MEDICINE
KING SAUD UNIVERSITY

436 TEAM
HUMAN GENETICS

Human genetics:

Human Chromosomes, Human Karyotype

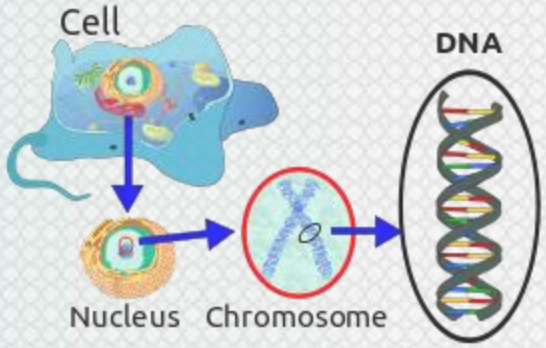
For revision only

- **Important**
- **Notes**

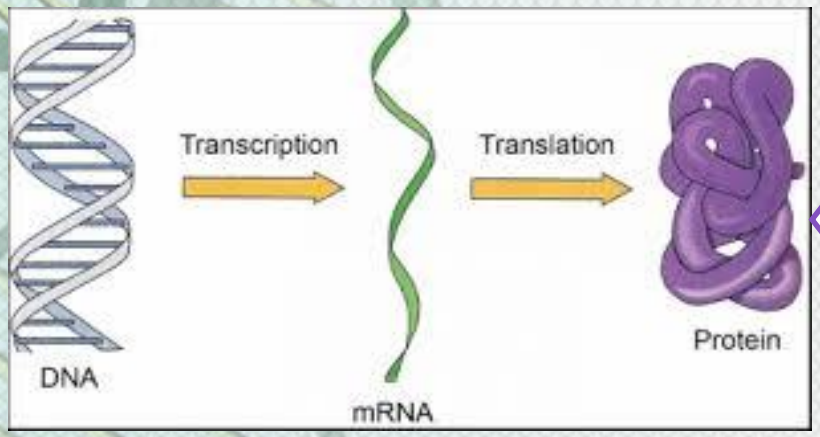
Objectives:

- Describe the number, structure, and classification of human chromosomes
- Explain what a Karyotype is and how it is obtained.
- Describe chromosomal banding and explain its use.
- Describe the process of in situ hybridization and the information it provides.

Gene Expression



cell → Nucleus → Chromosome → Gene → DNA



* In **transcription** Cell machinery copies the code making an mRNA molecule.
* mRNA moves into the cytoplasm
* **Translation:** Ribosomes read the code and accurately join amino acids together to make protein.

- **Only folded protein can perform function**

Eukaryotic cells

*** Eukaryotic cells present in humans and some other micro-organisms like Parasite and fungi**

*There are two types of organelles :

Membranous organelle	Non-Membranous organelle
Rough & Smooth Endoplasmic reticulum	Ribosomes
Mitochondria	Centrioles
Golgi apparatus	Microtubules
Peroxisomes	Inclusions
Lysosomes	Cilia - Flagella
Vacuoles & vesicles	Microvilli

Mitotic cell cycle

Interphase:

G1 Phase : It takes about 10-12 hrs (Growth and normal metabolic activity)

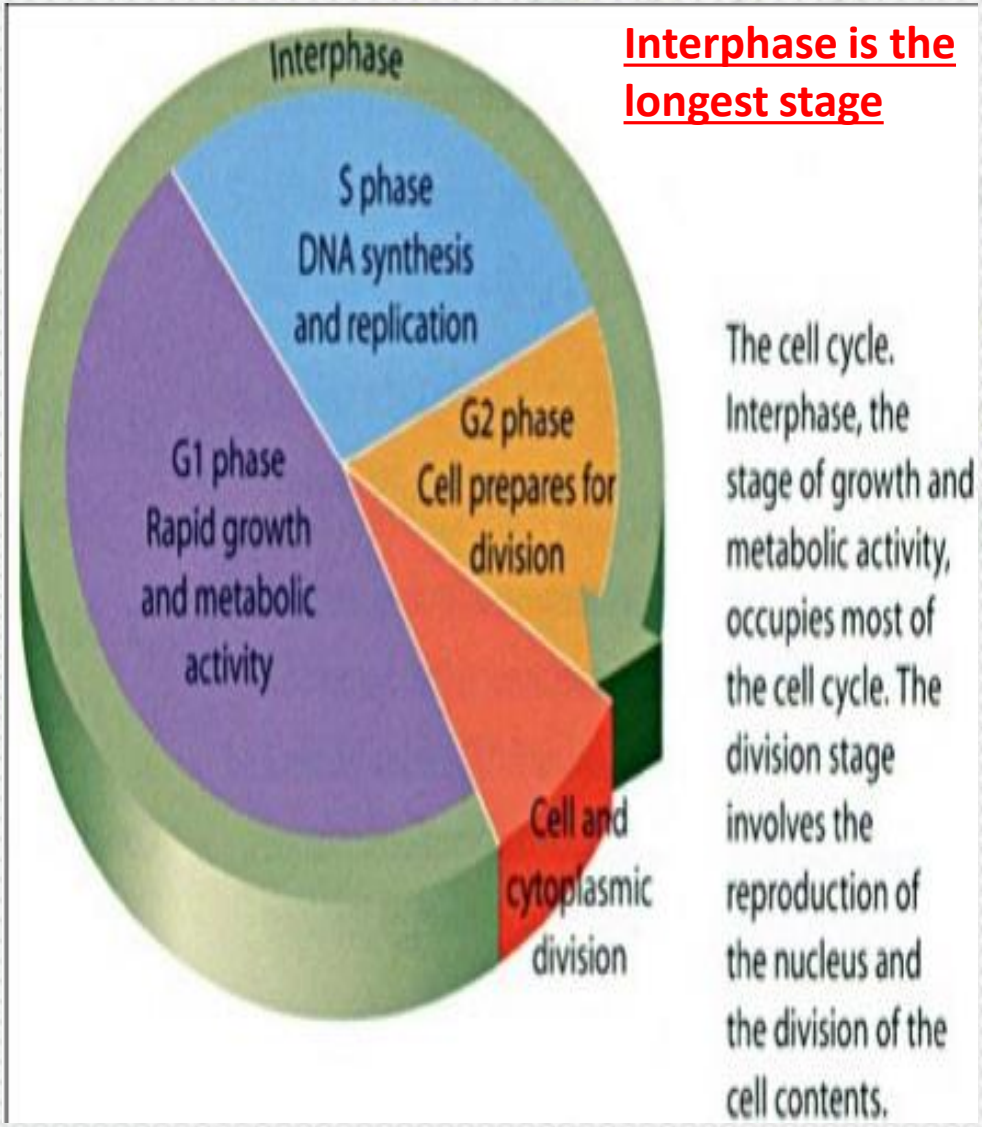
S Phase : It takes about 6-8 hrs (DNA replication)

