Chromosomal Mutations:

- Genetic Variation at the Chromosomal level
    - in Ch. 14 we looked at how mutations occur at the nucleotide level - but large scale rearrangements of genetic material also occurs - can have profound consequences
    - Can include changes in:
        - number of chromosomes deletion of segments of chromosomes, rearrangements of chromosomes
- Terminology for altered chromosomal number
    - plants are much more tolerant of ploidy than animals
    - Aneuploidy: 2n +/- x chromosomes
        - Monosomy: 2n-1
        - Disomy: 2n
        - Trisomy: 2n+1
        - Tetrasomy, Pentasomy, etc. : 2m+2, 2n+3, etc.
    - Euploidy: multiples of n
        - Diploidy: 2n
        - Polyploidy: 3n, 4n, 5n
        - Triploidy: 3n
        - Tetraploidy, pentaploidy, etc.: 4n, 5n, etc.
        - Autopolyploidy: mult. of the same genome
        - Allopolyploidy (amphidiploidy): mult. of closely related genomes
    - Non- disjunction causes changes in chromosome number
        - outcome depends on when nondisjunction occurs in meiosis I or meiosis II
        - monosomy can result in haploinsufficiency
    - Monosomy (2n-1)
        - loss of a single or part of a chromosome can have large effects
            - ex) cri-du-chat syndrome has a segmental deletion; a piece of the short arm of one member of the chromosome 5 homolog
    - Downs syndrome
        - caused by an extra copy of chromosome 21
        - occurs in about 1/800 births
        - series of about 12 characteristics associated and individuals live to about 50
        - prone to respiratory and heart malformations
        - one region of the chromosome seems to be critical for this condition
        - incidence increases with maternal ages
            - although extra X chromosome may be donated by father in 95% of cases the extra chromosome comes from the egg - possibly because the eggs have a long life - formed before birth

- Trisomies
  - few are viable in humans
  - other than trisomy 21 only trisomy 15 (Patau syndrome) and 18 (Edwards syndrome) survive to term - with severe malformations and early lethality
  - Estimated that about 20% of all conceptions about natural - about 30% of these have chromosomal abnormalities
- Polyploidy (>2n)
  - prevalent in plants
  - is where there is more than 2n chromosomes
  - few animals are polyploidy but not uncommon in plants
  - polyploids tend to be even numbered
  - Autopolyploids have mult. of the same chromosomes
  - Allopolyploids have mult. of chromosomes from two closely related species
- Colchicine
  - spindle inhibitor that can induce autopolyploidy in cells
  - inhabits spindle formation causing anaphase to fail and the chromosome number to double if the cell re-enters interphase
  - autopolyploid cells tend to be larger than diploid cells - this is important in many plants such as potatoes and bananas

- How can allopolyploids form?
  - the origin and propagation of an amphidiploid (a allotetraploid where he parent species are known)
    - ex) American cotton plant
  - species 1: contains genome A consisting of 3 distinct chromosomes, a1, a2, and a3
  - Species 2: contains genome B consisting of two distinct chromosomes b1 and b2
  - following fertilization between members of the two species and chromosome doubling a fertile amphidiploid containing two complete diploid genomes (AABB) is formed
- deletion of part of a chromosome
  - involves chromosome breaks and repair
    - a terminal deletion
    - an intercalary deletion
    - pairing occurs between a normal chromosome and one with and intercalary deletion by looping out The undeleted portion to form a deletion (or compensation) loop
- Duplication is repeated part of a chromosome
  - mispairing of a tetrad during synapsis results in a deficient and duplication chromosome then non-crossover chromosomes remain unchanged
  - in some cells some parts of chromosomes are selectively duplicated many times

        - ex) egg cells, the nuclear region can be amplified hundreds of times - may be visible as micronucleoli
- The Bar mutation in fruit flies
    - results in a duplication of part of chromosome 16A
    - normal eyes (B^-/B^-) have 800 facets but B/B^- have only 350 and B/B just 70
    - B^D/B^- flies have even fewer and are termed double bar
    - Duplication can be seen in stained chromosomes
- Role of gene duplication in evolution
    - Ohno 1970 proposed that duplication is essential to the origin of new genes during evolution
    - Idea that existing genes are indispensable but by making an extra copy there is one to 'tinker' with while original keep on doing its job
    - The new copy is free to accumulate mutations some of which may prove advantageous
    - this idea is now supported by the identification of genes with closely related sequence but different functions
        - ex) hemoglobin gene family and many others
    - major jumps in evolution appear to have involved duplication of entire genomes
- Inversions
    - change linear order of genes along a chromosome
    - during an inversion no information is lost
    - the inverted region may be short or long and may or may not include the centromere
    - if it does it is called a pericentric inversion and if not it's a paracentric inversion
    - **Paracentric inversion**
        - the effects of a single crossover (SCO) within an inversion loop in a paracentric inversion heterozygote where two altered chromosomes are produced, one acentric and one dicentric
        - Both chromosomes also contain duplicated and deficient regions
    - **Pericentric inversion**
        - the effects of a crossover in a pericentric inversion heterozygote where two altered chromosomes are produced both with duplicated and deficient regions
- Translocation
    - alter the location of a chromosomal segment in the gene
    - reciprocal exchange of genetic material occurs between nonhomologous chromosomes - four breaks are required - two on each chromosome the resulting 'translocated' chromosomes do not readily line up with the other homolog during meiosis
- Synapsis of a translocation 'heterozygote'
    - an unusual cross-shaped configuration occurs during synapsis