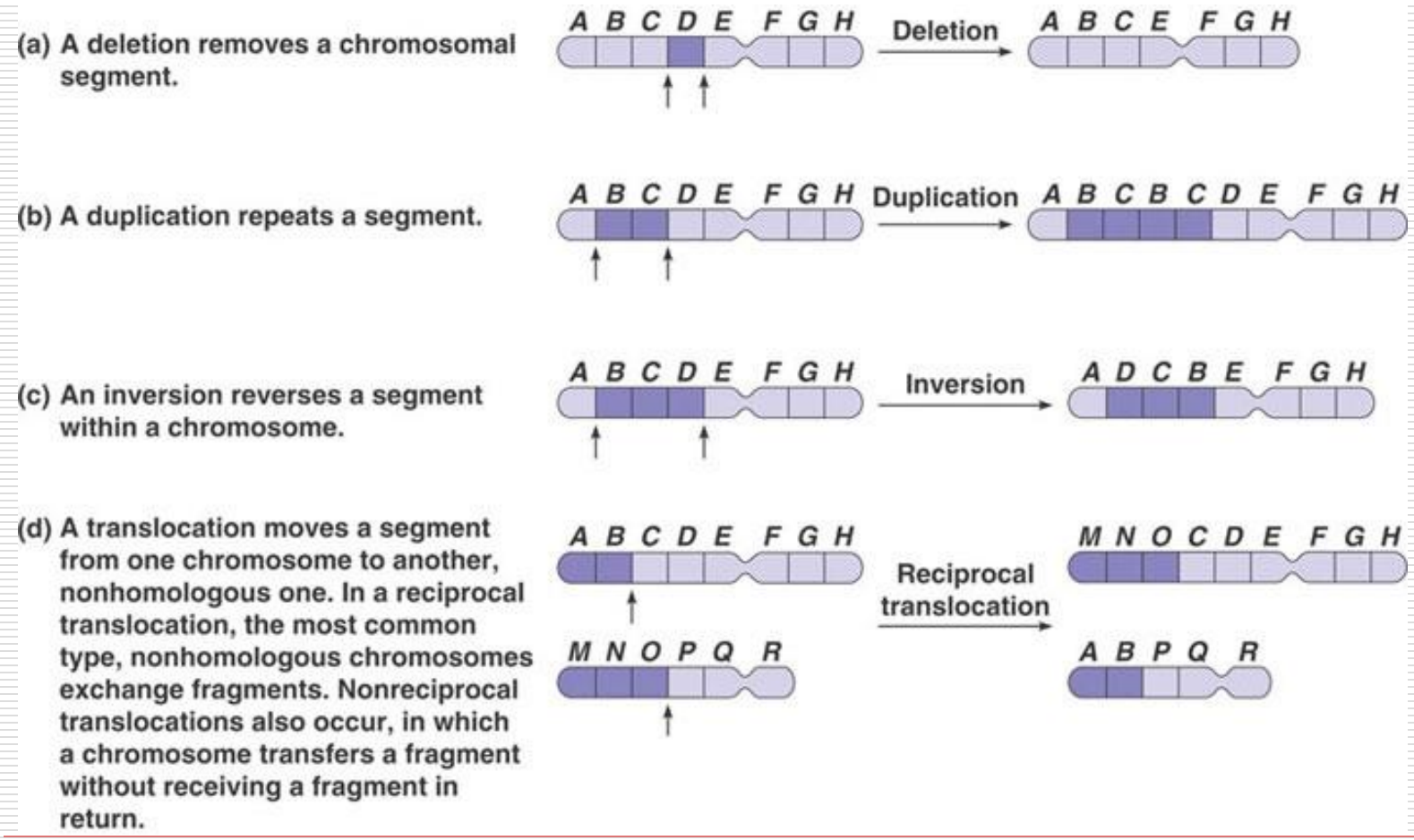
Changes in Chromosomes

- **Changes In Chromosome Structure**
  - Changes in the physical structure of chromosomes can occur:

