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National Institutes of Health
Turning Discovery Into Health

Genetic and Rare Diseases Information Center
National Center for Advancing Translational Sciences
Office of Rare Diseases Research
National Human Genome Research Institute

FAQs about Chromosome Disorders

What are chromosomes?
Chromosomes are organized packages of DNA found inside your body's cells.[1] Your DNA contains genes that tell your body how to develop and function. Humans have 23 pairs of chromosomes (46 in total). You inherit one of each chromosome pair from your mother and the other from your father. Chromosomes vary in size. Each chromosome has a centromere, which divides the chromosome into two uneven sections. The shorter section is called the p arm, and the longer section is called the q arm.[1][2] Genetics Home Reference (GHR) has a helpful picture of a chromosome.

Are there different types of chromosomes?
Yes, there are two different types of chromosomes; sex chromosomes and autosomal chromosomes. The sex chromosomes are the X and Y chromosomes. They determine your gender (male or female). Females have two X chromosomes, XX, one X from their father and one X from their mother. Males have one X chromosome from their mother and one Y chromosome, from their father, XY. Mothers always contribute an X chromosome (to either their son or daughter). Fathers can contribute either an X or a Y, which determines the gender of the child. The remaining chromosomes (pairs 1 through 22) are called autosomal chromosomes. They contain the rest of your genetic information.[1][2][3][4]

What are the different types of chromosome disorders?
Chromosome disorders can be classified into two main types; numerical and structural. Numerical disorders occur when there is a change in the number of chromosomes (more or fewer than 46). Examples of numerical disorders include trisomy, monosomy and triploidy. Probably one of the most well-known numerical disorders is Down syndrome (trisomy 21).[1][2] Other common types of numerical disorders include trisomy 13, trisomy 18, Klinefelter syndrome and Turner syndrome.

Structural chromosome disorders result from breakages within a chromosome. In these types of disorders there may be more or less than two copies of any gene. This difference in number of copies of genes may lead to clinical differences in affected individuals. Types of structural disorders include the following:[1][2] (click on each type to view an illustration)

- Chromosomal deletions, sometimes known as partial monosomies, occur when a piece or section of chromosomal material is missing. Deletions can occur in any part of any chromosome. When there is just one break in the chromosome, the deletion is called a *terminal deletion* because the end (or terminus) of the chromosome is missing. When there are two breaks in the chromosome, the deletion is called an *interstitial deletion* because a piece of chromosome material is lost from within the chromosome. Deletions that are too small to be detected under a microscope are called *microdeletions*.[1][2][5] A person with a deletion has only one copy of a particular chromosome segment instead of the usual two copies. Some examples of more common chromosome deletion syndromes include cri-du-chat syndrome and 22q11.2 deletion syndrome.

- Chromosomal duplications, sometimes known as partial trisomies, occur when there is an extra copy of a segment of a chromosome. A person with a duplication has three copies of a particular chromosome segment instead of the usual two copies. Like deletions, duplications can happen anywhere along the chromosome.[1][2][5] Some examples of duplication syndromes include 22q11.2 duplication syndrome, and MECP2 duplication syndrome.
- Balanced translocations occur when a chromosome segment is moved from one chromosome to another. In balanced translocations, there is no detectable net gain or loss of DNA.[1][2][5]
- Unbalanced translocations occur when a chromosome segment is moved from one chromosome to another. In unbalanced translocations, the overall amount of DNA has been altered (some genetic material has been gained or lost).[1][2][5]
- Inversions occur when a chromosome breaks in two places and the resulting piece of DNA is reversed and re-inserted into the chromosome. Inversions that involve the centromere are called *pericentric inversions*; inversions that do not involve the centromere are called *paracentric inversions.*[1][2][5]
- Isochromosomes are abnormal chromosomes with identical arms - either two short (p) arms or two long (q) arms. Both arms are from the same side of the centromere, are of equal length, and possess identical genes. Pallister-Killian syndrome is an example of a condition resulting from the presence of an isochromosome.[2][5]
- Dicentric chromosomes result from the abnormal fusion of two chromosome pieces, each of which includes a centromere.[5]
- Ring chromosomes form when the ends of both arms of the same chromosome are deleted, which causes the remaining broken ends of the chromosome to be “sticky.” These sticky ends then join together to make a ring shape. The deletion at the end of both arms of the chromosome results in missing DNA, which may cause a chromosome disorder. Genetics Home Reference (GHR) provides a diagram of the steps involved in the formation of a ring chromosome.[1][2][5] An example of a ring condition is ring chromosome 14 syndrome.

What causes chromosome disorders?

The exact cause is unknown, but we know that chromosome abnormalities usually occur when a cell divides in two (a normal process that a cell goes through). Sometimes chromosome abnormalities happen during the development of an egg or sperm cell (called germline), and other times they happen after conception (called somatic). In the process of cell division, the correct number of chromosomes is supposed to end up in the resulting cells. However, errors in cell division, called nondisjunction, can result in cells with too few or too many copies of a whole chromosome or a piece of a chromosome.[1][6] Some factors, such as advanced maternal age (older than 35 years), can increase the risk for chromosome abnormalities.[1]

What is mosaicism?

Mosaicism is when a person has a chromosome abnormality in some, but not all, cells. It is often difficult to predict the effects of mosaicism because the signs and symptoms depend on which cells of the body have the chromosome abnormality.[2][7] Genetics Home Reference (GHR) provides a diagram of mosaicism.

How are chromosome disorders diagnosed?

