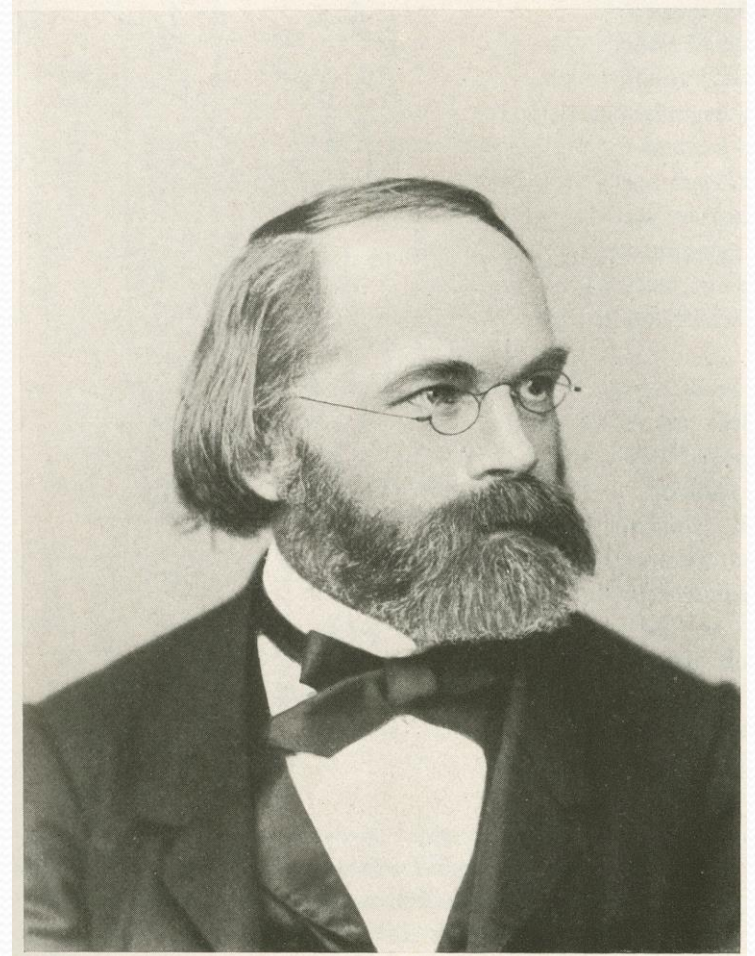


Zoo-352 Principles of genetics
Lecture 2

Chromosomes

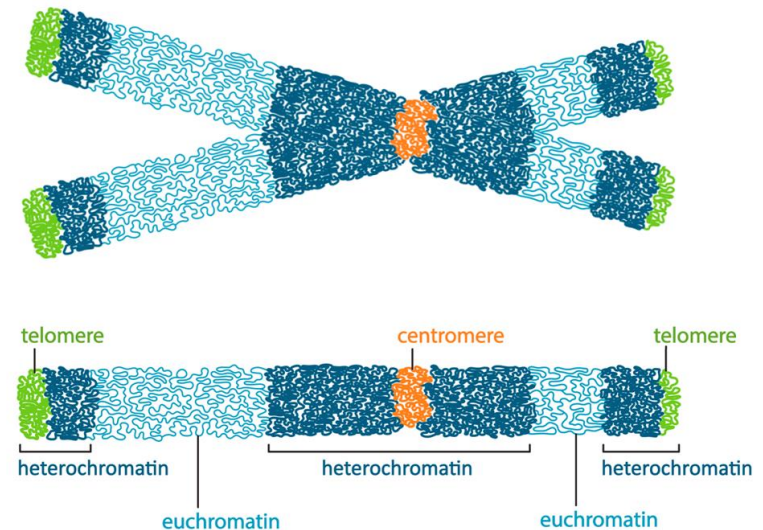
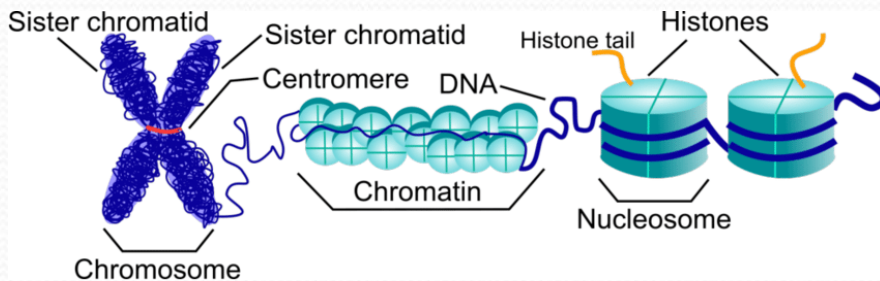
Chromosomes:

- Chromosomes were discovered by **Von Nageli** in 1842 after staining techniques were developed that made them visible in plant cells.
- The term chromosome means the colored body.

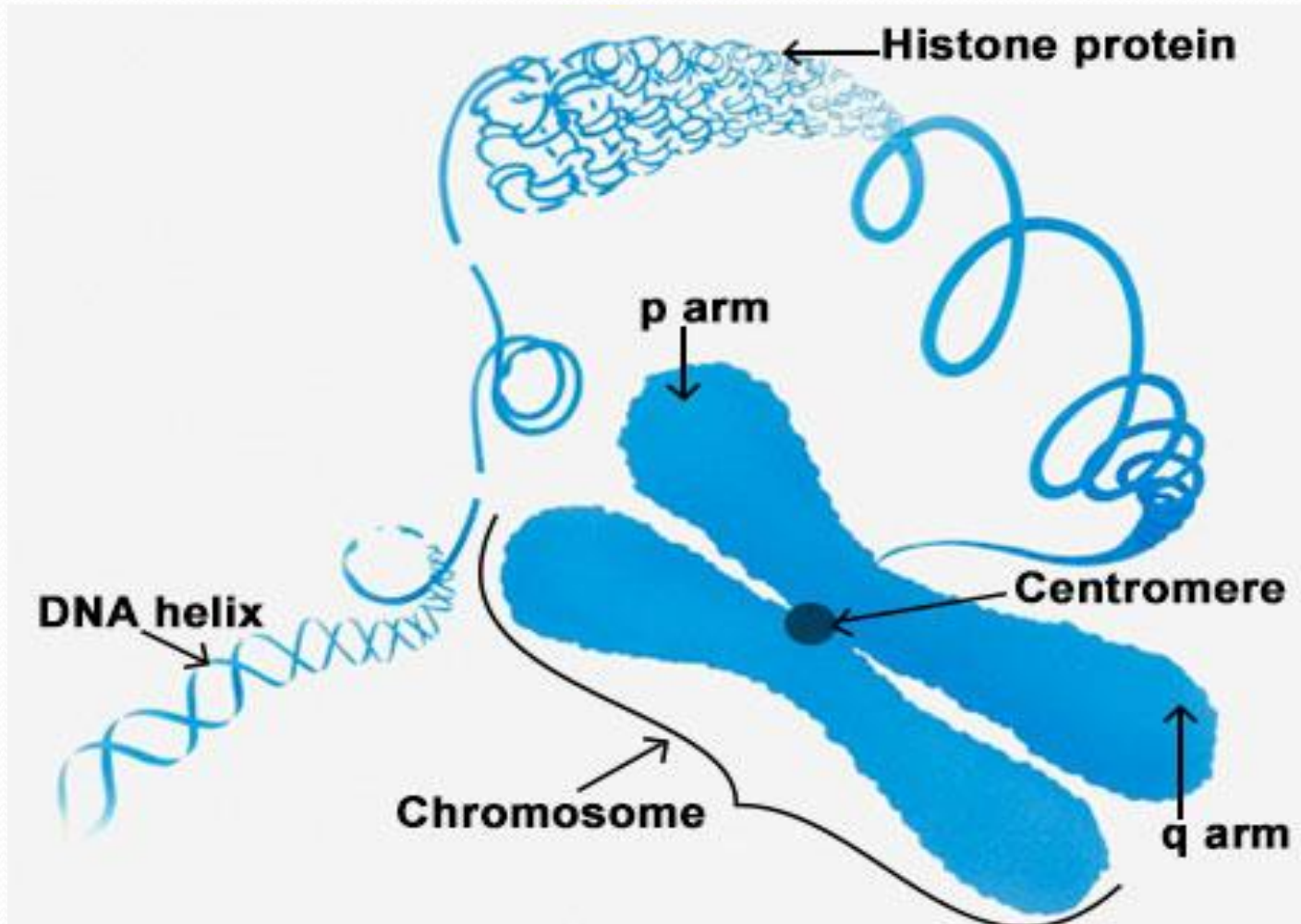


Chromosome structure:

- Linear eukaryotic chromosomes are composed of a complex of **double-stranded DNA** and **protein (histones)**, which is referred to collectively as **chromatin**.
- **DNA (negatively charged) + Histones (positively charged) (H2A, H2B, H3 and H4 = Nucleosome)**. H1 **links** two nucleosomes together.
- Many nucleosomes form a **chromatin**, chromatin further wrapped up around another protein producing a **chromosome**.
- Chromatin has two forms:
 1. **Euchromatin**: **unpacked** chromatin and genetically **active**. **Light** stained area
 2. **Heterochromatin**: **packed** chromatin and genetically **inactive**. **Dark** stained area (condensed).



Structure of chromosome



Chromosome structure:

- The location of the centromere often divides the chromosome into two parts that are referred to as the short arm (**p arm** for petite) and the long arm (**q arm**).
- A **telomere** is a region of repetitive nucleotide sequences at each end of a chromatid, which protects the end of the chromosome from degradation or from fusion with neighboring chromosomes.

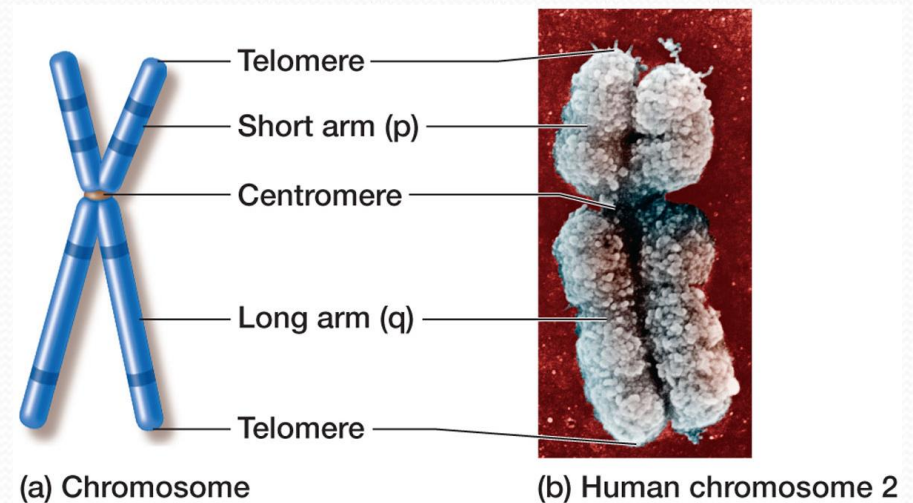


Figure: Schematic of Submetacentric chromosome (a) and an electron micrograph of human chromosome 2 (b).