    1. Spontaneously
    2. As a result of irradiation
    3. After exposure to certain chemicals

Structural Changes in Chromosomes



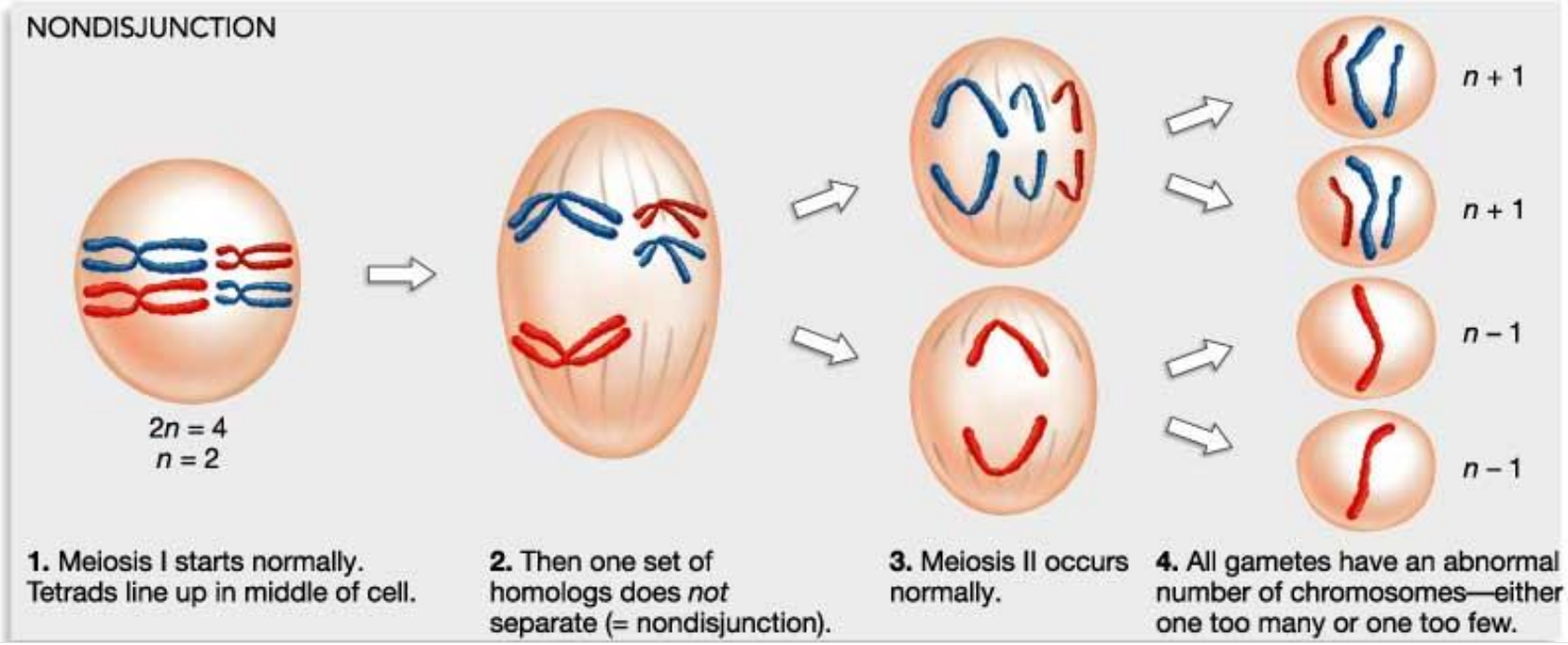
Structural Change & Disorders

- **Deletion**
  - Loss of a piece of chromosome #5
  - Cri-du-chat
  - Affects the larynx making cat sounds
- **Inversion**
  - Some forms of autism
- **Duplication**
  - Duplication in the X chromosome
  - Fragile X syndrome
- **Translocation**
  - Down Syndrome
    - # 14 and 21
  - Lukemia
    - #22 and 9

Nondisjunction

- Sometimes, chromosomes fail to separate from each other during meiosis. This produces gametes (eggs / sperm) which have either too many or too few chromosomes
- If a gamete which does not have the correct number of chromosomes is involved in fertilization, a zygote will be produced which has either too many or too few chromosomes
- This creates an embryo whose cells contain either more or less than 46 chromosomes. These embryos are usually aborted by the mother, but some survive and have genetic disorders

Nondisjunction



Pages 552 – 553 outlines genetic disorders which result from nondisjunction Monosomy, Down syndrome, Turner Syndrome

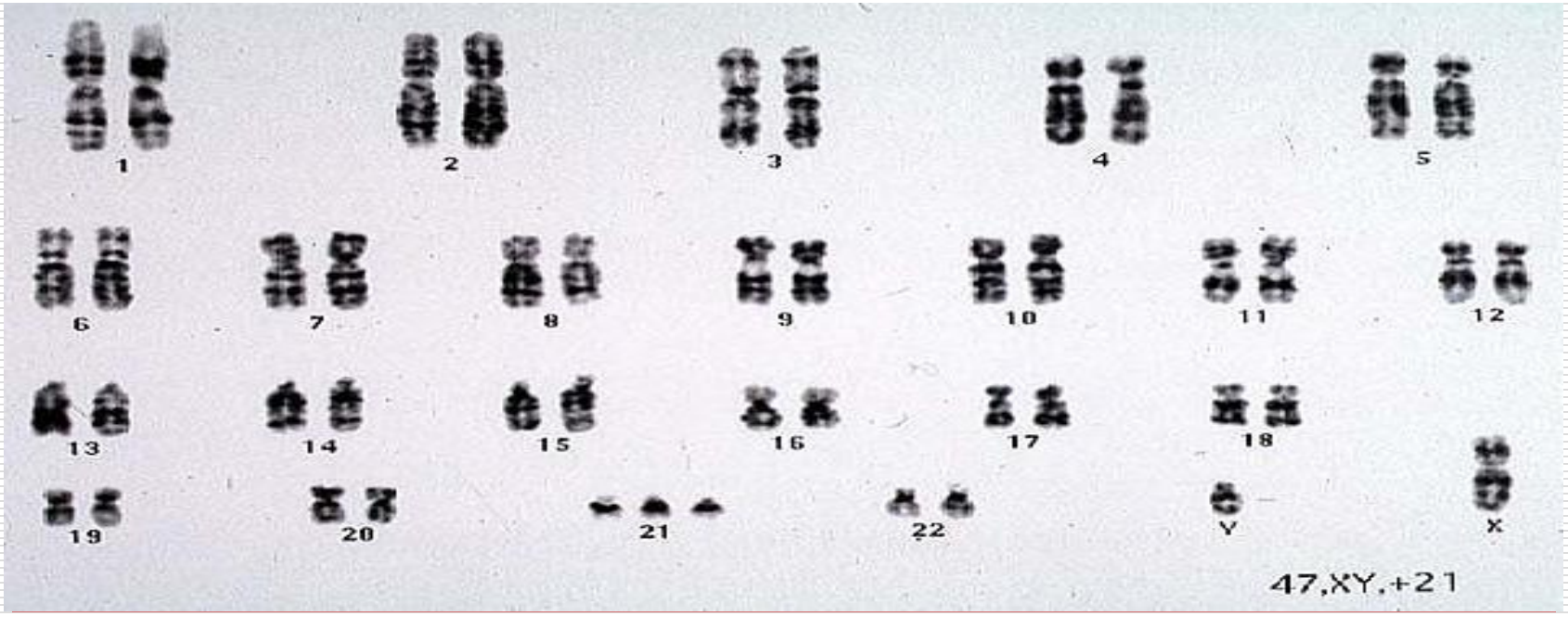
You need to know how each of these disorders arise in an individual for the test as well as the public exam.

Types of Nondisjunction

- **Trisomy** - When an individual inherits an extra chromosome.
- **Monosomy** - When an individual inherits one less chromosome.
- **Three disorders**
  - Down Syndrome
  - Turner Syndrome
  - Klinefelter Syndrome

Down Syndrome (Trisomy 21)

- This occurs when an individual receives three copies of chromosome 21 instead of the normal two.