Chromosome disorders may be suspected in people who have developmental delays, intellectual disabilities and/or physical abnormalities. Several types of genetic tests can identify chromosome disorders:

- Karyotyping
- Microarray (also called array CGH)

- Fluorescence in situ hybridization (FISH)

What signs and symptoms are associated with rare chromosome disorders?
In general, the effects of rare chromosome disorders vary. With a loss or gain of chromosomal material, symptoms might include a combination of physical problems, health problems, learning difficulties, and challenging behavior. The symptoms depend on which parts of which chromosomes are involved. The loss of a segment of a chromosome is usually more serious than having an extra copy of the same segment. This is because when you lose a segment of a chromosome, you may be losing one copy of an important gene that your body needs to function.[2]

There are general characteristics of rare chromosomal disorders that occur to varying degrees in most affected people. For instance, some degree of learning disability and/or developmental delay will occur in most people with any loss or gain of material from chromosomes 1 through 22. This is because there are many genes located across all of these chromosomes that provide instructions for normal development and function of the brain.[2] Health providers can examine the chromosome to see where there is a break (a breakpoint). Then they can look at what genes may be involved at the site of the break. Knowing the gene(s) involved can sometimes, but not always, help to predict signs and symptoms.

Can chromosome disorders be inherited?
Although it is possible to inherit some types of chromosomal disorders, many chromosomal disorders are not passed from one generation to the next. Chromosome disorders that are not inherited are called *de novo*, which means "new".[6] You will need to speak with a genetics professional about how (and if) a specific chromosome disorder might be inherited in your family.

How can I find individuals with the same chromosome disorder?
Chromosome Disorder Outreach (CDO) provides information on chromosomal conditions and family matching. You can search their list of Registered Disorders to see if anyone has registered with the same chromosome abnormality. Contact CDO for more information about how to connect with other families.

Chromosome Disorder Outreach
PO Box 724
Boca Raton, FL 33429
Family Helpline: 561-395-4252
E-mail: info@chromodisorder.org
Web site: http://www.chromodisorder.org

Unique is a source of information and support for families and individuals affected by rare chromosome disorders. This organization is based in the United Kingdom, but welcomes members worldwide. Unique also has a list of Registered Chromosome Disorders.

Unique – Rare Chromosome Disorder Support Group
P.O. Box 2189
Caterham
Surrey CR3 5GN
United Kingdom
Telephone: 440 1883 330766
E-mail: info@rarechromo.org
Web site: http://www.rarechromo.org

How can I find research studies for individuals with chromosome disorders?
The National Institute of General Medical Sciences (NIGMS) Human Genetic Cell Repository was established in 1972 to provide a readily accessible, centralized resource for genetic material from individuals with inherited defects in metabolism, chromosomal abnormalities, and other genetic disorders. This biobank creates cell lines, DNA and other materials from blood or tissue samples and makes these important resources available to scientists worldwide to facilitate research on the diagnosis, treatment and prevention of rare disorders. They are interested in collecting samples from individuals with chromosome disorders, including but not limited to: rare trisomies, ring chromosomes, micro deletion/duplication syndromes, and balanced and unbalanced translocations or inversions. Click on the link to learn more about this service.

The Developmental Genome Anatomy Project (DGAP) is a research effort to identify apparently balanced chromosomal rearrangements in patients with multiple congenital anomalies and then to use these chromosomal rearrangements to map and identify genes that are disrupted or dysregulated in critical stages of human development. Click on the link to learn more about this study.

Chromosome Disorder Outreach provides information about ongoing research studies for chromosome disorders. Visit the link to see if these studies may be of interest to you.

When might it be appropriate to speak with a genetics professional?
Individuals or families who are concerned about an inherited condition may benefit from a genetics consultation. The Genetics Home Reference (GHR) Web site provides a list of reasons why a person or family might be referred to a genetics professional.

For more information on a specific chromosome abnormality, we encourage you to speak with a genetics professional. Genetics clinics are a source of information for individuals and families regarding genetic conditions, treatment, inheritance, and genetic risks to other family members.

The following online resources can help you find a genetics professional in your community:

- GeneTests has a searchable directory of U.S. and international genetics and prenatal diagnosis clinics.
- The National Society of Genetic Counselors provides a searchable directory of U.S. and international genetic counseling services.
- The American College of Medical Genetics has a searchable database of U.S. genetics clinics.

Where can I find more information on chromosomes and chromosome disorders?
For more information on chromosomes and chromosome disorders, visit these resources from the National Institutes of Health (NIH):

- National Human Genome Research Institute (NHGRI)
- Genetics Home Reference (GHR)
- MedlinePlus

The advocacy organizations for chromosome disorders are other good sources of information. Unique has a general fact sheet on chromosomes and a list of chromosome disorder leaflets. Chromosome Disorder Outreach (CDO) also provides general information on chromosomes.

References:

1. Chromosome Abnormalities. National Human Genome Research Institute (NHGRI) Website. 2011. Available at: http://www.genome.gov/11508982#6.
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5. Can changes in the structure of chromosomes affect health and development? Genetics Home Reference (GHR). 2012. Available at: http://ghr.nlm.nih.gov/handbook/mutationsanddisorders/structuralchanges.
6. Are chromosomal disorders inherited? Genetics Home Reference (GHR). 2012. Available at: http://ghr.nlm.nih.gov/handbook/inheritance/chromosomalinheritance.
7. Can changes in the number of chromosomes affect health and development? Genetics Home Reference (GHR). 2012. Available at: http://ghr.nlm.nih.gov/handbook/mutationsanddisorders/chromosomalconditions.

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