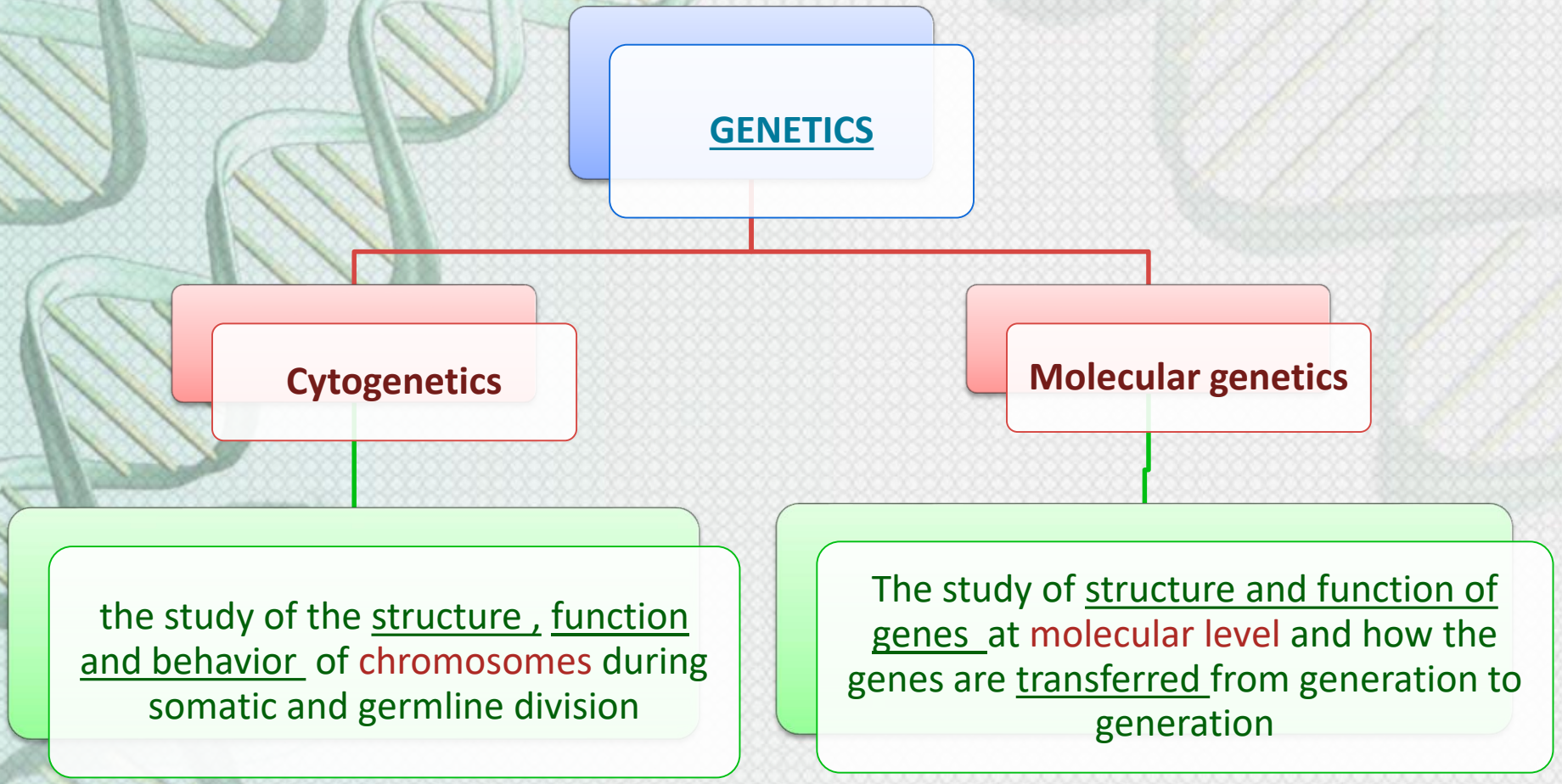
G2 Phase : It takes about 2-4 hrs (Preparation for mitosis)

Mitotic Phase :

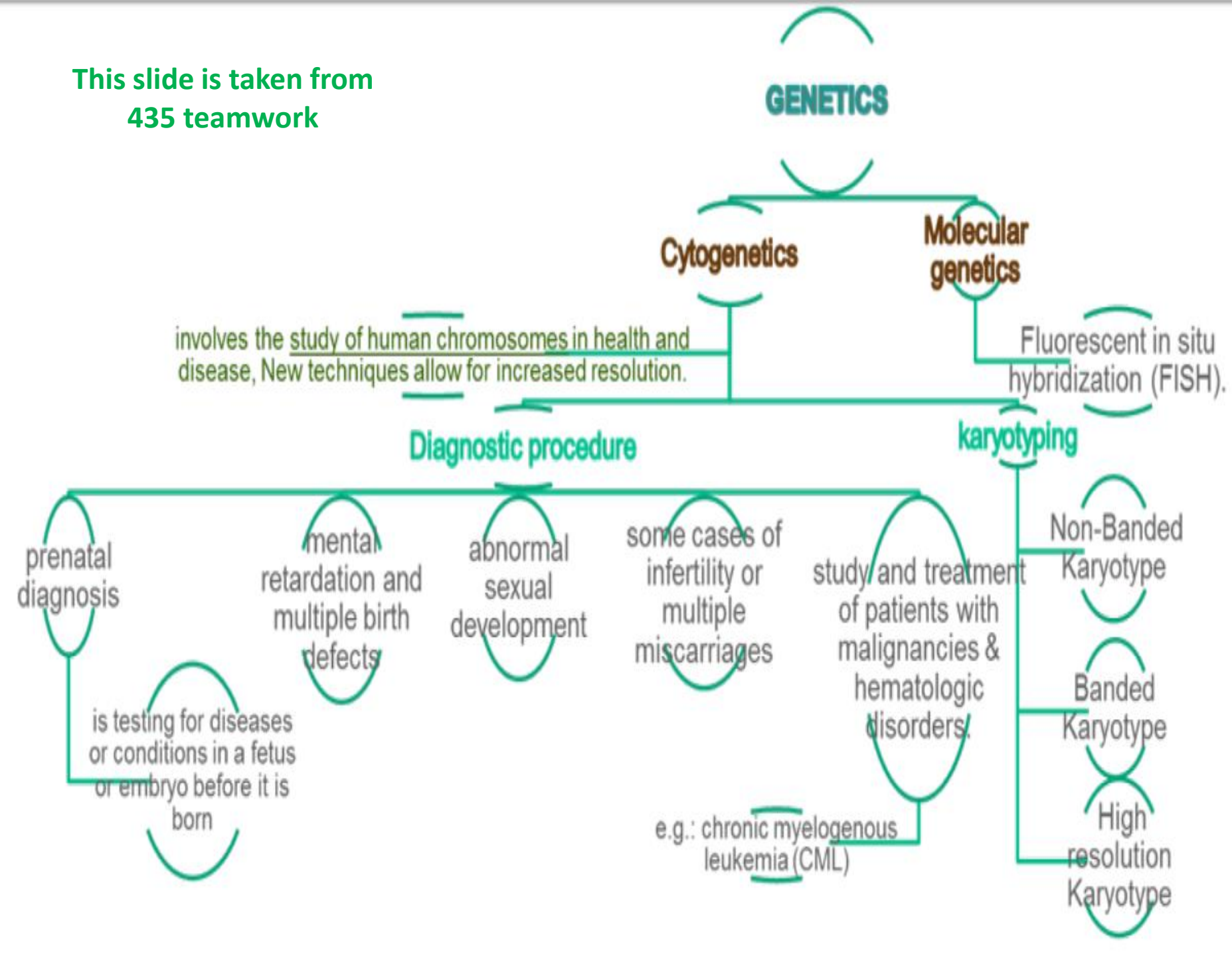
Prophase, Metaphase, Anaphase and Telophase

