



# Standard Chromosome Analysis

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## What is a chromosome and how are they inherited?

Chromosomes are microscopic structures that contain an individual's genetic material; a copy of a person's chromosomes is located within each cell of their body (except for red blood cells). This genetic material serves as the "instruction manual" for the body, containing the "directions" the body needs in order to form and function properly. In general, chromosomes serve as a way to organize the complex genetic code; if you imagine the genetic code as a library, the chromosomes would be like the books in the library, and genes would be like the specific chapters in each book, containing the instructions for each particular task the body needs to perform.

Typically, human cells have a total of 46 chromosomes, which are arranged into 23 pairs. We inherit one member of each pair from our biological mother, and the other member of each pair from our biological father. The first 22 pairs of chromosomes are called "autosomes" and the last pair is called the "sex chromosomes". The sex chromosomes determine whether a person is genetically male or female. Females typically have two "X" sex chromosomes, while males typically have one "X" and one "Y" sex chromosome.

When a cell divides to create new cells for the body, the chromosomes are copied in order to ensure that each new cell gets an exact replica of the "instruction manual." Egg and sperm cells, however, are different, as they divide an extra time to ensure that each egg or sperm cell gets only one member of each chromosome pair, for a total of 23 chromosomes. This happens so that when an egg and sperm cell join during reproduction, the resulting fetus has a complete set of 46 chromosomes, containing one copy of each pair from each parent.

## What is a chromosome analysis?

Chromosome analysis is a study of the number and general structure of all 46 chromosomes; it is also known as a karyotype. In a standard karyotype, chromosomes from cells in the body (usually white blood cells) are counted to ensure that the cells evaluated have the correct number of chromosomes, and their structure is evaluated to ensure that there are no large pieces of material that are missing (deleted), extra (duplicated), or rearranged in any way. It is important to realize that standard chromosome analysis may not be able to detect tiny deletions or duplications of genetic material (other tests are available that are better able to do this), and will NOT be able to detect single gene conditions, such as sickle cell disease.

Hundreds of different types of chromosome abnormalities causing well described syndromes have been reported in humans. They fall into 2 categories: **numerical** and **structural**. A **numerical** chromosome abnormality simply means that a person has a total number of chromosomes different from 46; usually 47 or sometimes 45 chromosomes, in each cell of their body, respectively. Health problems and birth defects are usually present as a result of having the extra or missing genetic material. An example of a numerical chromosome abnormality is Down syndrome, which is typically caused by having an entire extra chromosome 21, for a total of three copies of chromosome 21 instead of two.

The other type of chromosome abnormality, **structural**, means that a portion of the genetic material has been rearranged in some way; for example, a piece of one chromosome may be attached to another chromosome (translocation), or a piece of a chromosome may be turned upside down (inversion). A rearrangement may or may not result in obvious health problems. This depends on whether the structural problem ultimately results in a net gain or loss of chromosome material. If the

chromosome material is simply in a rearranged fashion, yet all of the genetic information is present, the person may have no clinical symptoms; this is known as a “balanced” rearrangement. However, this type of chromosome rearrangement can cause the individual to have an increased chance for pregnancy losses or infants born with birth defects. This is because chromosome rearrangements can make it difficult for the genetic information to be divided equally between each egg/sperm cell. If this occurs, and then that egg or sperm cell is used in reproduction, there can be too much or too little genetic material in the resulting fetus. The pregnancy is “unbalanced” chromosomally, and may miscarry or result in the birth of a child with health and/or learning problems. About 1 in 500 persons in the general population carry a rearrangement in their chromosome material. Persons with family or personal histories of multiple pregnancy losses, unexplained stillbirths, or early infant deaths, may be at a slightly greater chance to have a rearrangement in their chromosomes.

### **When is chromosome analysis indicated?**

Chromosome analysis is recommended as a routine diagnostic procedure for a number of indications, including (but not limited to) the following:

- *Problems noted during early growth/development:* Failure to thrive, developmental delay, dysmorphic (unusual) features, multiple birth defects, short stature, ambiguous genitalia, and mental retardation are frequent findings amongst individuals with chromosome abnormalities, although they are not exclusive to this group.
- *Stillbirths and neonatal deaths:* The incidence of chromosome abnormalities is much higher amongst stillbirths and infants who die shortly after birth (each about 10%) than amongst live births (0.7%). Chromosome analysis may be able to identify a cause for the loss and provide important information for prenatal diagnosis in future pregnancies for parents.
- *Fertility problems:* Chromosome analysis is recommended for women who are past the typical age of puberty and have never had a menstrual cycle as well as for couples with a history of infertility or recurrent miscarriage. Chromosome abnormalities can be seen in one or the other parent in approximately 3-6% of infertility or recurrent miscarriage cases.
- *Pregnancy in women 35 years or older at the time of delivery:* Though anyone at any age has a chance to have a child with a chromosome abnormality, the chances do increase with increasing maternal age. Chromosome analysis of the fetus should be offered as a routine part of prenatal care in such pregnancies.
- *Family History:* A known or suspected chromosome abnormality in a relative can be an indication for chromosome analysis under some circumstances.

Your geneticist/genetic counselor can help you decide if chromosome analysis is appropriate for you/your child based on your personal and family history.

### **Will a chromosome analysis detect all possible defects?**

No. There are thousands of genes contained on the 46 chromosomes. **A chromosome study has nothing to do with looking at the individual genes.** For example, even when both parents have normal chromosomes and the baby has a normal chromosome study on an amniocentesis, there is still a 2-3% chance for the baby to have a birth defect. Chromosome analysis only provides information relating to the number and structure of chromosomes, and does not evaluate for single gene disorders. It is important to understand the difference between a chromosome study and a separate DNA or biochemical test for the function of a specific gene. Unfortunately at present, there is no genetic test that screens for everything.