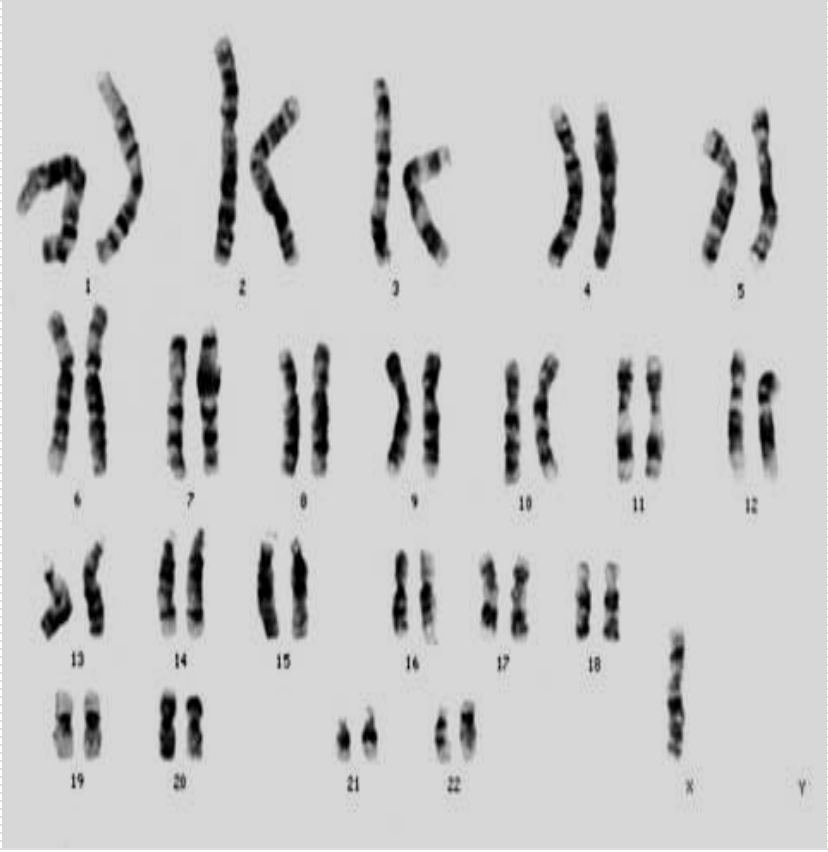


Symptoms of Down Syndrome

- Mild to moderate mental impairment
- A large, thick tongue
- Speech defects
- A poorly developed skeleton
- Short body structure
- Thick neck
- Abnormalities in one or more vital organs

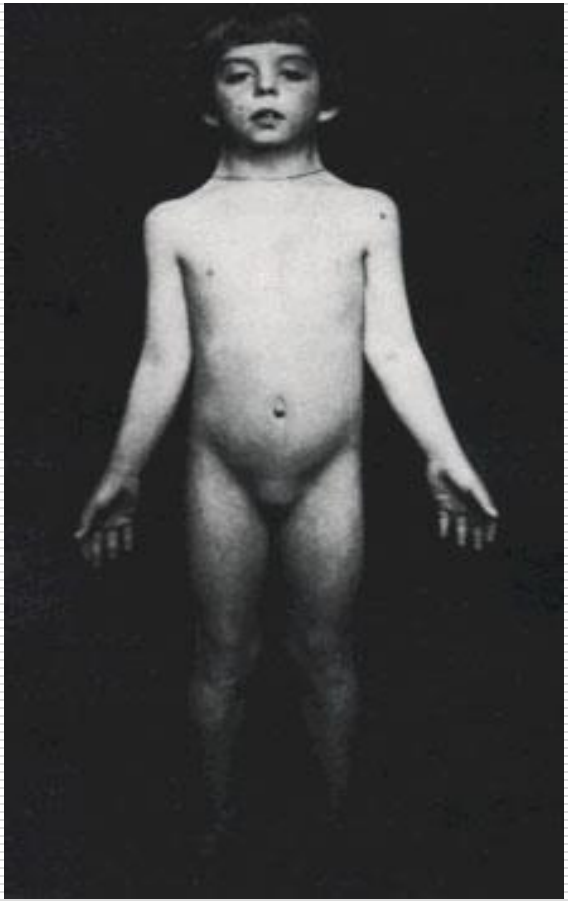
Turner Syndrome

- An individual inherits only a single X chromosome, as well the Y chromosome is missing.
- This results in a female with the genotype XO
  - O represents a missing chromosome