Interphase is the longest stage




GENETICS
Cytogenetics
Molecular genetics
the study of the structure , function and behavior of chromosomes during somatic and germline division
The study of structure and function of genes at molecular level and how the genes are transferred from generation to generation

This slide is taken from
435 teamwork

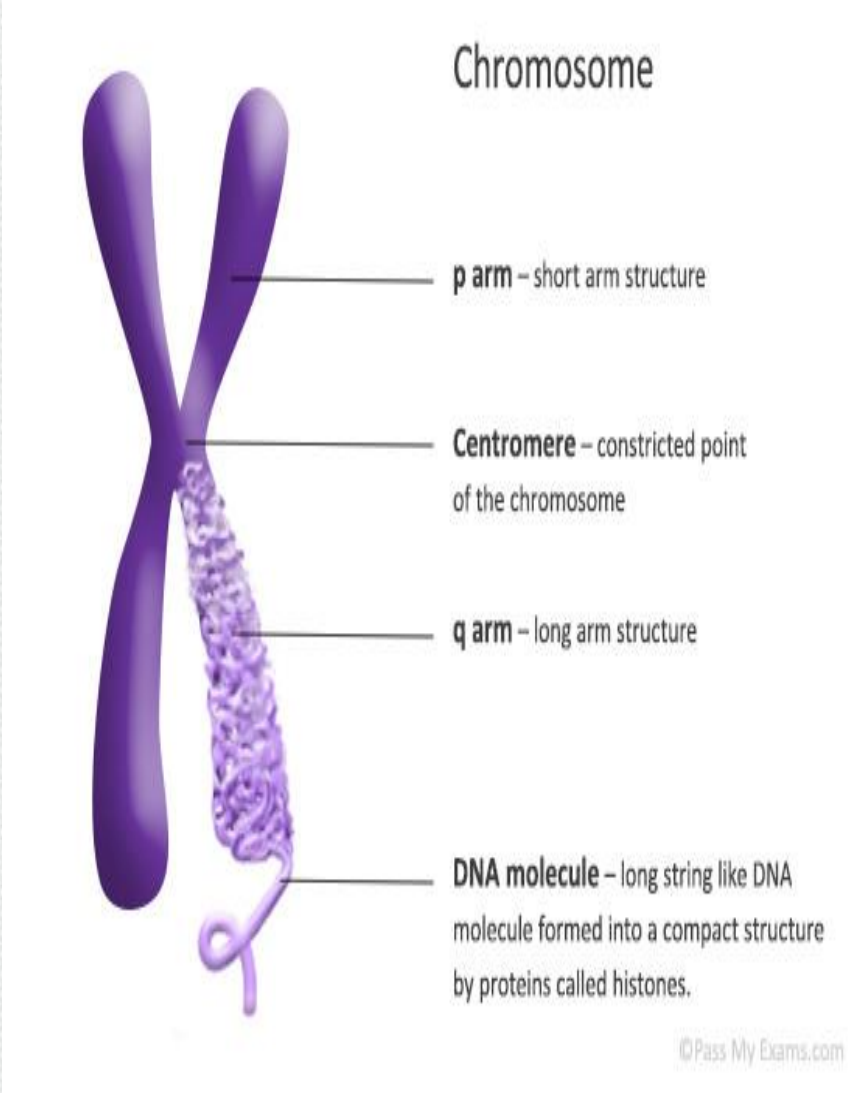


Chromosomes:

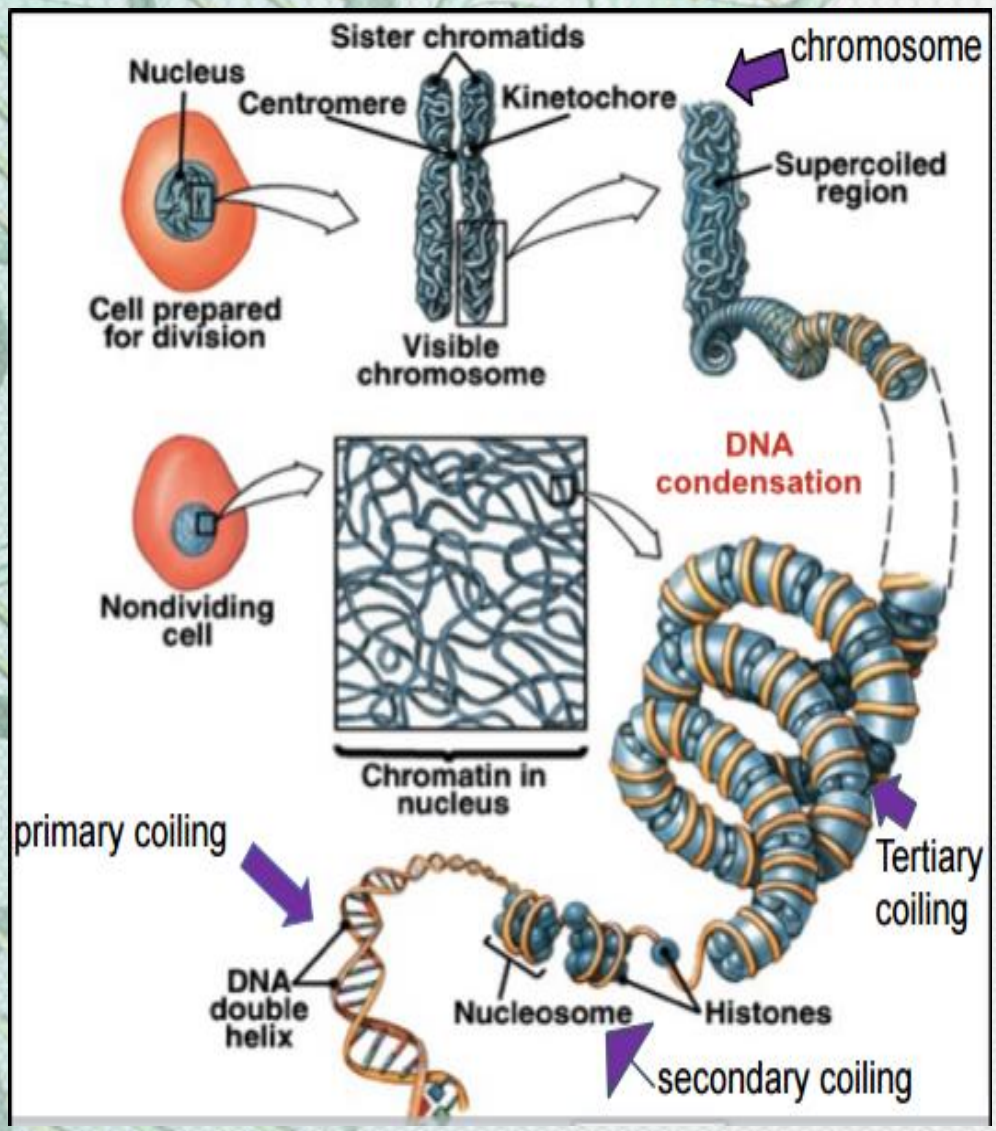
1- carry genetic material (On the form of DNA)

2-heredity: each pair of homologues consists of one paternal and one maternal chromosome

3- The intact set is passed to each daughter cell at every mitosis



Structure of chromosomes



Order of DNA coiling and folding :

1-Primary coiling: DNA double helix.

