SCIENCE OLYMPIAD®

*Exploring the World of Science*

# Heredity (B) -2027

# Event Rules – 2027

## DISCLAIMER

**This presentation was prepared using draft rules. There may be some changes in the final copy of the rules. The rules which will be in your Coaches Manual and Student Manuals will be the official rules.**

# Event Rules – 2027

- **BE SURE TO CHECK THE 2027 EVENT RULES FOR EVENT PARAMETERS AND TOPICS FOR EACH COMPETITION LEVEL**

# SOSI TRAINING MATERIALS

- **Training Power Point – content overview**
- **Training Handout - content information**
- **Practice Problems & Solutions – several problem types**
- **Practice Activities – sample lab practical**
- **Sample Tournament – sample problems with key**
- **Event Supervisor Guide – prep tips, event needs, and scoring tips**

# SO WEBSITE TRAINING MATERIALS

**EVENT RESOURCES – the Science Olympiad website www.soinc.org under Event Information-will be posted throughout the fall**

- **Training Power Point – content overview**
- **Internet Resource – links to good resources for learning content**
- **Training Handouts – overview, general principles**
- **Sample Tournament – sample problems with key**
- **Event Supervisor Guide – prep tips, event needs, and scoring tips**

**The Science Olympiad Store at www.soinc.org**

- **Biology-Earth Science (Digital CD) – current year topics for all bio events with training materials and extra resources**
- **Genetics (Digital CD) 2019 – all content, extra resources, exams for Heredity and Designer Genes**
- **Division B and Division C Test Packets – national exams from the previous year**

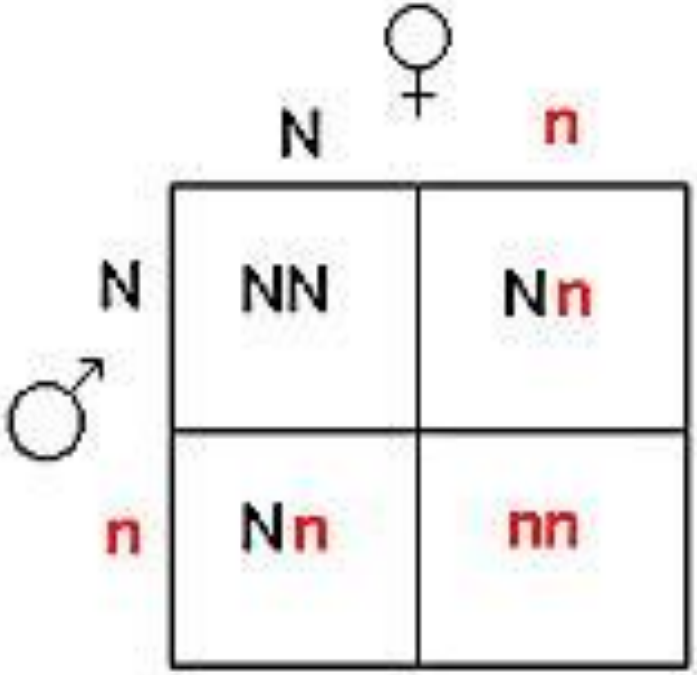
# PRINCIPLES OF GENETICS

- **GENES** – come in pairs
  - Section of DNA – codes protein or part of protein
  - One from each parent
- **ALLELE** – different forms of a gene
- **MULTIPLE ALLELES** – more than 2 forms of a gene
- **HOMOZYGOUS** – same alleles
- **HETEROZYGOUS** – different alleles

# Dominant vs. Recessive

- **Dominant** – always expressed
  - Capital letters – **N**
  - Homozygous - **NN**
  - Heterozygous - **Nn**
- **Recessive** – prevented by dominant
  - Lower case letters – **n**
  - Homozygous – **nn**

