Human Chromosome Nomenclature

Prof Vandana Rai
Department of Biotechnology
VBS Purvanchal University
Jaunpur

"Cytogenetics is a branch of science that deals with the study of chromosomes, chromosomal alterations and its relation in the disease development."

In simple words, "The study of chromosomes is called cytogenetics."

The techniques of cytogenetics are

(i) karyotyping,

(ii) banding,

(iii) Fluorescence *in situ* hybridization (FISH) and

(iv)whole chromosome microarray etc

With cytogentic techniques, we can study-

i. The structural properties of a chromosome (deletion, duplication, translocation or alteration).
ii. The functional properties of a chromosome (loss or gain of function)
iii. Numerical chromosomal abnormalities (trisomy, tetrasomy or

Importance of cytogenetics

Cytogenetic techniques are a very important tool for detection and indication of chromosomal abnormalities, it used for the study of,

- Aneuploidy and polyploidy
- Gametogenesis
- Nondisjunction and sister chromatid exchange
- Genetic imprinting and uniparental disomy s
- Identification, characterisation and nomenclature of chromosomes
- Sex chromosomal abnormalities
- Cell cycle and replication analysis

The history of human chromosome idendifcation

- **1897-Arnold**- First visualization of human chromosome

- **1888- Waldayer-** The word chromososme (Chroma-colour, soma- body)
- **1921- L.S. Painter-** 48 chromosomes, X and Y (Science)
- **1950:** Colchicine was used to arrest chromosomes at metaphase.
- **1956:** Moorehead and coworkers developed a method called “Peripheral blood leukocyte culture” for karyotyping. Later on, the method becomes popular and adopted by cytogenetics worldwide.
- **1956- Jo Hin Tijo and Albert Levan-** 46 human chromosome (Heriditas)
- **1959: Ford and coworker** observed the presence of a single X

Karyotyping Conference

- Several International conferences were organized for the standardization of human karyotype.
- 1960- **Denev**- Chromosome numbered 1-22 based on their size
- 1963- **London**- grouping (A-G)
- 1966- **Chicago**- big chromosome syndromes
- 1971- **Paris**- chromosome banding
- 1976- **Mexico**- chromosome banding
- 1978- **Stockholm**- chromosome banding
- 1995-**ISCN**- International System for Human Cytogenetic Nomenclature

Human Cytogenetics

- 1956: Tjio and Levan count the full complement of 46 human chromosomes
- serendipitous addition of water to a suspension of fixed cells
- 3 years after description of DNA structure
- 30 years after count of 48 chromosomes by Thomas Painter

Cytogenetic Nomenclature

Chromosome are visualized during metaphase when they condense prior to anaphase and division. There are 22 pairs of autosomes in a human cell and one pair of sex chromosomes.

2n=44+XY

Human male G banded chromosomes

Karyotype

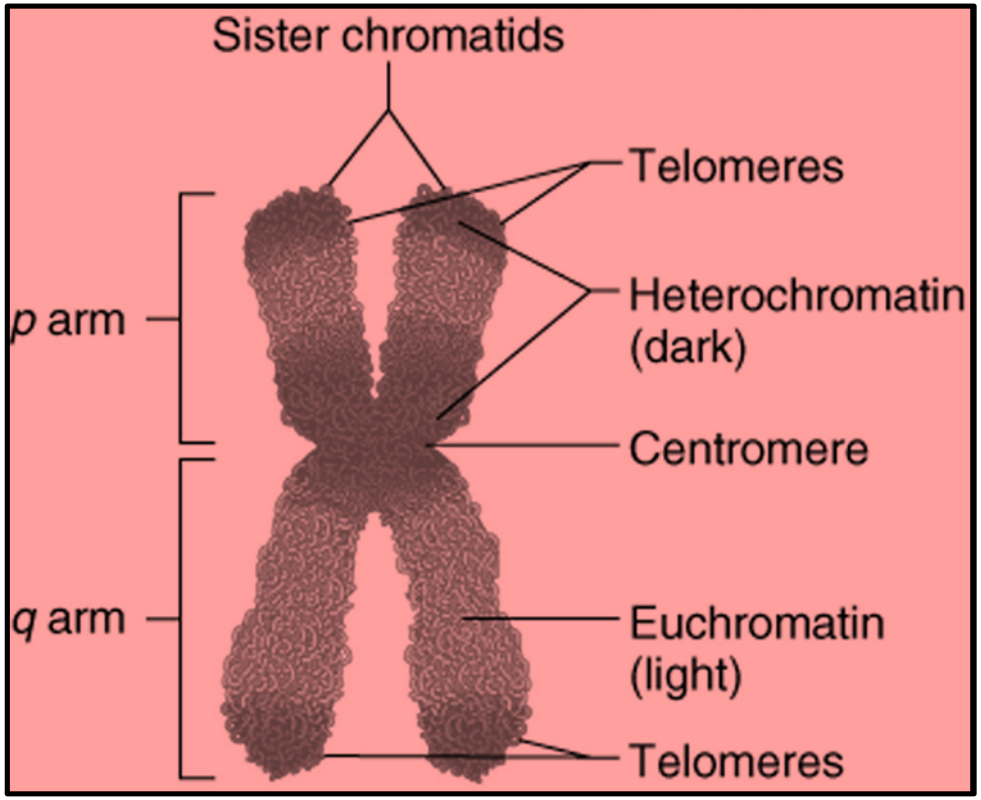
- Karyotyping is the process by which photographs of chromosome are taken in order to determine the chromosome complement of an individual, including the number of chromosomes and any abnormalities. The term is also used for the complete set of chromosomes in a species or in an individual organism, and for a test that detects this complement or measures the number.
- Different species often have different karyotypes.

