way to predict how seriously affected any person in any family with NF1 will be, or which NF1 complications he or she will develop.

What Is A Gene?

Our body is made up of millions of cells. Each cell contains a set of chemical structures known as chromosomes. There are 46 chromosomes, arranged in 23 pairs, in each cell in the body. One chromosome of each pair was contributed by the father, and the other by the mother.

A gene is a small section of a chromosome. Genes also come in pairs. About 100,000 genes are arranged in a very specific order on the 23 chromosome pairs. One of these pairs, called the sex chromosomes, differs in males and females; the other 22 pairs, called autosomcs, are the same in both sexes.

What Do Genes Do?

Genes direct cell behavior. When a gene is activated, a variety of events can occur in the cell, depending on the particular function of that gene. Some genes are responsible for obvious traits such as eye color; others control the production of substances essential to chemical processes inside our bodies. Certain genes simply act as on-off switches for other genes. The sum total of these reactions—which are like orders to the cell—are all the instructions needed for the first cell to develop into a human being and for the body to carry on all the functions of life.

What Is A Gene Mutation?
A mutation is a change. Gene mutations have occurred since the beginning of time and continue to do so. Most mutations are not detectable, and some are not harmful. When a "mutagen" (an agent that causes a mutation) alters the structure of a gene, the gene's "instructions" to the cell are changed or even stopped completely. An alteration of this kind can have serious effects, and may result in a genetic disorder.

NF is the result of such a changed gene.

NF is an "autosomal dominant" disorder. "Autosomal" means the NF gene is located on one of the 22 pairs of chromosomes called "autosomes." (NF1 is located on chromosome 17; NF2 on chromosome 22.) Since these chromosomes are the same in males and females, the gene can be present in either sex, and it can be passed on from either a mother or a father to a son or a daughter.

The term "dominant" means that the presence of only one changed or affected gene causes the disorder to appear; the action of the unaffected gene which is paired with the dominant gene cannot prevent the disorder. Because one gene is enough to cause the disorder, NF can be passed from one generation to the next when only one parent has the gene. "Recessive" disorders, on the other hand, generally occur only in the presence of a pair of affected genes, each inherited from one of the affected individual's parents.

The 50-50 Odds of Autosomal Dominant Inheritance

Why are the odds always 50-50 for a child to inherit NF from an affected parent?

The explanation for this lies in the process that brings egg cells and sperm cells to maturity. These cells carry our genetic heritage from one generation to the next. Before reaching maturity each of these cells contains 23 pairs of chromosomes, the full complement of genetic material just like any other body cell. As they approach maturity, however, these cells go through a special process (called "meiosis") that results in each egg or sperm having a single chromosome from each pair half of its original genetic material.

It happens this way:

1. Chromosomes line up in pairs inside the egg or sperm cell.
2.The pairs separate.
3. And the cell divides
4. Two cells are produced, each with one member

When an egg and sperm, each with 23 single chromosomes, unite, a new cell is formed which contains the 23 pairs of chromosomes required for normal human development.

What has this to do with the 50-50 chance to inherit the NF gene?
A person who has NF makes two different kinds of reproductive cells, one which will—if it happens to be used in conception—cause a child to have NF, and the other which will produce an unaffected child if it is the one that happens to be used.

When a person with NF mates with an unaffected individual, there are four possible combinations of cells. Two will yield a child with NF, two will yield an. unaffected child. This is how it happens:

Thus, there is a 50% chance with each pregnancy for the child to receive the NF gene, and a 50% chance for the child to receive two unaffected genes and to be free of NF.

DECIDING WHETHER TO HAVE A CHILD
When a husband or wife has NF, some couples may find it difficult to decide whether to have a child. No one can make this decision for anyone else. It may be helpful, however, to summarize some of the concerns that are often expressed.

The 50-50 risk:
A parent with NF has a 50% risk with each pregnancy to have a child with NF. This can be compared to the 4 to 7% risk of any couple in the general population to have a child born with a serious problem.