**Punnett Square** – Box showing allele combinations



# Dominant and Recessive

- **Autosomal Dominant**

  Dominant gene on an autosome

- **Autosomal Recessive**

  Recessive gene on an autosome

- **Sex-linked Dominant**

  Dominant gene on a sex chromosome

- **Sex-linked Recessive**

  Recessive gene on a sex chromosome

# Monohybrid Cross

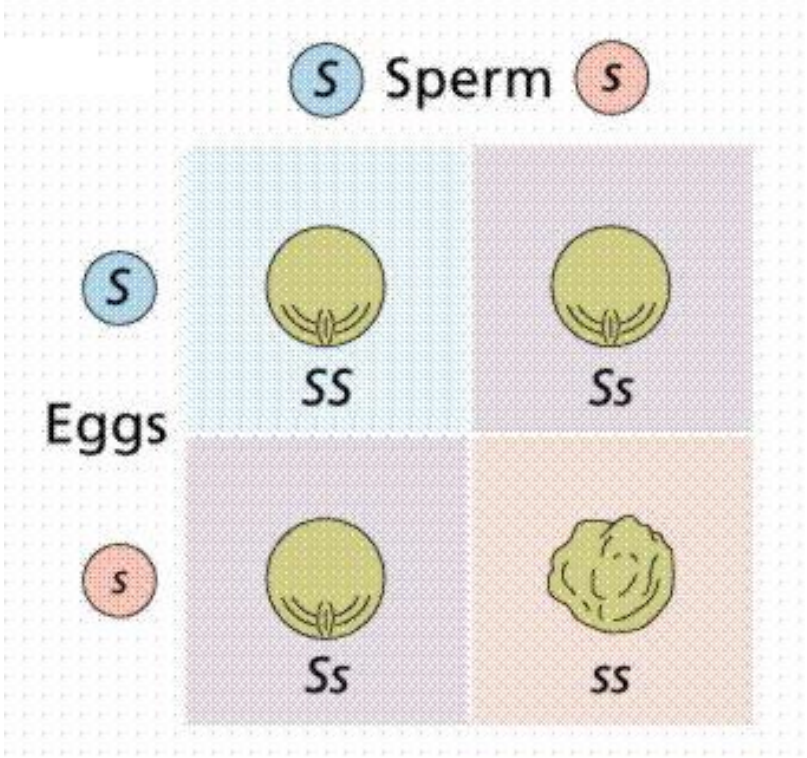
**Hybrid – Ss X Ss**

**One Trait – Smooth vs wrinkled**

**Two gametes per parent**

**S and s**

**Punnett Square with 4 boxes – 4 offspring**



# Genotype & Phenotype

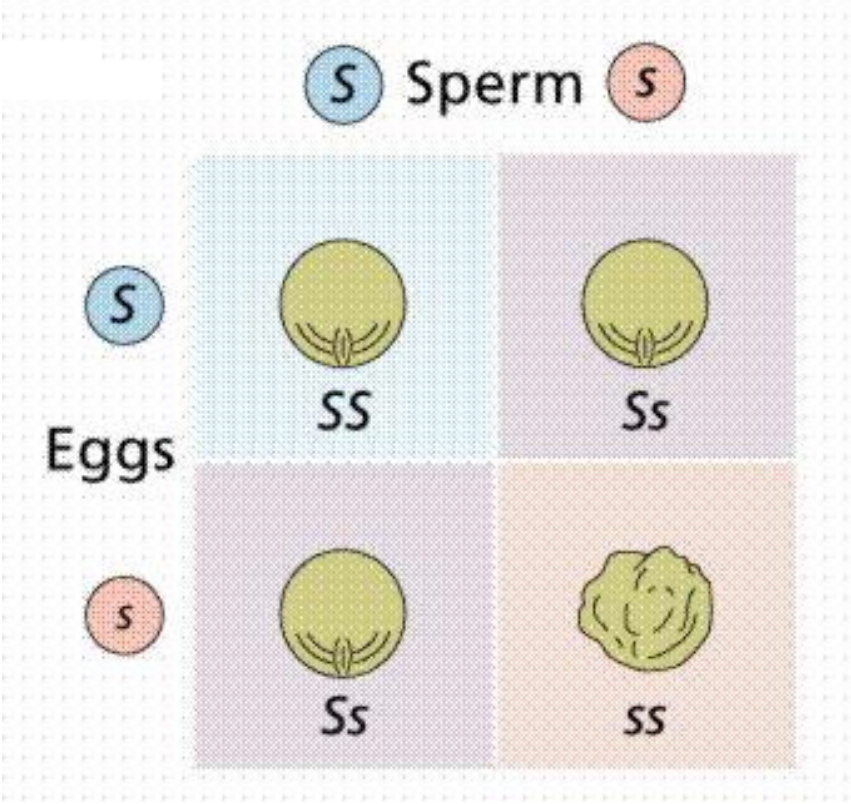
| Genotype | Phenotype |
| --- | --- |
| SS or Ss | Round |
| ss | Wrinkled |