2-Secondary coiling: around histones (basic proteins) nucleosomes

3-Tertiary coiling: chromatin fiber -Chromatin fibers form long loops on non-histone proteins tighter coils chromosome.

***folding the protein makes it active**
***The histones are positively charged**
*** the DNA is negatively charged**

Chromosomal classification

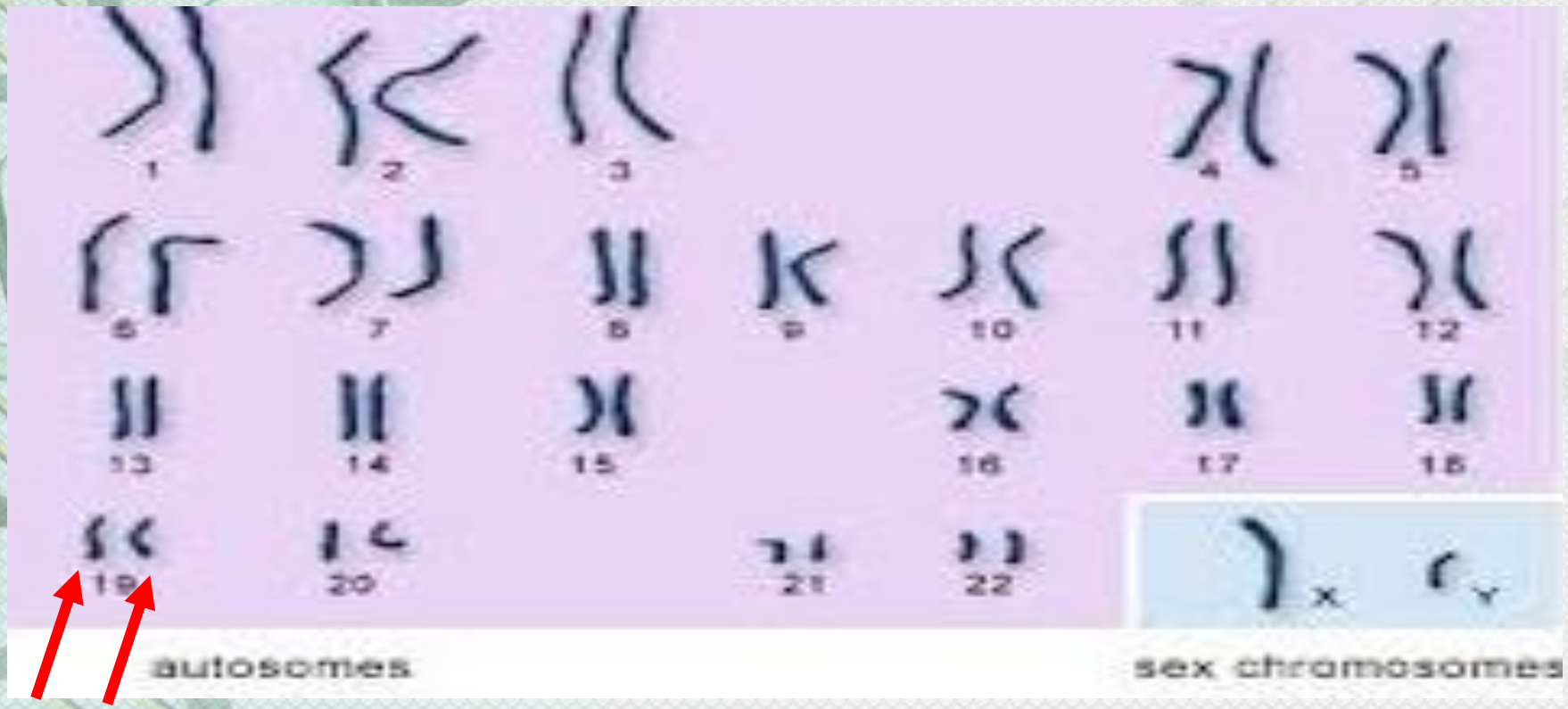
22 pairs of autosomes, numbered from1 to 22 by order of decreasing length

1pair of sex chromosomes :

- XX in female
- XY in male

karyotype

The number and appearance of chromosomes in the nucleus of a eukaryotic cell



These are pair of homologous chromosomes :

*** One from the father and one from the mother**

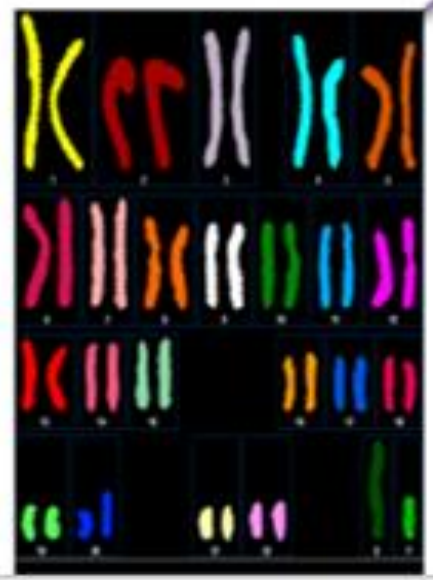
***They have the same genes arranged in the same order**

*** Slightly different DNA sequences**

Spectral karyotype:

The preparation and study of karyotype is part of cytogenetic

It contains 23 pairs of homologue chromosomes:



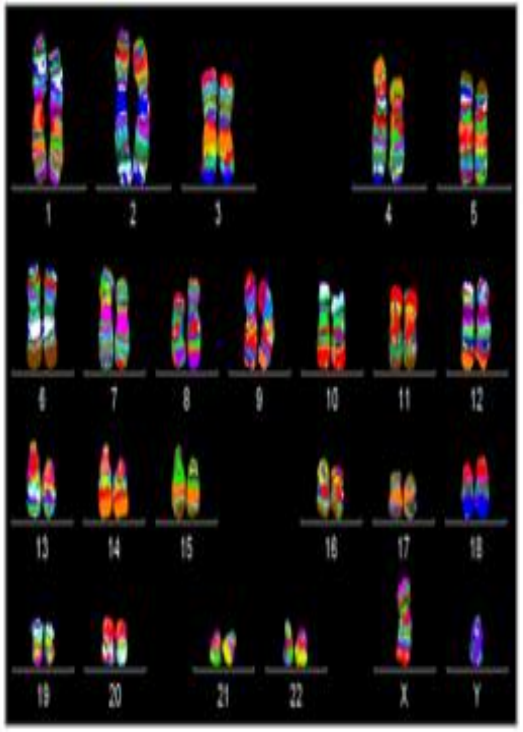
Karyotype: describe the chromosomes, attention is paid to their

- Presence or absence of Satellites
- Position of centromere
- Length

- One strand of the pair comes from the mother 'maternal' and one from the father 'paternal'
- The intact set is passed to each daughter cell at every mitosis.