Centromeres are the largest constriction of the chromosome

Site of attachment of spindle fibers

100,000s of 171 base pair repeat, called alpha satellite sequences

Centromere associated proteins are bound

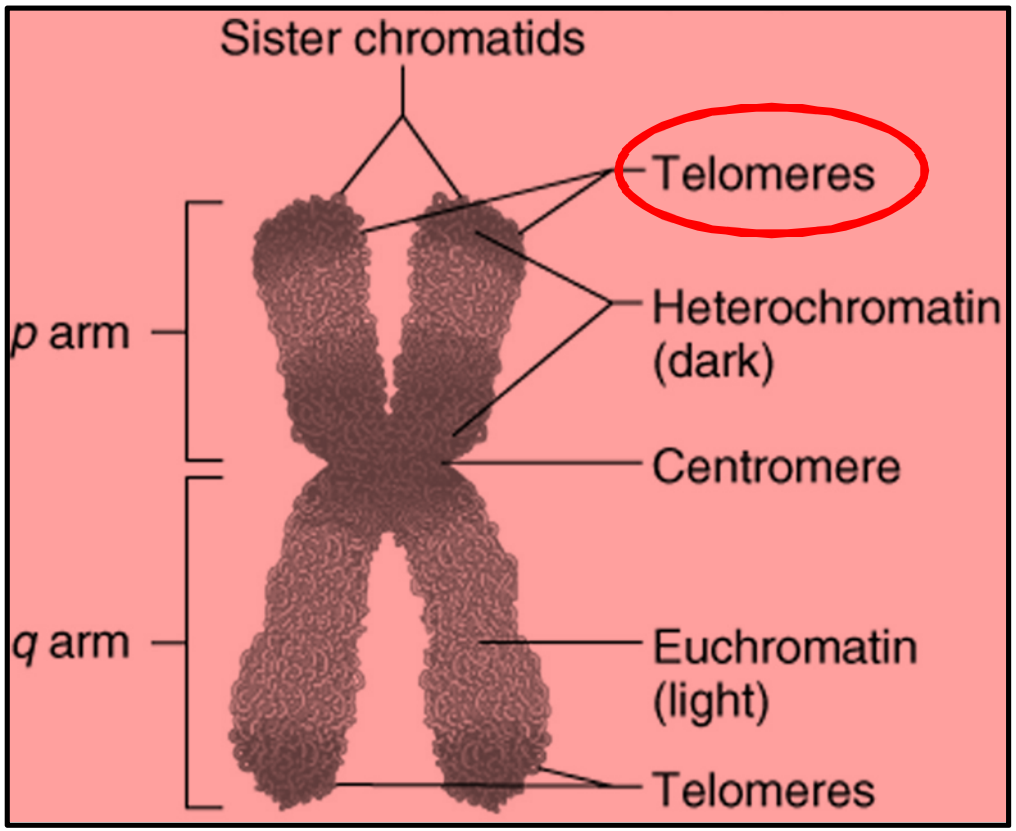


Telomeres are:

At the tips of chromosomes

Many repeats of the sequence TTAGGG

Subtelomeres have more varied short repeats



ISCN 1995

Ideogram of human chromosomes

International System for Human Cytogenetic Nomenclature

Group A (1-3)

Group B (4-5)