**Genotype frequency**

**1:2:1**

**Phenotype frequency**

**3:1**



# Dihybrid Cross

**Dihybrid – 2 traits**

**Gametes per parent = 4**

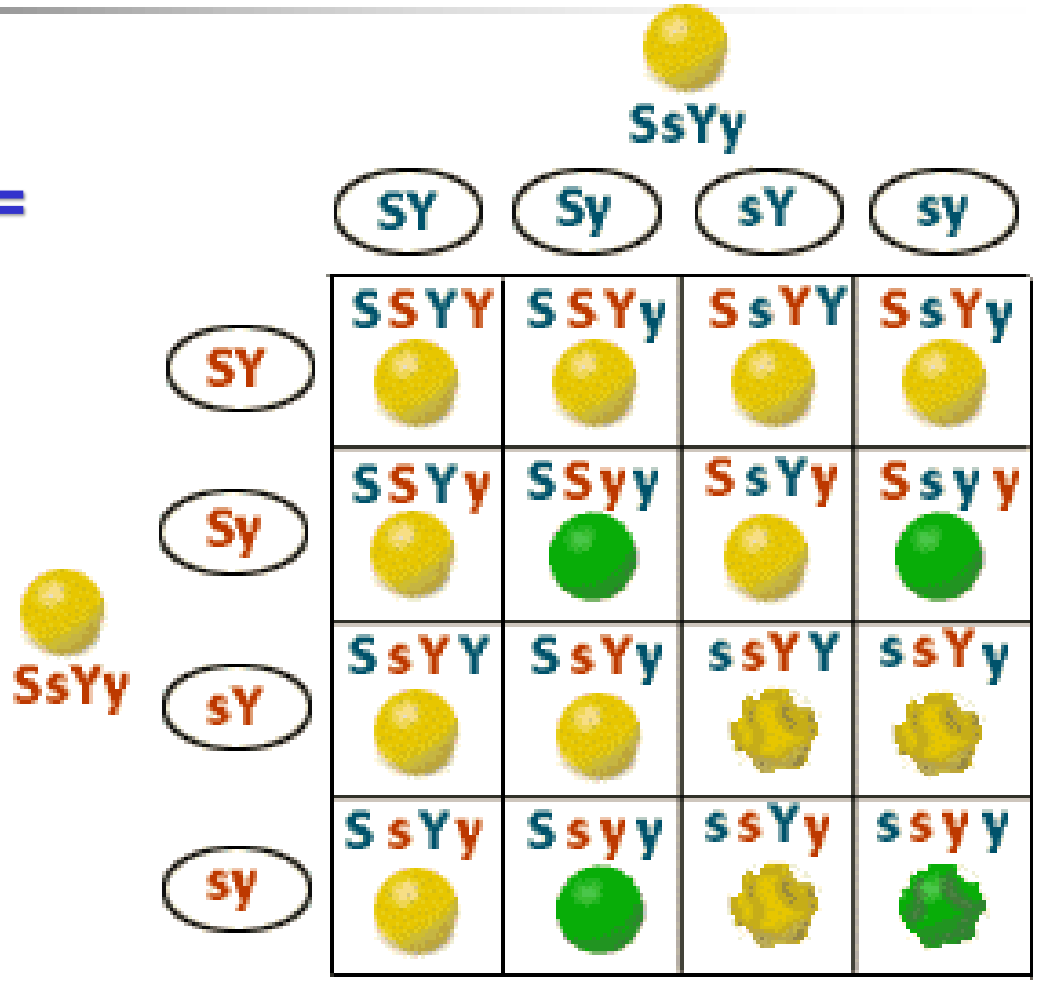
**Punnett Square – 16 boxes**

**Genotype ratio**

**1:2:1:2:4:2:1:2:1**

**Phenotype ratio**

**9:3:3:1**



# Trihybrid Cross

## triple-het x triple-het cross

**SsYyAa x SsYyAa**

| | SYA | SYa | SyA | Sya | sYA | sYa | syA | sya |
|---|---|---|---|---|---|---|---|---|
| SYA | SSYYAA | SSYYAa | SSYyAA | SSYyAa | SsYYAA | SsYYAa | SsYyAA | SsYyAa |
| SYa | SSYYaA | SSYYaa | SSYyaA | SSYyaa | SsYYaA | SsYYaa | SsYyAa | SsYyaa |
| SyA | SSyYAA | SSyYAa | SSyyAA | SSyyAa | SsyYAA | SsyYAa | SsyyAA | SsyyAa |
| Sya | SSyYaA | SSyYaa | SSyyaA | SSyyaa | SsyYaA | SsyYaa | SsyyaA | Ssyyaa |
| sYA | sSYYAA | sSYYAa | sSYyAA | sSYyAa | ssYYAA | ssYYAa | ssYyAA | ssYyAa |
| sYa | sSYYaA | sSYYaa | sSYyaA | sSYyaa | ssYYaA | ssYYaa | ssYyaA | ssYyaa |
| syA | sSyYAA | sSyYAa | sSyyAA | sSyyAa | ssyYAA | ssyYAa | ssyyAA | ssyyAa |
| sya | sSyYaA | sSyYaa | sSyyaA | sSyyaa | ssyYaA | ssyYaa | ssyyaA | ssyyaa |

**Phenotypes:**
Out of 64 births.

- normal
- albinos
- anerythristic
- striped
- snow
- striped-albino
- striped-anery
- striped-snow