Telomere



Light (G) bands

Less condensed chromatin (Euchromatin)



Centromere

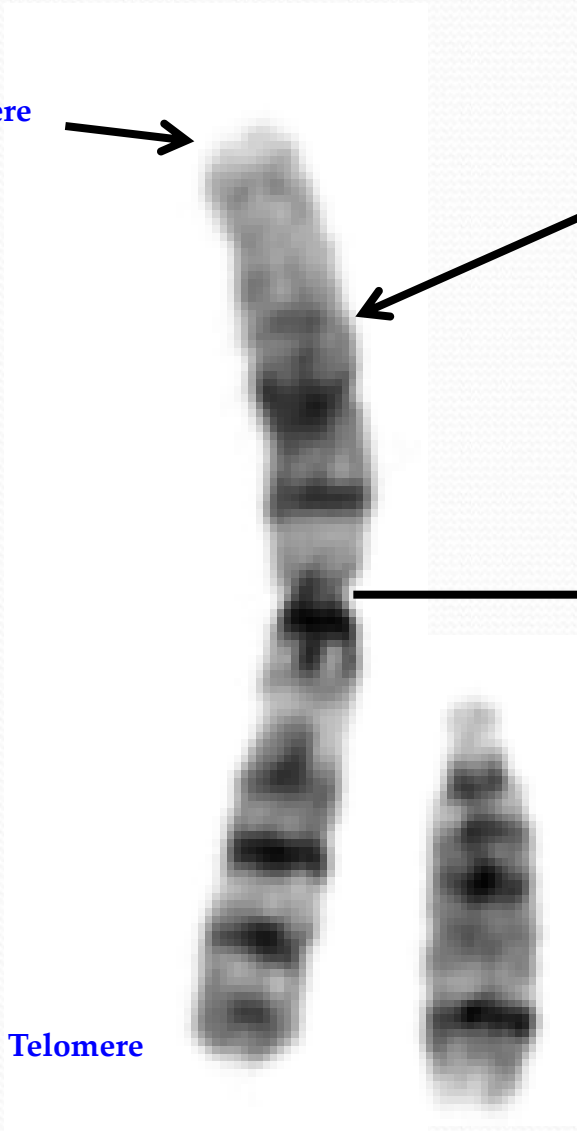
Joins two sister chromatids together



Telomere

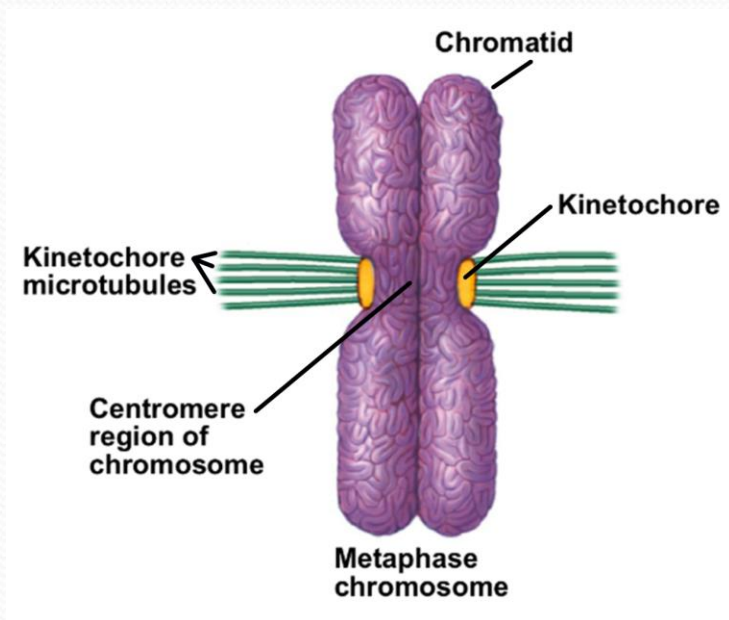
Dark (G) bands

Contain condensed chromatin (Heterochromatin)



The structural concept for the classification of chromosomes:

- Chromosomes are classified by the location of their spindle attachment point, which have distinct positions.
- The attachment point occurs at a construction in the chromosome termed the **centromere**.
- Centromere is composed of several specific DNA sequences.
- The **kinetochore** is the proteinaceous structure on the surface of the centromere to which the spindle microtubules attach.
- The **centromere** and the **kinetochore** are structural units that are essential for mitosis and meiosis.