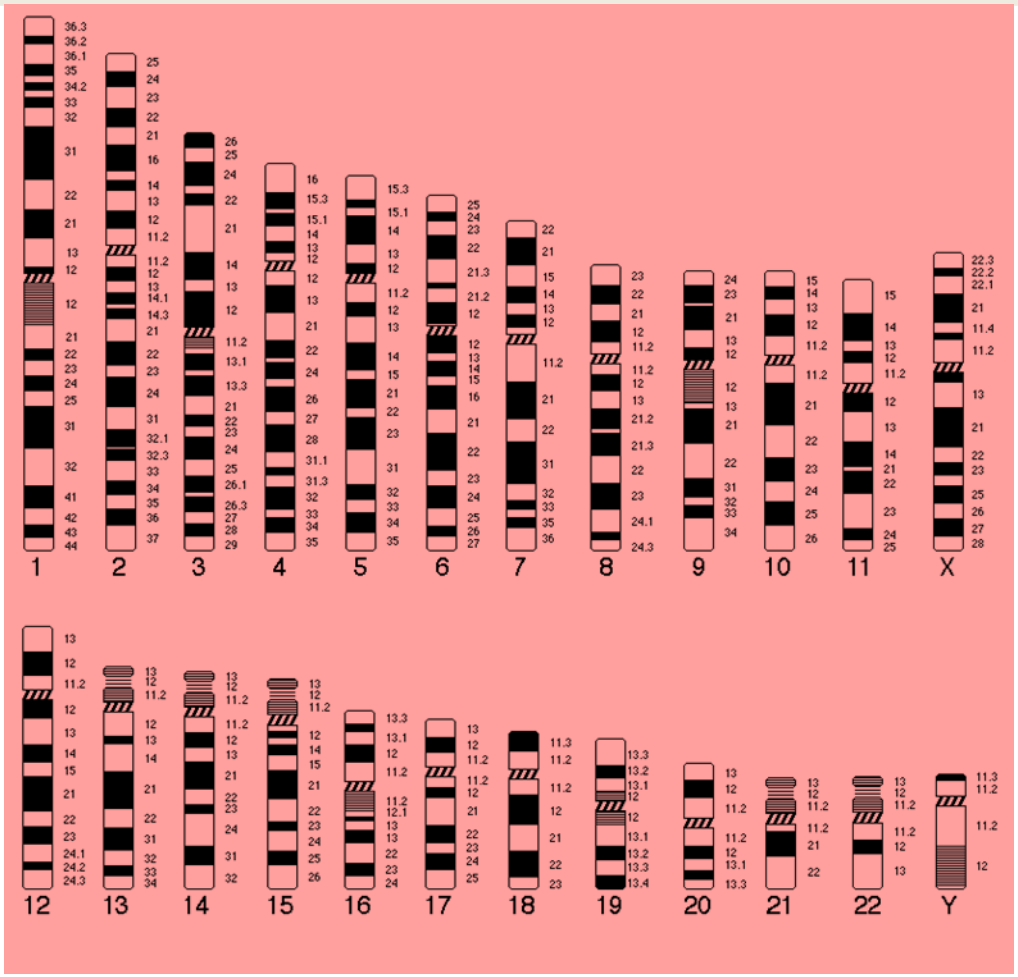
Group C (6-12, X)

Group D (13-15)

Group E (16-18)

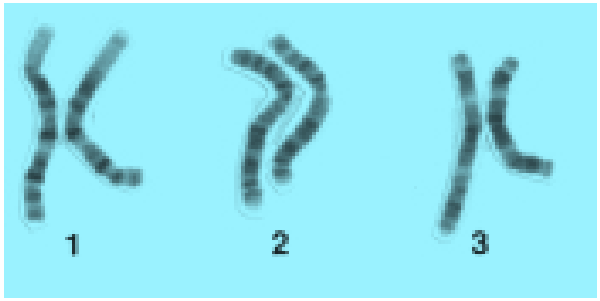
Group F (19-20)

Group G (21-22)