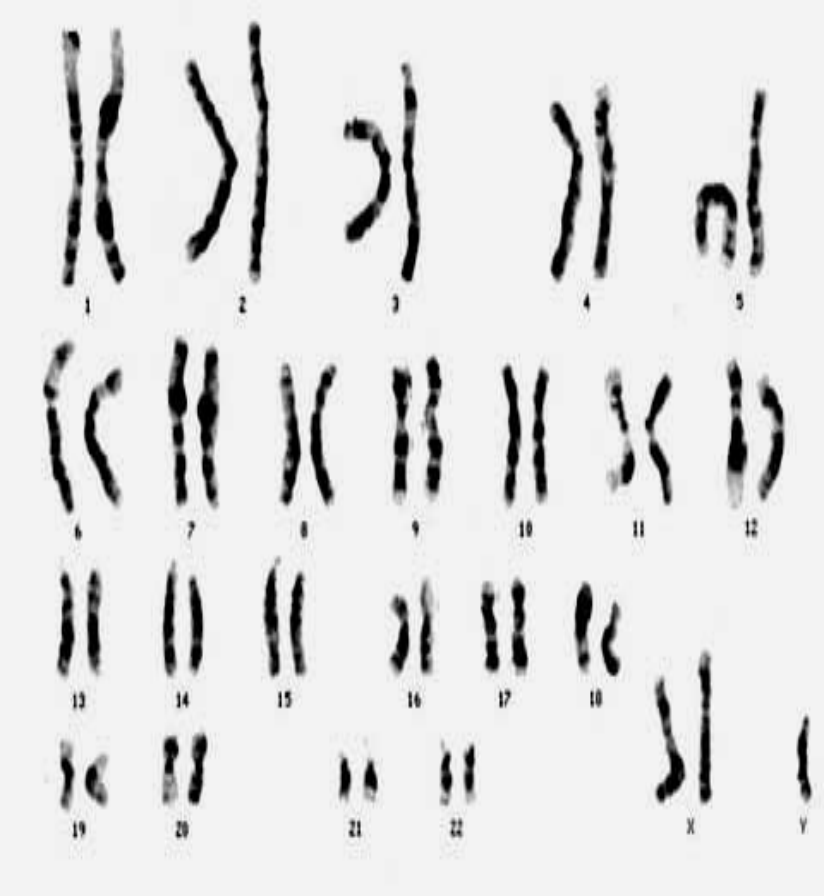
Turner Syndrome Symptoms

- Infertility
- External female genitalia, but no ovaries.
- Webbed neck
- Heart defects
- Kidney abnormalities
- Skeletal abnormalities
- Learning difficulties
- Thyroid dysfunction



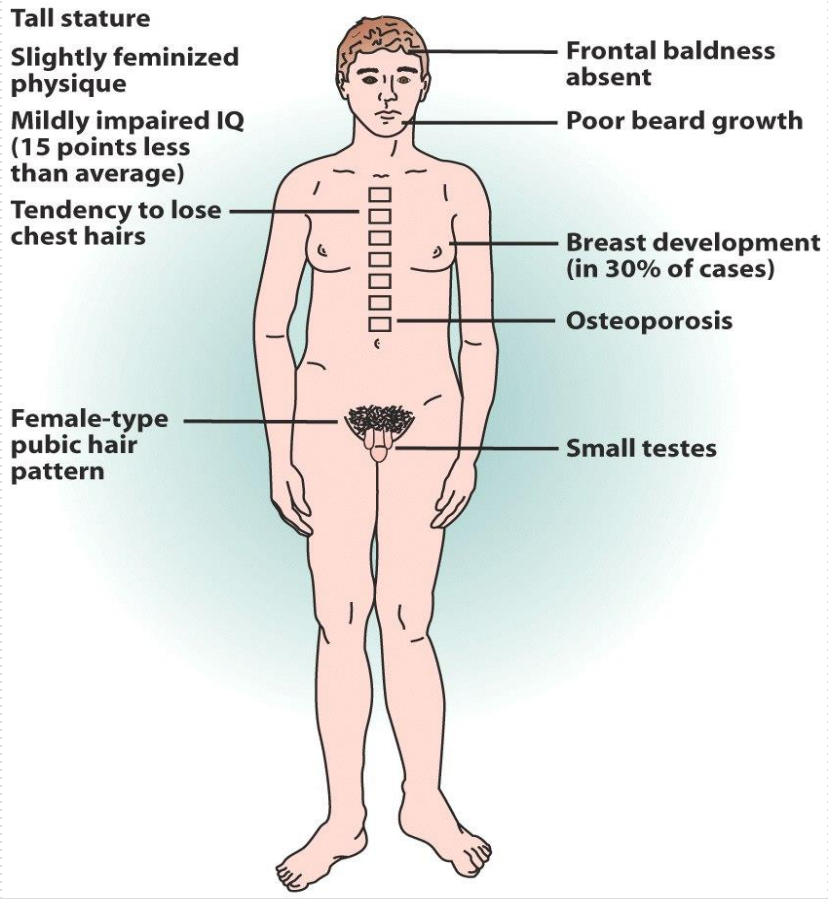
Klinefelter Syndrome

- A male who has an extra X chromosome.
- These individuals have the genotype XXY instead of XY



Klinefelter Symptoms

- Immature male sexual organs
- Lack of facial hair
- Some breast development

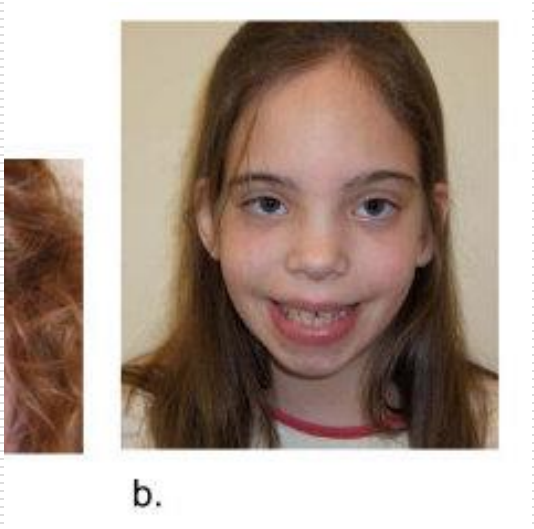


Jacobs Syndrome

- Males with an extra Y chromosome, having the genotype XYY
- Symptoms
  - Speech and reading problems
  - Delayed emotional maturity
  - Persistent acne
- Generally XYY males have normal potency and sexual libido, though in rare cases they may also have Klinefelter symptoms

Triple X

- Females with an extra X chromosome having
- XXX


b.

- Vertical folds of skin that cover the inner corners of the eyes (epicanthal folds)
- Widely spaced eyes.
- Abnormally curved pinky fingers.
- Flat feet.
- Abnormally shaped breastbone.
- Weak muscle tone (hypotonia)
- Seizures.

- Kidney abnormalities.

16.4 - Introduction

- The study of human genetics is a complicated field. This is due to a number of reasonsHumans have long life spans.