Classification of chromosomes:

- Chromosomes can be classified according to the location of the centromere as bellow:

1. **Metacentric chromosome:** The centromere is in the middle of the chromosome. Human chromosome 1 - 3, 16, 19 and 20.
2. **Submetacentric chromosome:** The centromere is located between the middle and the end of the chromosome. Human chromosomes 4 -12 , 17, 18 and X.
3. **Acrocentric chromosome:** The centromere is near to the end of the chromosome. Human chromosomes 13, 14, 15, 21, 22 and Y.
4. **Telocentric chromosome:** The centromere is located at the end of the chromosome. Not exist in human (found in other species such as mice).

Classification of chromosomes

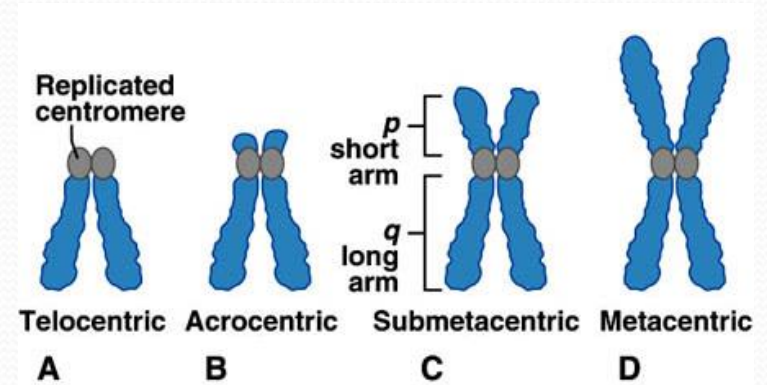
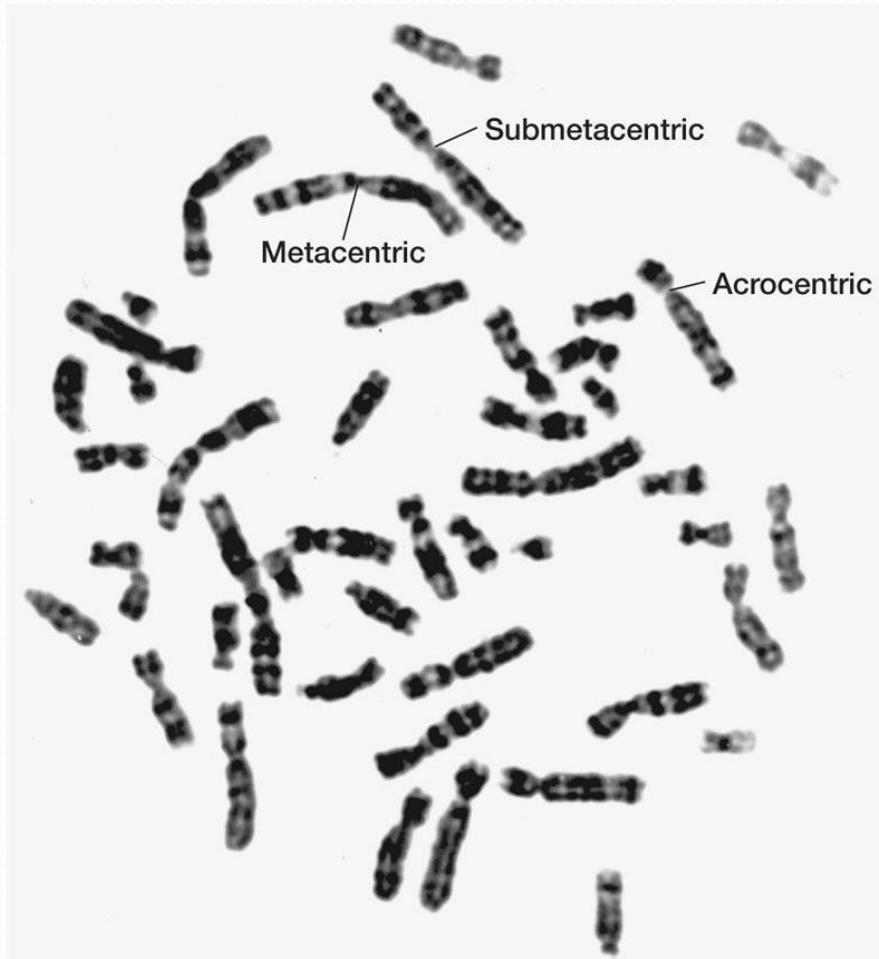