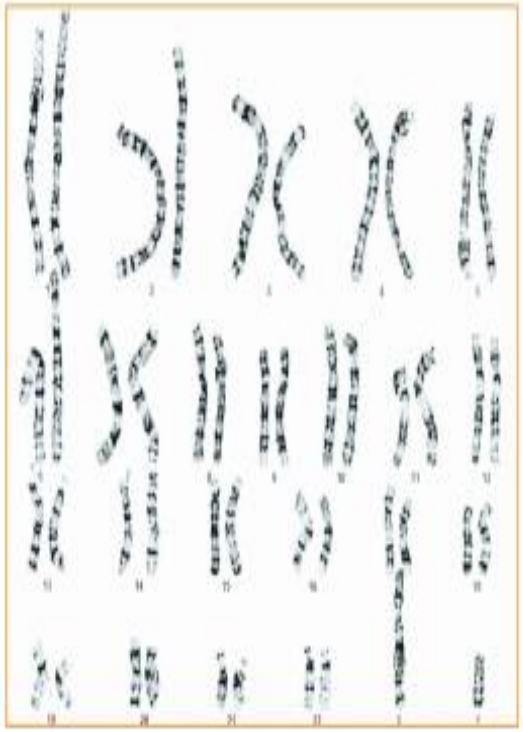
This slide is taken from 434 team work

High resolution Karyotype



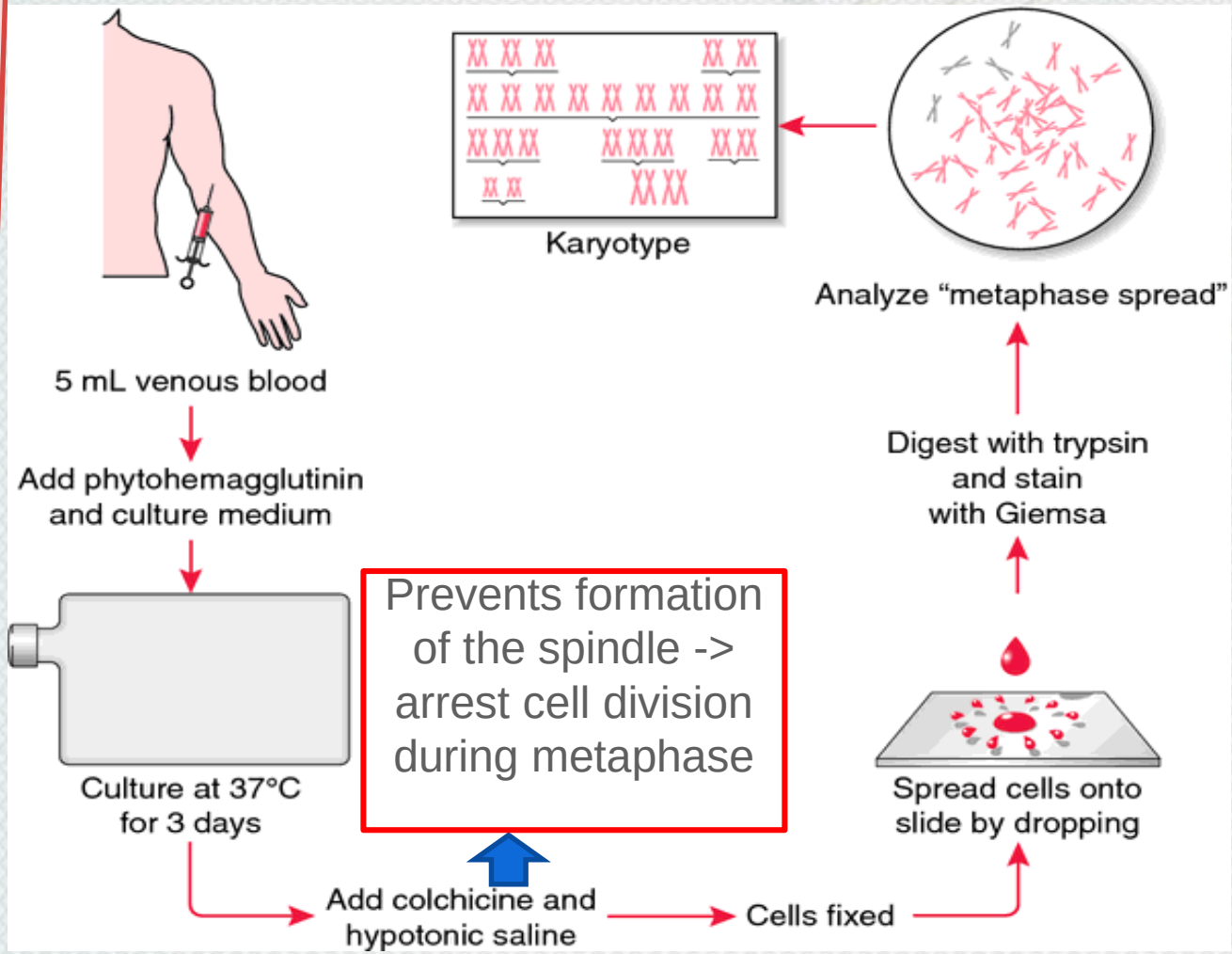
Non-Banded Karyotype

Banded Karyotype



Procedure of Chromosome Preparation from Peripheral Blood

Visual Demonstration For Karyotyping:
https://youtu.be/7ShPzzrCetE

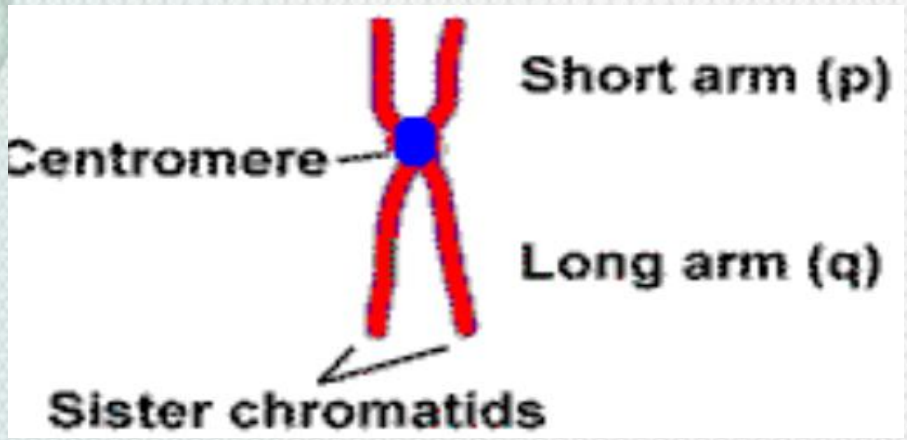


Culture media contains Phytohemagglutinin to stimulate T lymphocytes to divide

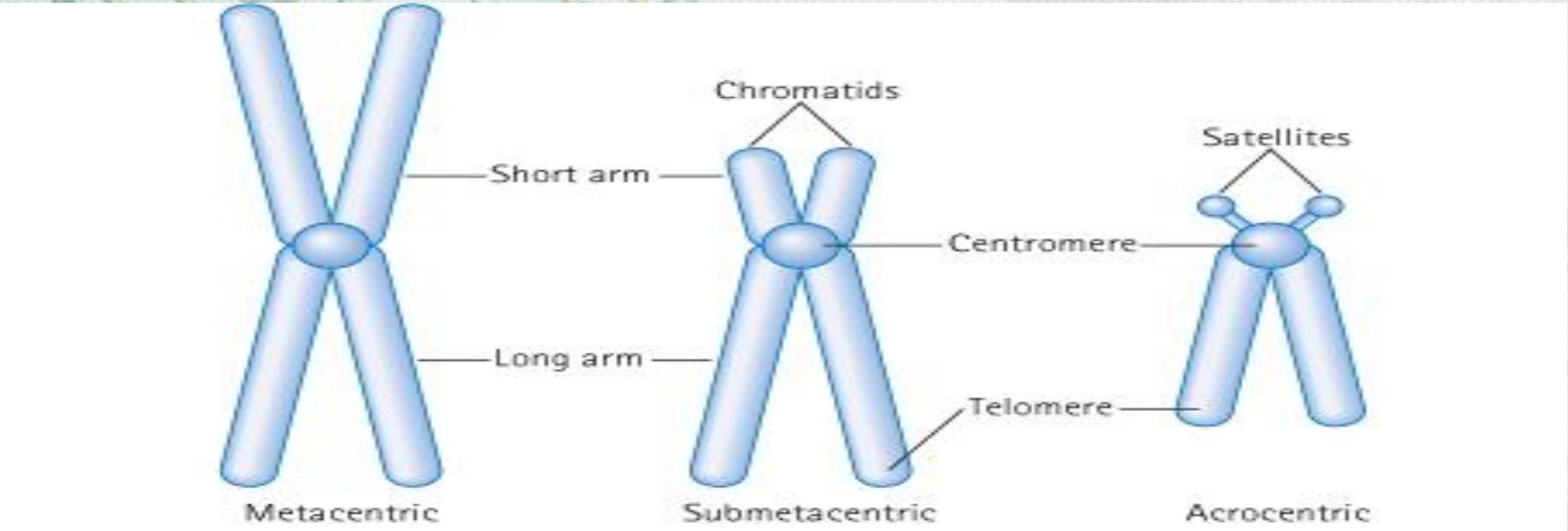
Prevents formation of the spindle -> arrest cell division during metaphase

Metaphase chromosomes:

- The 2 sister-chromatids are principally held together at the centromeric region.
- Each chromosome has a centromere (CEN), region which contains the kinetochore,
- CEN divides the chromosome into two arms: the short arm (p arm) and the long arm (q arm).
- Each arm terminates in a **telomere.**



Centromeric position and arm length:



The ratio of the lengths of the two arms is constant for each chromosome.