Unaffected parents who have a child born with NF because of a spontaneous mutation do not have a 50-50 risk in future pregnancies. Their chance for another child with NF1 is about the same as that of any couple in the general population, that is, one chance in 8,000. One additional birth in every 8,000 results in a child who has inherited NF1 from a parent with the disorder. Thus, a total of 2 children in 8,000 or 1 in 4,000 are born with NF1. In order to assess their risks accurately, however, it is essential for parents of an affected child to be examined by a knowledgeable physician to be as certain as possible that neither of them has a mild case of NF.

The child with NF, as a result of a new mutation, does have the 50-50 chance of passing the NF gene on to his or her children.

Unpredictability:
NF1 is variable arid unpredictable. A parent's case gives no indication of how severe (or mild) a child's case will be, or what NF1 complications a child will have.

Living with NF:
Children with NF may have medical problems, which require on-going attention. Because of the stresses associated with NF, social and emotional problems may also develop. Parents may be troubled with feelings of guilt about the child's difficulties. The financial cost of caring for a child with NF can be considerable.

Help With Making The Decision
Genetic counseling can help couples to work through the decision-making process. Genetic counselors do not tell anyone what to do; they provide information, clarify issues, and can also explain possible alternatives such as adoption or artificial insemination. In this way, the couple is encouraged, with the support of the counselor, to arrive at a decision that is right for them.

Most university-based medical centers and major hospitals offer genetic counseling services.

THE CHILDREN'S TUMOR FOUNDATION, INC.
The Children's Tumor Foundation is a nonprofit voluntary health organization, which was established in 1978 to respond to the needs of people with NF and their families.

Education
The Foundation offers information on NF, responds to individual requests for guidance, holds educational symposiums for the public and for professionals, and publishes numerous brochures, a quarterly Newsletter for patients and families and a Research Newsletter for medical professionals.

In 1994, the Foundation established The NF Website on the Internet (http://www.ctf.org). It has enabled scientists, clinicians, patients and families with NF as well as general audiences around the world to readily access detailed and accurate information about neurofibromatosis and the Foundation at low cost.

Chapter & Affiliates
A growing number of State Chapters and Affiliates of the Foundation provide opportunities for those affected by NF across the Unites States to know each other and help each other, and to participate in the activities of the Foundation. The Chapters and Affiliates conduct patient support, public education, and/or fundraising activities. For locations, addresses and telephone numbers of present chapters and affiliates, please contact the Children's Tumor Foundation or visit NF Web Site at www.ctf.org.

Medical Advisory Boards
The Medical Advisory Boards of the Children Tumor's Foundation are comprised of distinguished physicians and scientists actively involved with neurofibromatosis in medical centers across the Unites States and abroad.

The Foundation's Research Advisory Board encourages research proposals aimed at understanding the causes and finding a cure for neurofibromatosis. The Research Advisory Board approves grant awards on the basis of an intensive peer review process modeled after that used by the National Institute of Health.

The Foundation's Clinical care Advisory Board oversees the development of specialized clinical care centers in the Unites States and develops diagnostic standards and procedures.

Research
Beginning in 1983, the Children's Tumor Foundation has made peer-reviewed awards to outstanding scientists to study NF in institutions across the Unites States and abroad.

As a result of their research, the gene for NF1 and "neurofibromin", the gene product it encodes, was discovered in 1990. In 1993, the NF2 gene and "Merlin", its gene product, was discovered. Current research includes all aspects of NF1 and NF2, as well as research into related areas such as learning disabilities and cancer.

You can help us
The Children's Tumor Foundation is working hard to increase public awareness of NF, to provide help and support to families affected by this long overlooked and devastating disorder and to stimulated research. We have made real progress. We

need your help to continue to seek answers to NF through research and, until a cure is found, to provide hope and support to people with NF around the world.

The Children's Tumor Foundation
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GLOSSARY OF MEDICAL TERMS RELATING TO NEUROFIBROMATOSIS

AUTOSOMAL DOMINANT INHERITANCE
The process by which one gene of a pair causes the expression of a trait or disorder. Such a gene has a 50% chance to be passed on to each child of an affected parent.

CAFE-AU-LAIT SPOTS
Light brown flat spots, variable in shape and size. Six or more spots, at least 1M inch in diameter in children, and 3/4 inch in diameter in adults are usually a sign of neurofibromatosis.