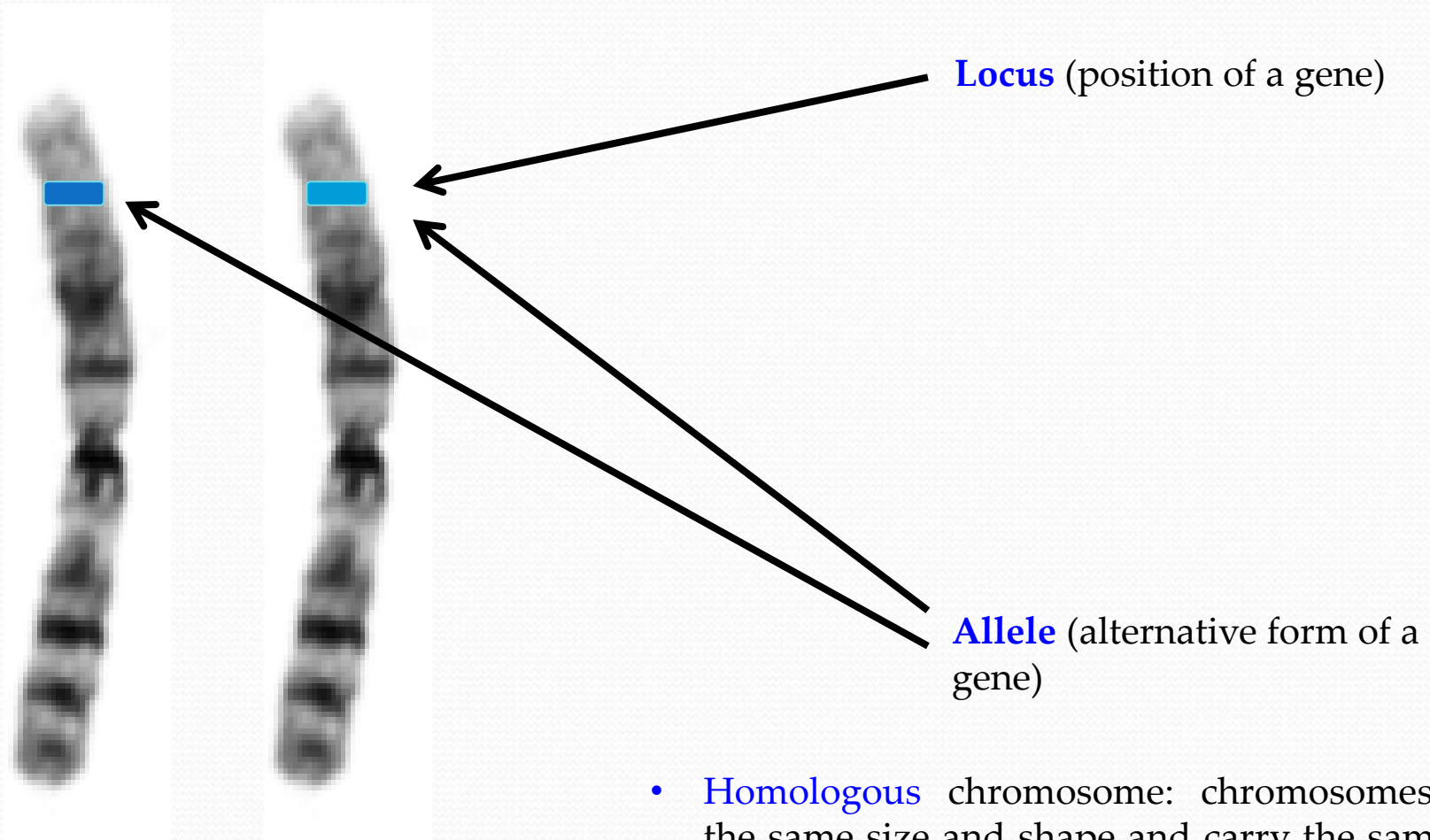
Figure: Metacentric, Submetacentric and acrocentric chromosomes