1. We produce very few offspring.

2. Most people do not keep very accurate records of their family history.

Patterns of Inheritance

- There are certain patterns of inheritance which scientists have determined for particular human genetic disorders. These include:
  - Autosomal Recessive Inheritance
  - Codominant Inheritance
  - Autosomal Dominant Inheritance
  - Incomplete Dominance
  - X-linked Recessive Inheritance

Autosomal Recessive Inheritance

- Disorder is carried on the autosomes (body chromosomes), not sex chromosomes

- Examples include:
  - Tay-Sachs disease
  - Phenylketonuria (PKU)

Tay-Sachs Disease

- Individuals lack an enzyme in the lysosomes which are located in their brain cells.
  - The lysosomes are unable to break down specific lipids. Thus the lipids build up inside the lysosomes and eventually destroy the brain cells.
- Children appear normal at birth, but experience brain and spinal cord deterioration around 8 months old.
- By 1 year of age, children become blind, mentally handicapped, and have little muscular activity.
  - Most children with their disorder die before age 5.
- There is no treatment for this disorder.

Phenylketonuria (PKU)

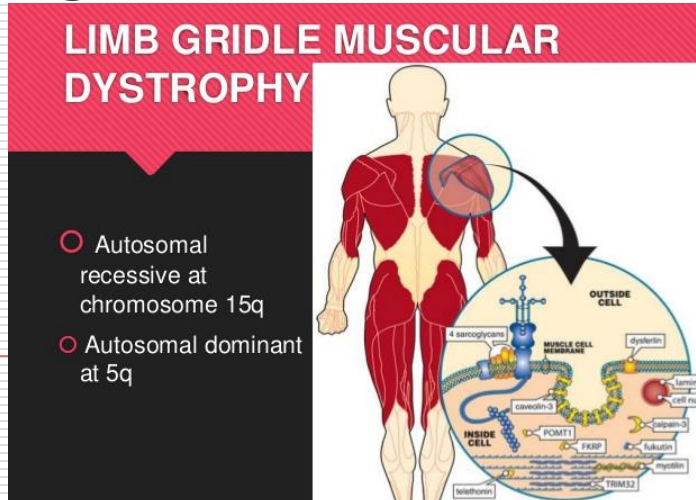
- A enzyme which converts a substance called phenylalanine to tyrosine is either absent or defective.
- Phenylalanine is an amino acid which is needed for regular growth and development and protein metabolism.
- Tyrosine is another amino acid which is used by the body to make the pigment melanin and certain hormones

PKU

- When phenylalanine is not broken down normally, harmful products accumulate and cause damage to the individual's nervous system.
  - This results in PKU
- Babies who develop PKU appear normal at birth.
  - Can become mentally handicapped within a few months
- Today, testing and proper diet can prevent PKU from occurring in children

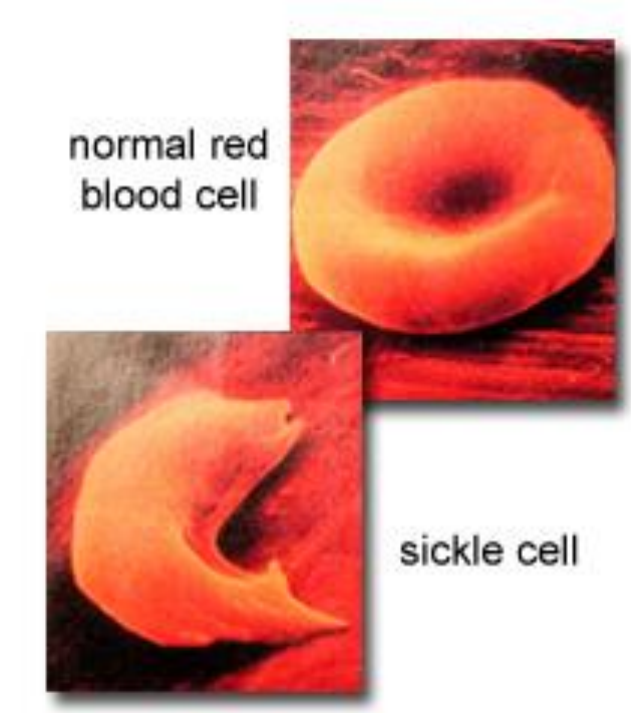
Muscular Dystrophy

- muscular dystrophy, abnormal genes (mutations) interfere with the production of proteins
- Frequent falls.
- **Difficulty** rising from a lying or sitting up position.
- Trouble running and jumping.
- Waddling gait.
- **Walking on the toes**.
- Large calf muscles.
- Muscle pain and stiffness.
- Learning disabilities



Co-dominant Inheritance

- Sickle-cell Anemia
  - Best example of a co-dominant disorder
- Symptoms
  - Defect in the hemoglobin and the red blood cells
  - Defect leads to clots and reduced blood flow to vital organs
  - Low energy, suffer from various illnesses and are in constant pain
  - May die prematurely

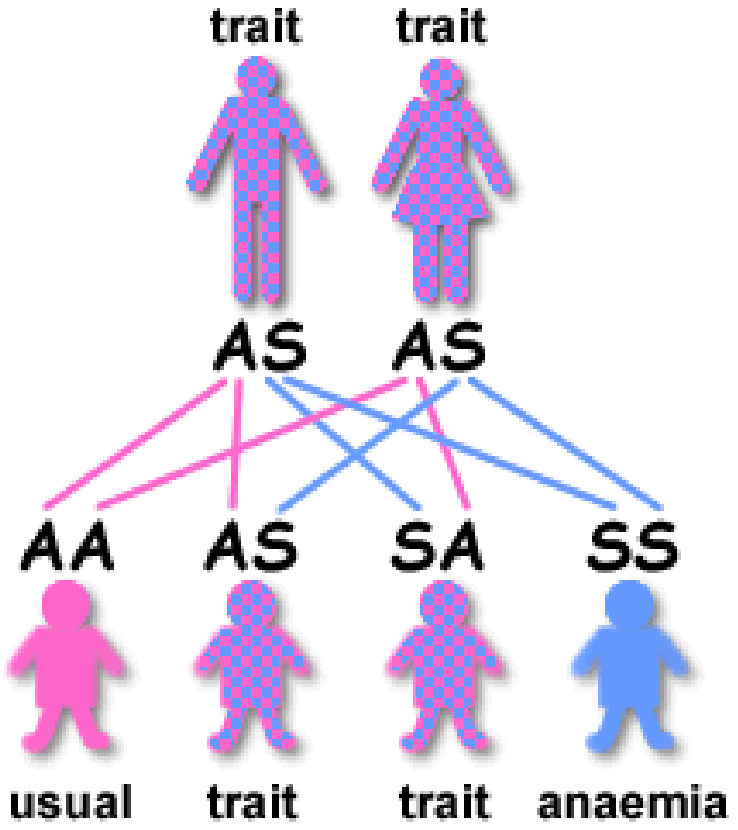


Both Parents as Carriers

- Cross:

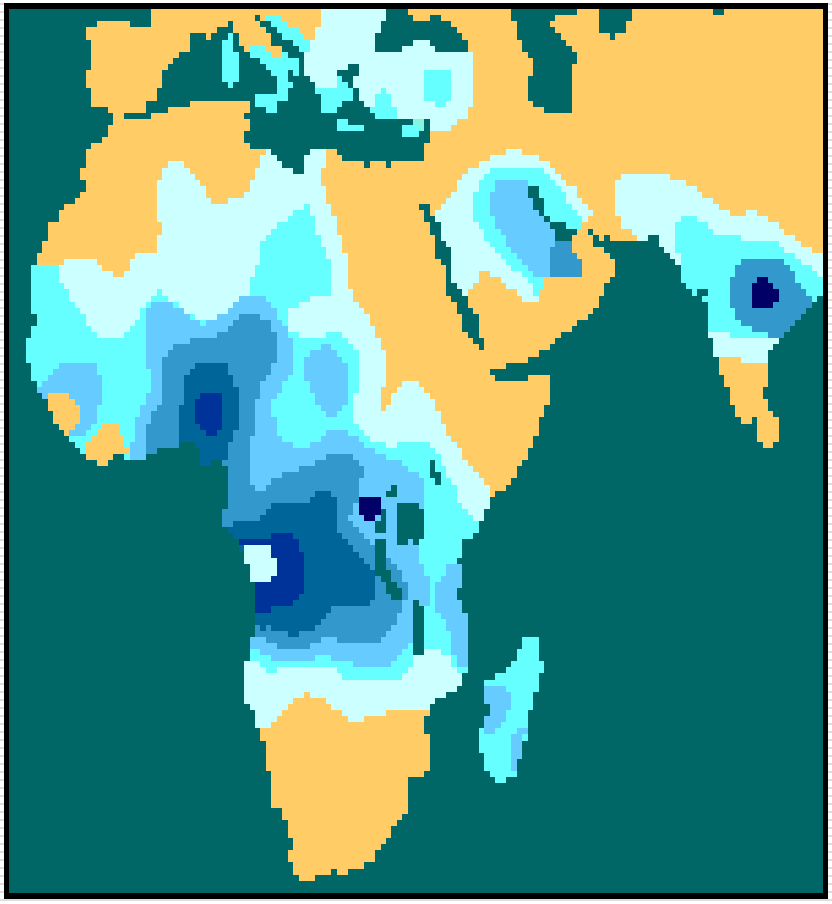
Hb^AHB^S x Hb^AHB^S

- Results:
  - 25% Normal
  - 50% Normal carriers
  - 25% Anemia



Heterozygous Advantage

- Sickle – Cell Anemia is largely predominant in Africa
- Malaria is the leading cause of death among young people
- Heterozygous individuals have been found to be less likely contract Malaria, and thus more likely to live and pass on the anemia allele
- Anemia alleles are normally lost from the population because the individuals rarely live to have children



Autosomal Dominant Inheritance

- Genetic disorders which are caused by autosomal dominant alleles, recessive condition is normal
- Very rare in humans, but they do exist.
- Caused by chance mutations or after individuals have passed their child bearing age.
- Two examples:
  - Progeria
  - Huntington's disease

Progeria (Pp)

- Deletion or duplication
- Rare disorder causing affected person to age rapidly
- Usually dies by age 10 - 15
- Affects 1 in 8 million newborns
- Results from a spontaneous point mutation in a gene
- Mutated gene is dominant over the normal condition (pp)