This ratio is an important parameter for chromosome identification and allows classification of chromosomes into several basic morphologic types:

i-metacentric ii-sub-metacentric iii-acrocentric

In the human karyotype chromosome pairs 13, 14, 15, 21, 22 are acrocentric

Chromosomes Banding

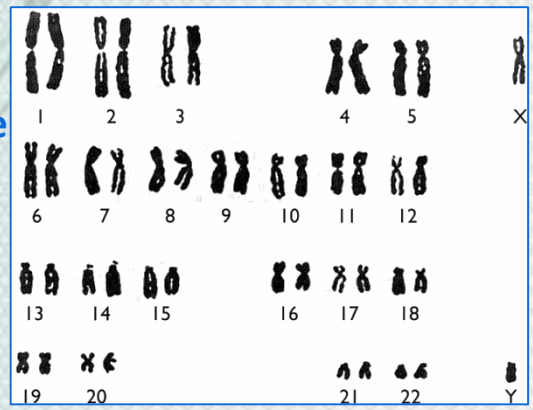
Banding is using certain "staining techniques" to make the chromosome take on a banded appearance (each arm presenting a sequence of dark and light bands)

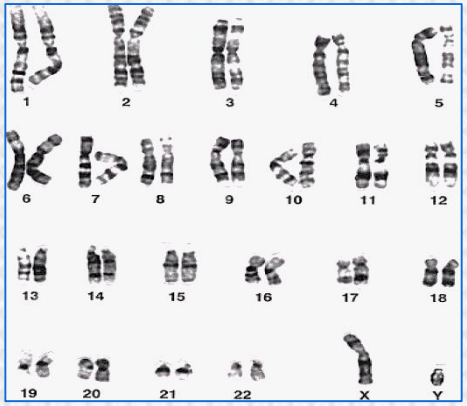
Why is banding important?

It allows accurate identification of the chromosomes and accurate longitudinal mapping

And that's is to: locate gene positions and characterize structural changes (helps us in identifying the location of the gene and if there are any abnormalities such as chromosome breakage, loss, duplication or translocation

Non-banded karyotype (no bands)





Banded karyotype (we can see dark and light bands alternating)