CHEMOTHERAPY
Treatment of tumor growth by chemical agents.

CHROMOSOMES
Bearers of genes, the basic units of heredity. The nucleus of each body cell contains 23 pairs of chromosomes.

COMPUTERIZED TOMOGRAPHY
(also known as CT or CAT scan). A computerized X-ray, which provides detailed X-ray images of internal organs, head and limbs.

DOMINANT
Pertains to a gene, which by itself causes the expression of a trait or disorder. An identical, paired gene need not be present.

FIBROMA
A tumor composed mainly of fibrous or connective tissue.

GENE
The basic unit of heredity. Thousands of genes, arranged in specific linear order, form a chromosome. Genes, like chromosomes, come in pairs; one of each pair is located on one chromosome, with the matching gene on the other chromosome of that pair.

GLIOMA
A type of brain tumor.

GLIOBLASTOMA
A type of malignant brain tumor.

HAMARTOMA
A benign growth consisting of an overgrowth of the tissues, which normally occur in an area. A neurofibroma is an example of a hamartoma.

HEMIHYPERTROPHY
Overgrowth of one half of the body or of a part of the body, such as the face. Rarely, this may occur in NF.

LEARNING DISABILITY
A problem with a specific cognitive function necessary for learning in spite of average or above average intelligence. Learning disabilities can affect one's ability to listen, think, read, write, spell, speak and/or compute math.

LISCIJ NODULES
Small harmless clumps of pigment on the iris of the eye, often seen in NF. Also called iris nevi. They do not cause problems with vision.

MAGNF.TIC RESONANCE IMAGING (MRI)
A diagnostic technique, which uses magnetic energy to image the brain and body.

MENINGIOMA
A benign tumor of the covering of the brain.

MUTATION
A permanent change in the genetic material, usually in a single gene.

NEURAL CREST
An embryonic structure from which many of the cell types which tend to be affected by NF develop.

NEURO
Denotes relationship to a nerve or nerves, or to the nervous system.

NEUROFIBROMA
A benign tumor caused by proliferation of Schwann cells and fibroblasts.

NEUROFIBROMATOSIS (nu-ro-fi-bro-mah-to-sis)
A genetic disorder characterized by developmental changes in the nervous system, muscles, bones and skin and marked superficially by the formation of multiple soft tumors (neurofibromas), and by areas of pigmentation (cafe-au-lait spots). Also called von Recklinghausen's Disease.

NEURONS
Electrically active cells of the nervous system responsible for controlling behavior and body function.

OPTIC GL1OMA
Tumor affecting the optic (visual) nerve, which may occur in neurofibromatosis.

ORBIT
Bony cavity of the skull in which the eyeball is located.

PEEXIFORM NEUROFIBROMA
A diffuse, flat type of growth. Usually occurs below the skin internally.

PERIPHERAE
Situated away from the center of the central nervous system, toward the surface of the body.

PSEUD ARTHROSIS
Failure of a fracture to heal, resulting in a "false joint".

RECESSIVE
Pertaining to a gene, a pair of which is generally required for full expression of a trait or disorder.

SARCOMA
Malignant soft tissue tumor.

SCHWANN CELL
The cell of which myelin (the insulation of peripheral nerves) is composed.

SCHWANNOMA
A benign rumor caused by proliferation of Schwann cells.

SCOLIOSIS
Lateral deviation in the normally straight vertical line of the spine.

SPONTANEOUS MUTATION.
A change in a gene, occurring with no identifiable cause.

VESTIBULAR SCHWANNOMA (ACOUSTIC NEUROMA)
Benign tumor of the eighth cranial nerve, causing hearing impairment.

VON RECKLINGHAUSEN'S DISEASE
Another name for neurofibromatosis type one.

ADDITIONAL INFORMATION
The Children's Tumor Foundation can be a source of educational materials and support. They can be reached at:

The Children's Tumor Foundation
95 Pine Street, 16th Floor
New York, NY 10005
212-344-6633 or 1-800-323-7938
Email: Info@ctf.org
Internet: www.ctf.org