Chromosome complement:

- Most cells of eukaryotic organisms are **diploid**; that contain two sets of chromosomes. In the diploid state, members of the same chromosome pair are referred to as **homologous chromosome**, or **homologs**. One member of each pair comes from each parent.
- Humans have 23 homologous chromosome pairs, which is often expressed as $2n=46$. This expression indicate that humans are diploid ($2n$) and have a total of 46 chromosomes. The diploid chromosome numbers of several species appear in Table 1.
- **Haploid** cells, which include some eukaryotic organisms and the reproductive cells (gametes), have only one set of chromosomes.
- In humans, Chromosome pair 1-22 are called **autosomes**, determine body trait. The 23rd pair is called **sex chromosomes** (XX is female, XY is male), determine sex.
- **Genes** are arranged in the linear order on chromosome.

Species	$2n$
Human being (<i>Homo sapiens</i>)	46
Garden pea (<i>Pisum sativum</i>)	14
Fruit fly (<i>Drosophila melanogaster</i>)	8
House mouse (<i>Mus musculus</i>)	40
Roundworm (<i>Ascaris</i> sp.)	2
Pigeon (<i>Columba livia</i>)	80

Table 1: Chromosome number for selected species



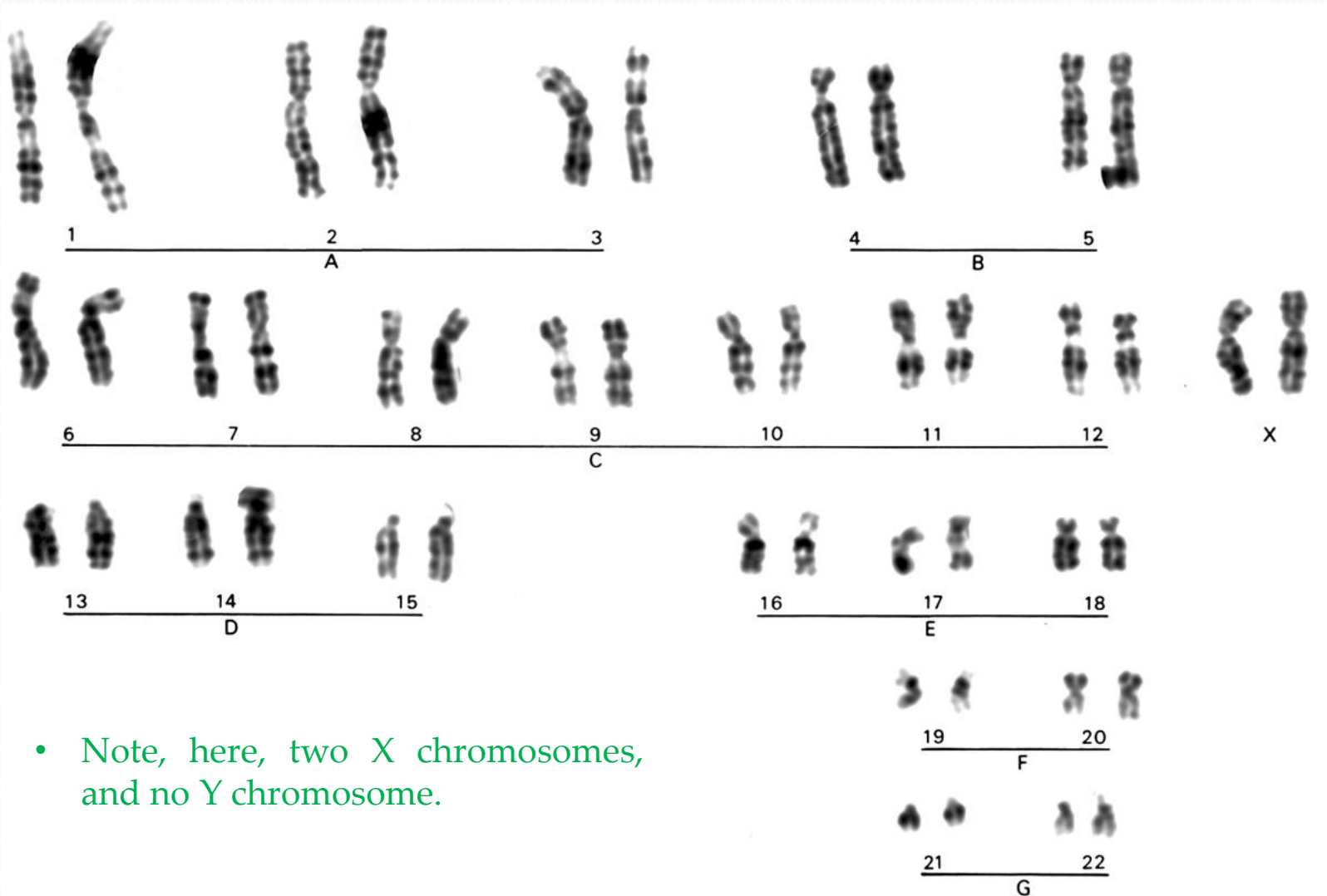
- **Homologous** chromosome: chromosomes have the same size and shape and carry the same type of genes. (With exception of X,Y chromosome).