15 yr old male

16 yr old female

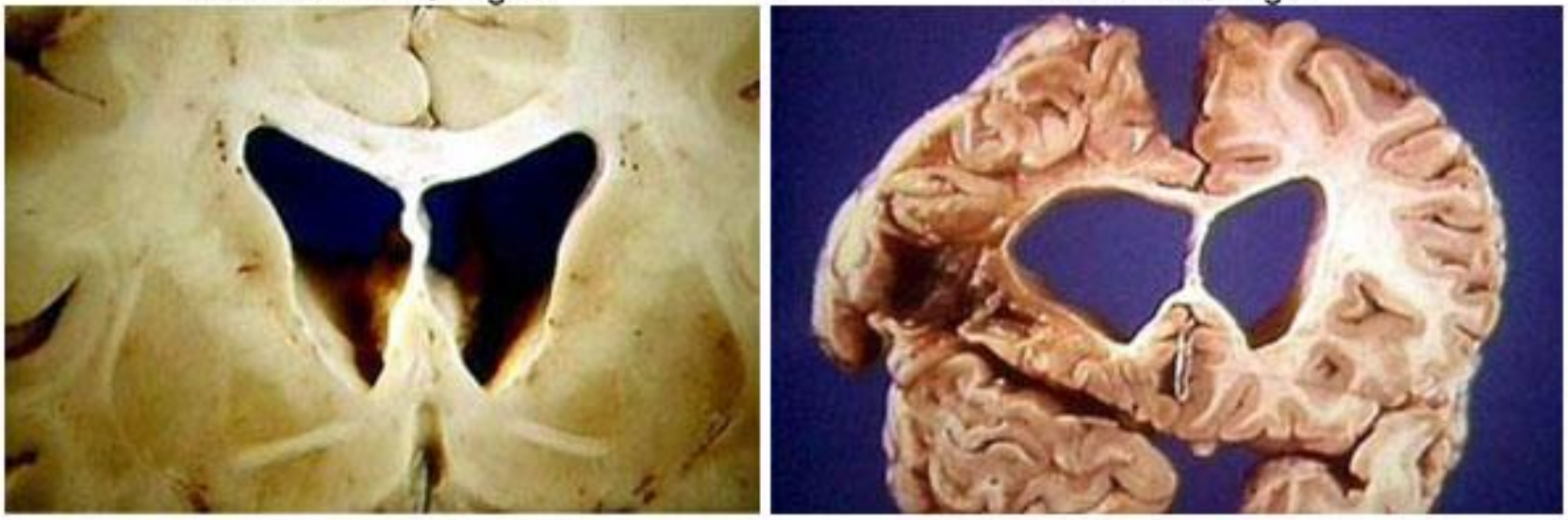
Huntington Disease

- Lethal disorder in which the brain progressively deteriorates over a period of about 15 years
- Symptoms arise after the age of 35
  - After the person has had a chance to pass the allele to their children
- Symptoms include:
  - Irritability and memory loss
  - Involuntary leg / arm movements
  - Symptoms worsen s brain deteriorates
    - Loss of speech and further loss of memory
  - Person dies by 40 – 60 yrs old before they know if their children have the mutant allele

Huntington Diseased Brain

Figure D-4: Effect of HD on the Basal Ganglia

Normal Basal Ganglia vs. HD Basal Ganglia



The basal ganglia of the human brain, showing the impact of HD on brain structure in this region. Note especially that the brain of a person with HD has bigger openings due to the death of nerve cells in that region.

Source: Singer, Jonathan. Huntington's Disease. Online. Available at: http://ist-socrates.berkeley.edu/~jmp/HD.html

Incomplete Dominance

- Disorder exhibits a phenotype which is midway between the dominant and recessive traits

- Familial Hypercholesterolemia (FH)
  - Normal cells have surface receptors which absorb low-density lipoproteins (LDLs) from the blood.
  - Individuals who have the FH disorder have cells which only have half the normal number of LDL receptors on their surface
  - Person then suffers from high cholesterol because LDLs are not efficiently absorbed from the blood
  - Normal cells have surface receptors which absorb low-density lipoproteins (LDLs) from the blood.
  - Individuals who have the FH disorder have cells which only have half the normal number of LDL receptors on their surface

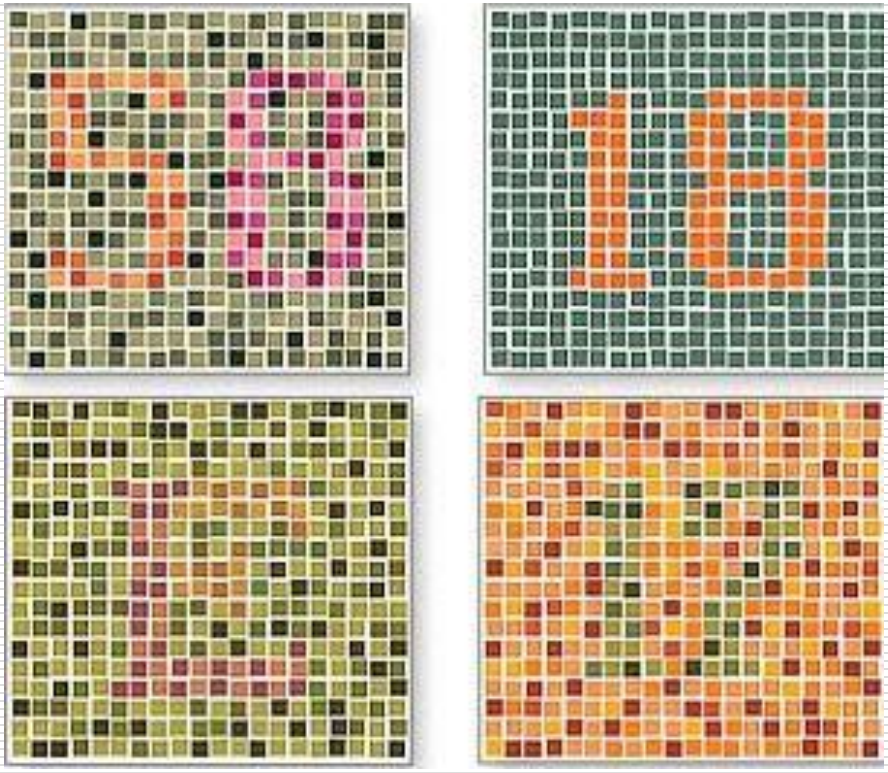
X-Linked Recessive Inheritance

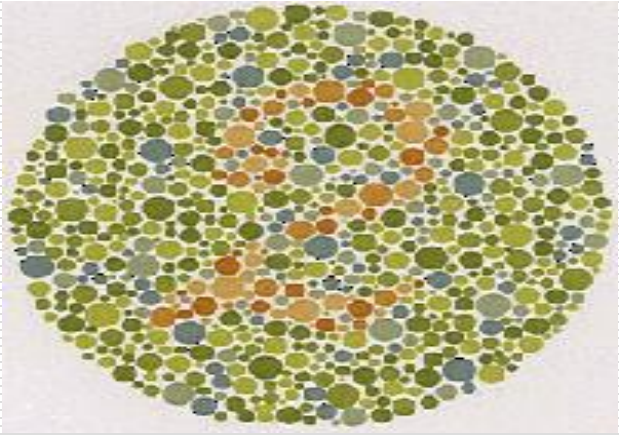
- Disorders linked to genes on the X chromosome
- Are due to the recessive form of the gene, and only occurs if there is no dominant form of the gene present
- Example: Colour blindness