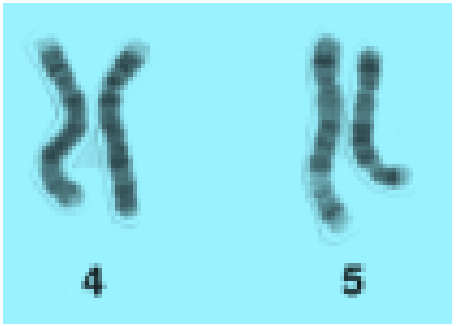


Human chromosomes grouping

Group A: chromosomes 1,2,3
largest metacentric



Group B: chromosomes 4,5
large submetacentric



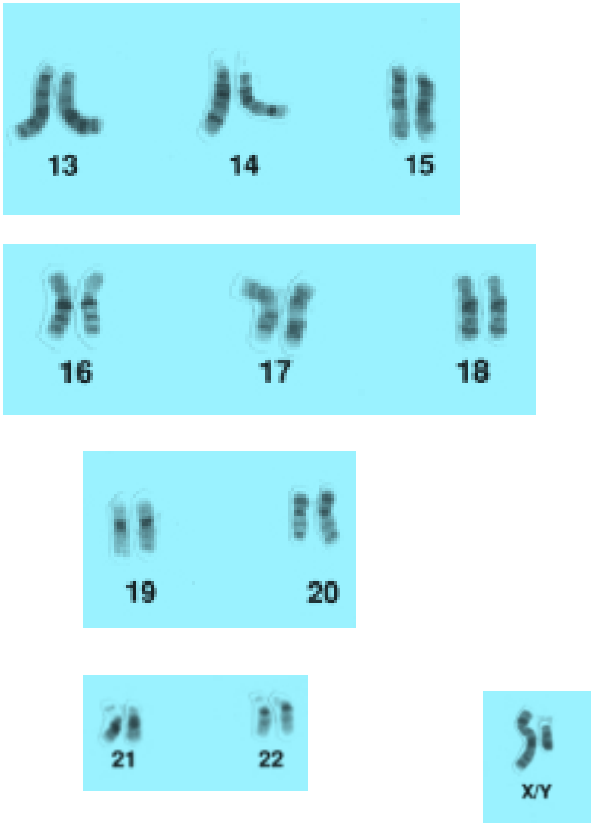
Group C: chromosomes 6,7,8,9,10,11
and 12 medium submetacentric