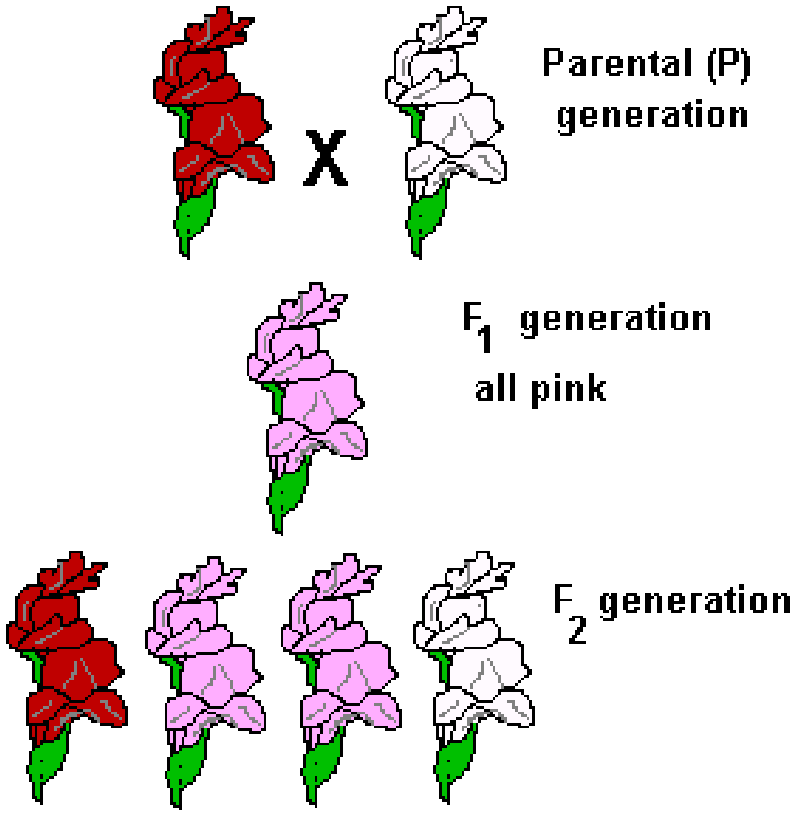
# Incomplete Dominance

- **Hybrid is a blend of two traits**
- **Genotype frequency**

  **1:2:1**
- **Phenotype frequency**

  **1:2:1**
- **Examples:**

  **Flowers, Animal fur**

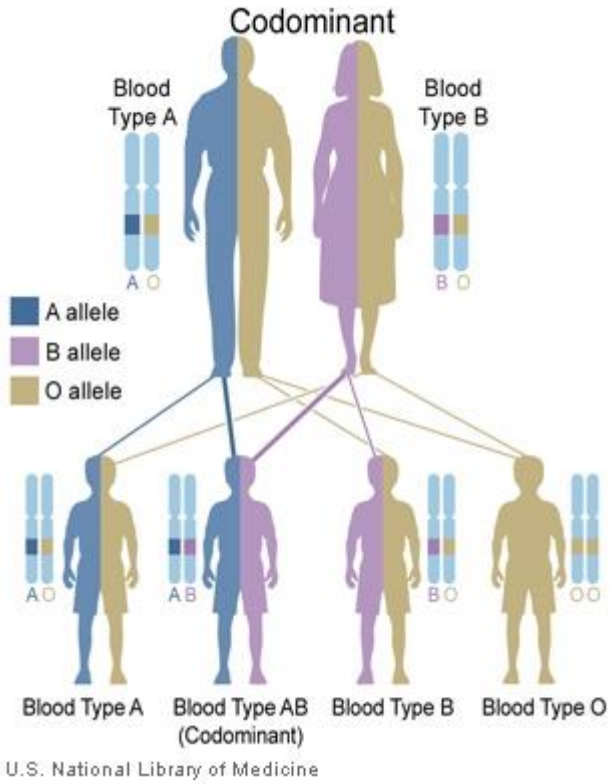


# Co-dominance

- More than one dominant allele
- Blood types – A,B,O alleles
- Phenotypes Genotypes

| | |
|---|---|
| A | $I^AI^A$ or $I^Ai$ |
| B | $I^BI^B$ or $I^Bi$ |
| AB | $I^AI^B$ |
| O | ii |

# Co-dominance




| Blood Type | Genotype | | Can Receive Blood From: |
|---|---|---|---|
| A | $i^A i$<br>$i^A i^A$ | AA<br>AO | A or O |
| B | $i^B i$<br>$i^B i^B$ | BB<br>BO | B or O |
| AB | $i^A i^B$ | AB | A, B, AB, O |
| O | $ii$ | OO | O |

- **co-dominance – both dominant alleles (genes) in an individual are expressed as blood types**
- **A and B genes are co-dominant and both dominant over the O gene which is recessive**

# ABO Blood System

## The ABO Blood System

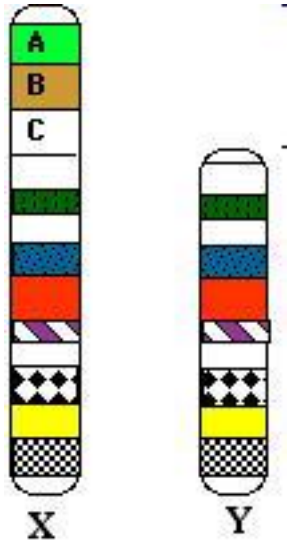
| Blood Type (genotype) | Type A (AA, AO) | Type B (BB, BO) | Type AB (AB) | Type O (OO) |
|---|---|---|---|---|
| Red Blood Cell Surface Proteins (phenotype) |  A agglutinogens only |  B agglutinogens only |  A and B agglutinogens |  No agglutinogens |
| Plasma Antibodies (phenotype) |  b agglutinin only |  a agglutinin only | NONE. No agglutinin |  a and b agglutinin |

# Independent Assortment vs. Linkage

- **Independent Assortment** – genes on different chromosomes separate independently during meiosis
- **Linkage** – genes on the same chromosome are inherited as a group
  - **Autosomal linkage** – on autosomes
  - **Sex-linked** – on sex chromosomes

# Linkage – Sex Linkage

- **Linkage** – genes on the same chromosome inherited as a group
- **Sex-linkage** – genes on sex chromosomes (esp. X)
- **Y-chromosome shorter** – some genes from X missing
- **X-linked traits** more common in men
- Men get X-chromosome from mom
- Red-green colorblindness, hemophilia



# Environmental influence on genes expression

- **Gene function** is influenced by environment as with identical twins
- **Genes** have blueprint for proteins or parts of proteins
- **Proteins** can be structural proteins (parts of body) or functional proteins (hormones/enzymes)