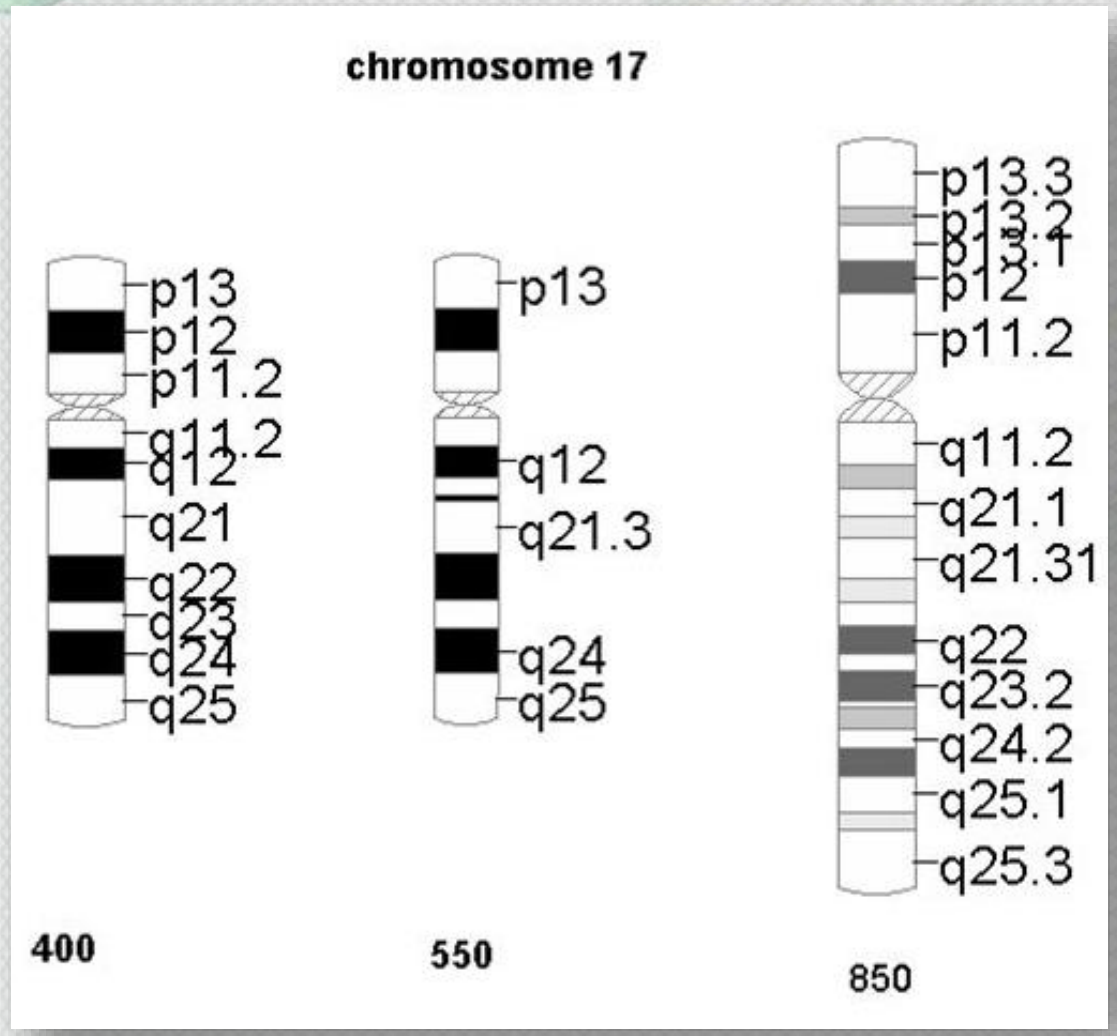
Chromosome Banding (continued):

Banding resolution

=

estimate number of light and **dark** bands per haploid set of chromosomes

400 → 850+

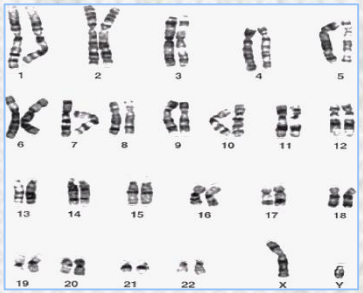


(in the picture the same chromosome with different resolutions)

Different protocols for banding:

G- Banding

Treat with trypsin then with Geimsa stain



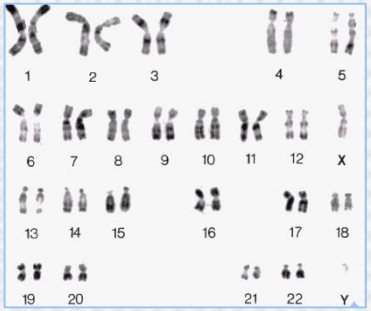
G-banding karyotype for a normal male

R- Banding

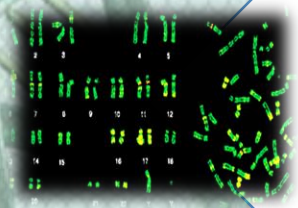
Heat then treat with Geimsa stain

To remember: R-banding bands are Reversed to G-banding bands (light in place of dark)

We notice reversed light and dark bands between G and R banding



R-banding karyotype for a normal male



Q- Banding

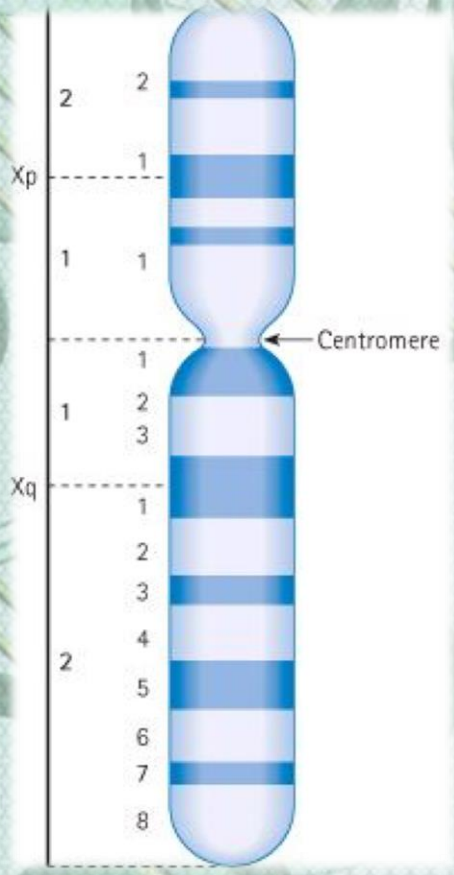
Treat with Quinicrine dye giving rise to florescent bands. It requires an ultraviolet fluorescent microscope

C-banded chromosomes for a female
(shows centromere darkness)

C- Banding

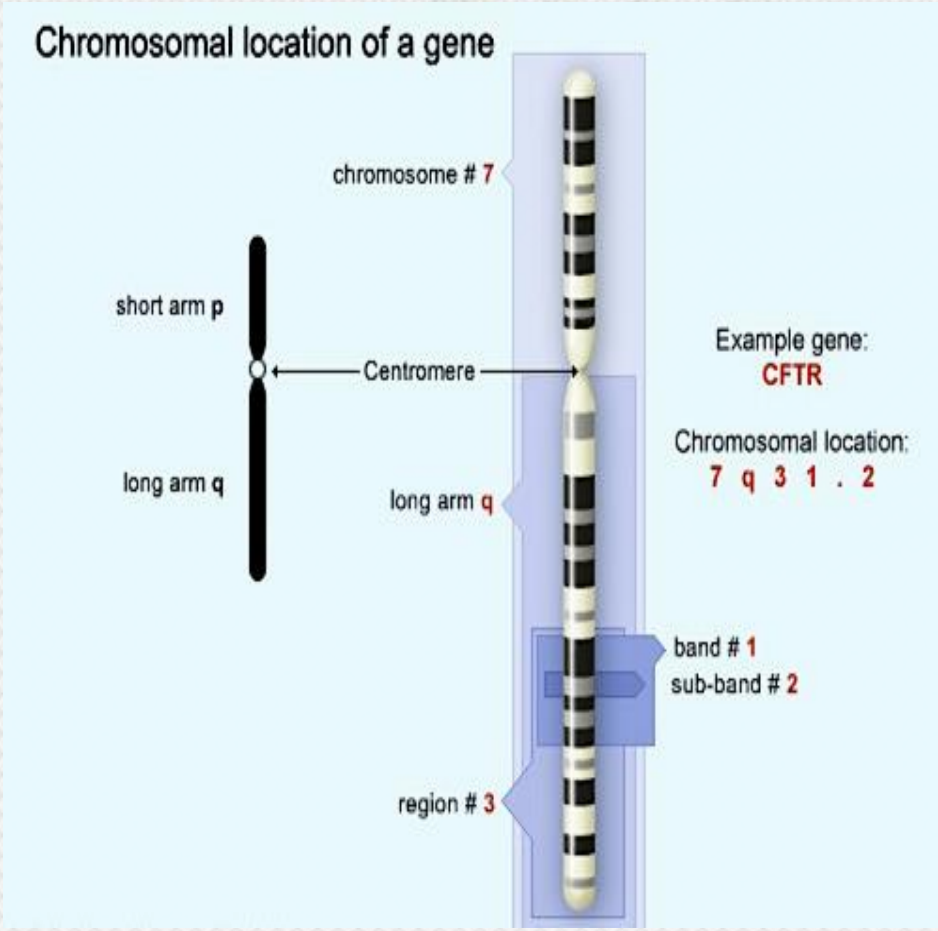
Staining of the centromere. Treat with acid followed by alkali prior to G banding