Group D: chromosomes 13, 14, 15
medium acrocentric

Group E: chromosomes 16, 17, 18
short metacentric or submetacentric

Group F: chromosomes 19, 20
short metacentric

Group G: chromosomes 21, 22
very short acrocentric



Numerical & Structural changes in chromosomes

- **Numerical chromosome changes/aneuploidy**

  result from errors occurring during meiotic or mitotic segregation

- **Structural chromosome changes**

  translocations

  inversions

  deletions

  duplications

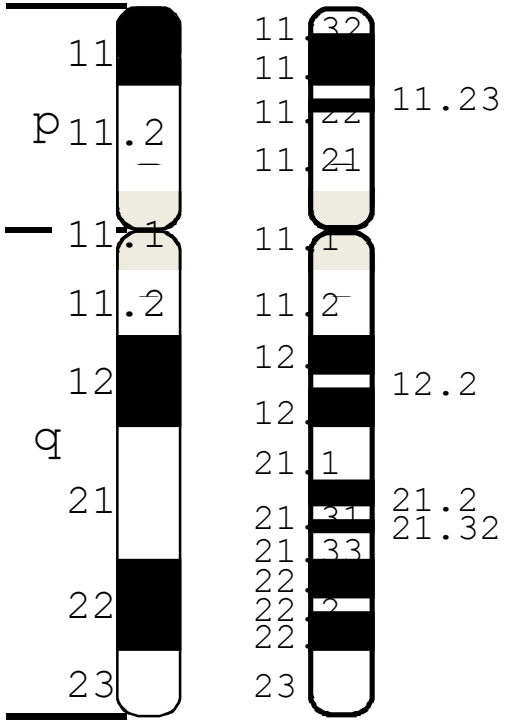
Nomenclature

International System for Human Cytogenetic Nomenclature(ISCN) 2009

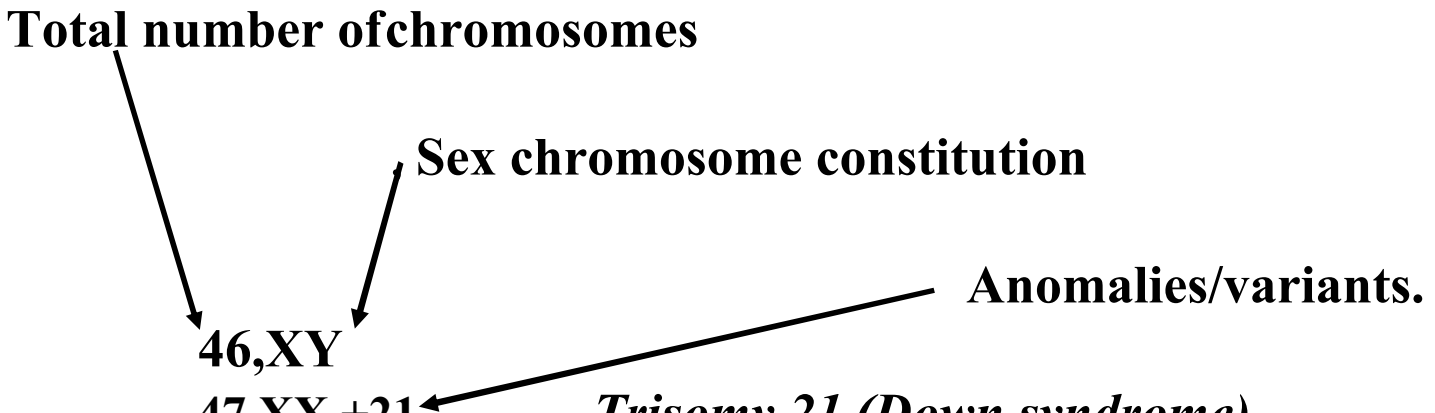
In designing a particular band

- Chromosome number
- Arm symbol (p or q)
- Region number
- Band number (2.1/2.1.1)
- Description of chromosome abnormalities
- Total number of chromosomes including sex chromosomes (46,XY)
- Sex chromosome constitution (XX/XY)
- **Numerical abnormalities**

For example a female Down syndrome or trisomy 21 is written as -


p
q
11
11.2
11.1
11.2
12
21
22
23
11.32
11.23
11.22
11.21
11.1
11.2
12.2
21.1
21.2
21.31
21.32
21.33
22.1
22.2
22.3
23

The Karyotype: an international description



46,XY

47,XX,+21 *Trisomy 21 (Down syndrome)*

47,XXX *Triple X syndrome*

69,XXY *Triploidy*

45,XX,der(13;14)(p11;q11) *Robertsonian translocation*

46,XY,t(2;4)(p12;q12) *Reciprocal translocation*

46,XX,del(5)(p25) *Deletion tip of chromosome 5*

46,XX,dup(2)(p13p22) *Duplication of part of short arm Chr 2*

46,XY,inv(11)(p15q14) *Pericentric inversion chromosome 11*

46,XY,fra(X)(q27.3) *Fragile X syndrome*

46,XY/47,XXY *Mosaicism normal/Klinefelter syndrome*

Chromosomal shorthand

Abbreviation	What it means
46, XY	Normal male
46, XX	Normal female
45, X	Turner syndrome female
47, XXY	Klinefelter syndrome male
47, XYY	Jacobs syndrome male
46, XY del (7q)	Male missing part of long arm of chromosome 7
47, XX+21	Female with trisomy 21
46, XY t (7;9) (p21.1;q34.1)	Male with translocation between short arm of chromosome 7 band 21.1 and long arm of chromosome 9 band 34.1

Karyotype nomenclature

Karyotype	Description
46,XY	Normal male
47, XX, +21	Female with trisomy 21, Down Syndrome.
47, XY, +21 / 46, XY	Male mosaic for trisomy 21 and normal cells
46, XY, del(4)(p14)	Male with distal deletion of the short arm of chromosome 4 band designated 14.
46,XX, dup (5p)	Female with a duplication of short arm of chromosome 5.
45, XY, -13, -14, t(13q;14q)	Male with a balanced Robertsonian translocation of chromosome 13 and 14, with a normal 13 and normal 14 missing.
46, XX, t(11;22)(q23;q22)	Male with a balanced reciprocal translocation
46,XX, inv(3)(p21;q13)	Female with an inversion on chromosome 3 from p21 to q13; because it includes the centromere this is a pericentric inversion.
46, X,r(X)	A female with one normal X and one ring X chromosome.
46, X, i(Xq)	Female with one normal X chromosome and and isochromsome of the long arm of the X.

Suggested Reading

1. Human Molecular Genetics – Tom Stratchen & Andrew P. Read. Pub: John Wiley & Sons.
2. An introduction to Genetic Analysis– Griffith, Miller, Suzuki, Lewontin, Gelbard. Pub: W.H. Freeman & Co.
3. Genomes 2 – T.A. Brown, Pub: Wiley-Liss. John W. & Sons.
4. Emery's Elements of Medical Genetics– R.F. Mueller, I.D. Young, Pub: Churchill
5. An Introduction to Human Molecular Genetics– J.J. Pasternak, Pub: Fitzgerald Science