Figure: A pair of homologous chromosome 1 in humans

Human Karyotype:

- The total human's chromosomes can be photographed during mitosis and rearranged in pairs to make a picture called a **karyotype**.
- From karyotype, it is possible to see whether the chromosome have any **abnormalities** and to identify the **sex** of the individual.
- The chromosome in humans are grouped into categories (A-G, X, Y) based on (**Denver system**):
 1. **their length (size)**
 2. **centromere position** (location) and
 3. **the pattern of dark and light G** (Giemsa) bands.

Karyotype of a human female



- Note, here, two X chromosomes, and no Y chromosome.

Karyotype of a human male



- Human body cells contain 46 chromosomes in 23 pairs.
- Chromosome pairs 1 – 22 are called **autosomes**.
- The 23rd pair are called **sex chromosomes**:

- Note, here, one X chromosome, and one Y chromosome.

Quiz: Chromosome Structure, Karyotypes

1. A human being has autosomes ____ and ____ sex chromosomes:

- 23, 1
- 22 pairs, 1 pair
- 23, 23
- 2, 2

3. Somatic cells of a human have ____ chromosomes and are called ____:

- 10, haploid
- 92, diploid
- 23, haploid
- 46, diploid

2. A section of chromosomes that codes for a trait can be called a (n):

- nucleotide
- base-pair
- gene
- nucleus

4. Each chromosome consists of two identical:

- genes
- nuclei
- chromatids
- bases