Nomenclature



An "X" chromosome showing the short and the long arms (p and q) each subdivided into **regions** and **bands**

Example of chromosome 7
(good picture for understanding)

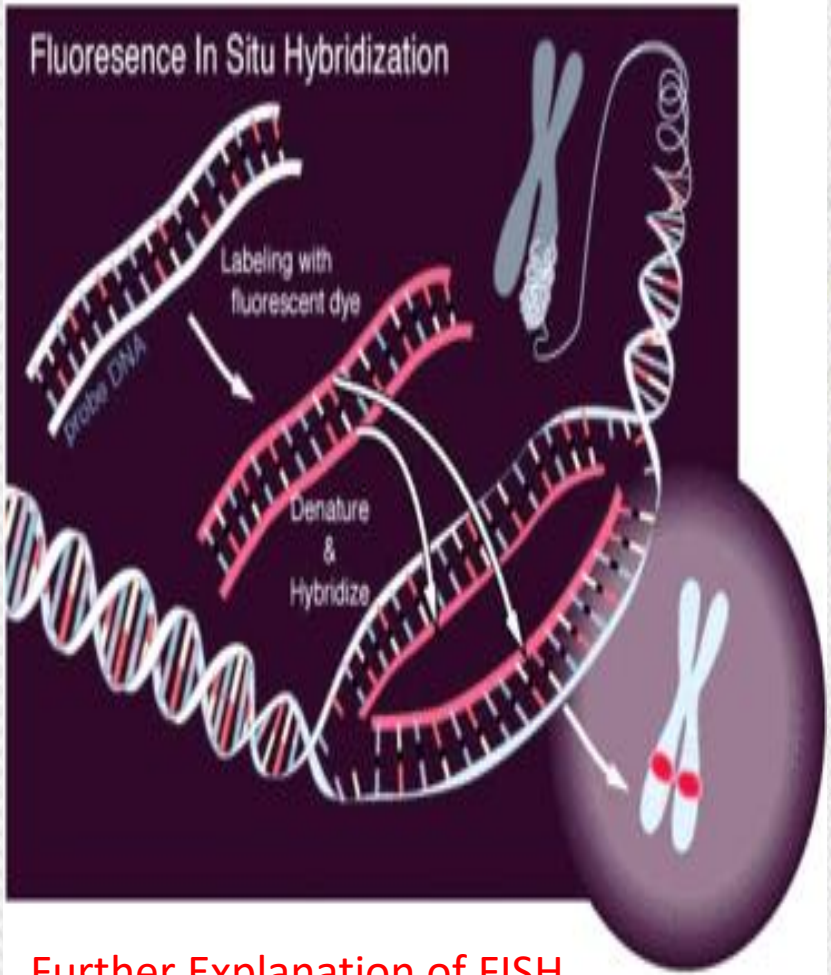


Remember that:

- **For each chromosome, patterns are specific and repeatable**
- **Patterns and nomenclature for defining positional mapping have been standardized**

fluorescent in situ hybridization (FISH)

- *FISH is a cytogenetic technique where a chromosome is labeled with fluorescent tag to create a probe (a fragment of DNA or RNA which is radioactively labeled) this probe will only hybridized with a complementary DNA sequence from the patient's chromosome . the probe will mark the segment being tested , Which can be visualized under a fluorescent microscope .*
- *FISH can be applied to detect genetic abnormalities such as characteristic gene fusions, deletions , translocations , aneuploidy .*
- They can be used to study chromosomes in metaphase or interphase.

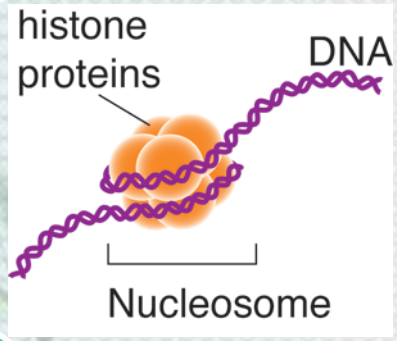


Further Explanation of FISH
https://youtu.be/w5l5SmKvS1o

Summary

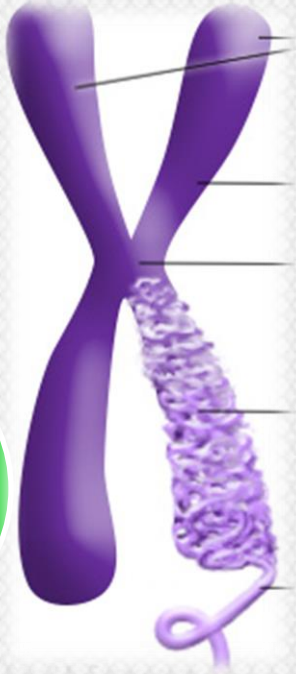
DNA
double helix

Nucleosomes



Long loops work as tighter

Chromatin fibers



coils

Chromosome


Karyotype steps
1
Culturing
2
Harvesting
3
Slide making
Phytohemagglutinin to stimulate T lymphocytes to divide
Banding and staining
Karyotyping Based on
Chromosomes analysis
Length:
Position of centromere
Presence and absence of satellites
metacentric
sub-metacentric
acrocentric
Normal
46, XY/46,XX
Abnormal
47, XY +21 /45, XY,t(D;G)
R
Heat
Geimsa stain
G
Trypsin
Geimsa stain
Q
Quinicrine dye
Ultraviolet Fluorescent microscope
C
Staining of centromere
Acid followed by alkali prior

Online Quiz !

- https://www.onlinequizcreator.com/human-genetics-1/quiz-219352

Thank You !

Girls team:

- Jumana Alghtani (Leader)
- Haifaa Saud Bin Taleb
- Dania Alkelabi
- Nada Alsomali
- Leen Altamimi
- Nora Almohideb

Boys team:

- Abdulrahman ALrajhi (Leader)
- Abdulmohsen Alghannam
- Abdulmalik Alghannam
- Saleh Altwaijri
- Abdullah Alharbi

@HGteam46

Email: humangenetics436@gmail.com