Colour Blindness

- Genotypes: X^cX^c X^cY
- Heterozygous females will have normal vision but they will be carriers → X^CX^c
- Person is unable to distinguish between colours red and green
- Affects about 8% of males and 0.04% of females
- Do sample problems

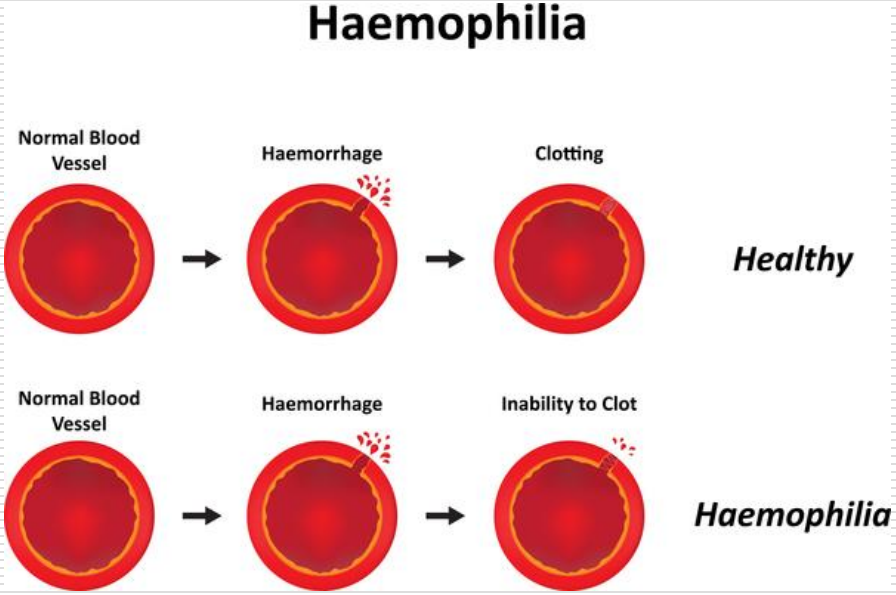
Can you see the numbers?





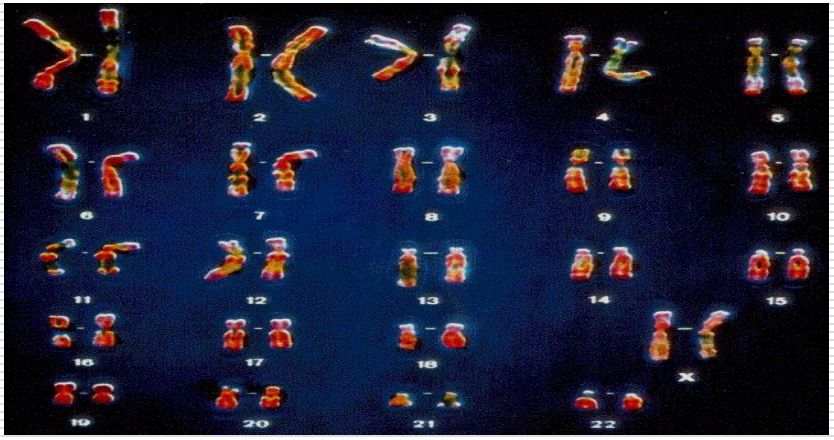
Hemophelia

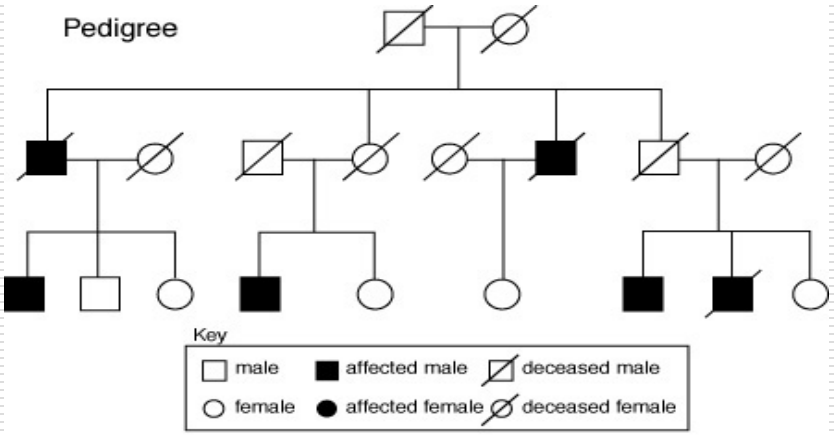
- **Hemophilia** is a rare disorder in which your blood doesn't clot normally because it lacks sufficient blood-clotting proteins (clotting factors).
- blood in the urine.
- blood in the stool.
- deep **bruises**.
- large, unexplained **bruises**.
- excessive **bleeding**.
- **bleeding** gums.
- frequent **nosebleeds**.
- **pain** in the **joints**.



Human Genetic Analysis

- Geneticists are able to analyze the patterns of human inheritance using two methods
  - Examination of karyotypes
  - Construction of pedigrees





Human Karyotype

- Within our body cells, humans normally possess 46 chromosomes.
  - 44 of these are autosomes (body chromosomes)
  - 2 are sex chromosomes.
- A karyotype is a photograph of the chromosomes which are located in the nucleus of a somatic cell
- Once a photograph has been taken of the chromosomes in a cell's nucleus, they are cut out and arranged in pairs according to their size, shape, and appearance.
- By observing the karyotype, disorders may become apparent.

YOU WILL BE DOING A KARYOTYPE LAB FOR HOMEWORK ☺

Constructing Pedigrees

- A pedigree is a chart which shows the genetic relationships between individuals in a family.
- Using a pedigree chart and Mendelian genetics, scientists can determine whether an allele (gene) which is responsible for a given condition is dominant, recessive, autosomal, sex-linked, etc.
- A pedigree can also be used to predict whether an individual will inherit a particular genetic disorder.
- An example of such a disorder is hemophilia. This is a disorder in which a person's blood lacks certain clotting factors, thus the blood will not clot. Because of this, a small cut or bruise may kill an individual.