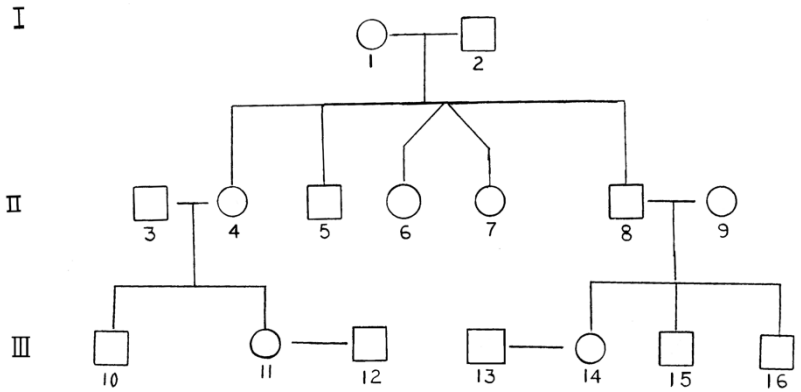
# EPISTASIS

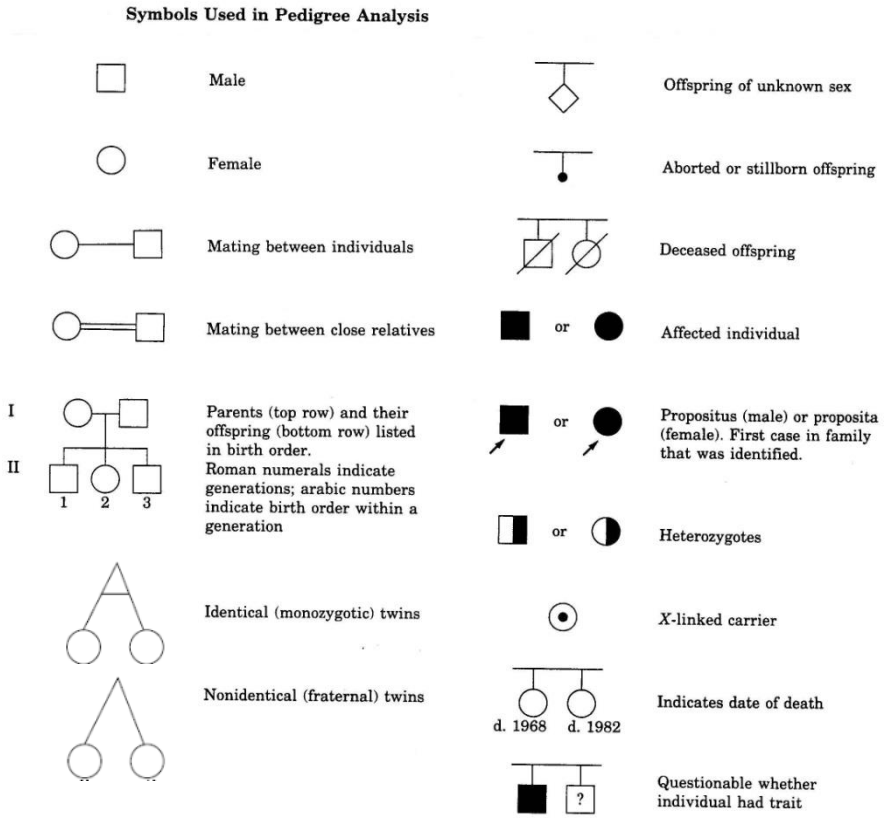
- the interaction between two or more genes to control a single phenotype
- the effect of one gene is dependent on the presence of one or more 'modifier genes
- involves not genes so much as the proteins they code for. (So do dominant and recessive, for that matter.)
- Genes with epistatic relationships tend to code for proteins that work together in the same processes.

# MULTIFACTORIAL TRAITS

- **Multifactorial inheritance - many factors (multifactorial) both genetic and environmental are involved in producing the trait or condition. Examples: height, weight, cleft palate, spina bifida**
- **Traits involve multiple genes and complicated patterns of inheritance**

# Pedigree Symbols



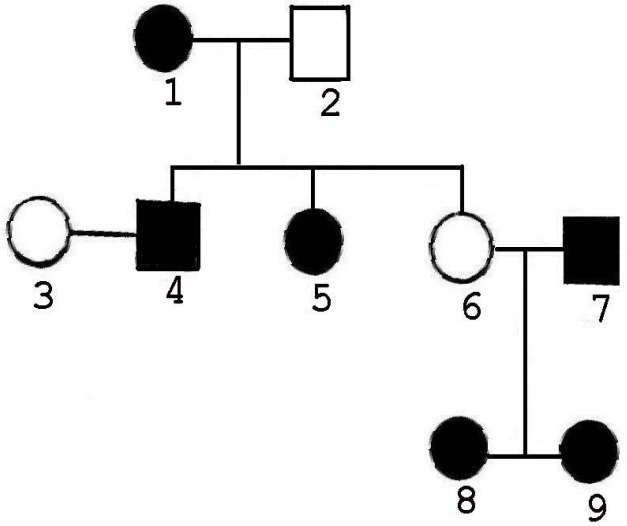




- **Generations** = I – Original Parents, II- F1 (children), III – F2 (grandchildren)

# Pedigree – Curly vs Straight Hair

## Types of Analysis

- Relationships
- Dominant Gene – H
  Curly
- Recessive Gene – h
  Straight
- Genotypes
- Phenotypes



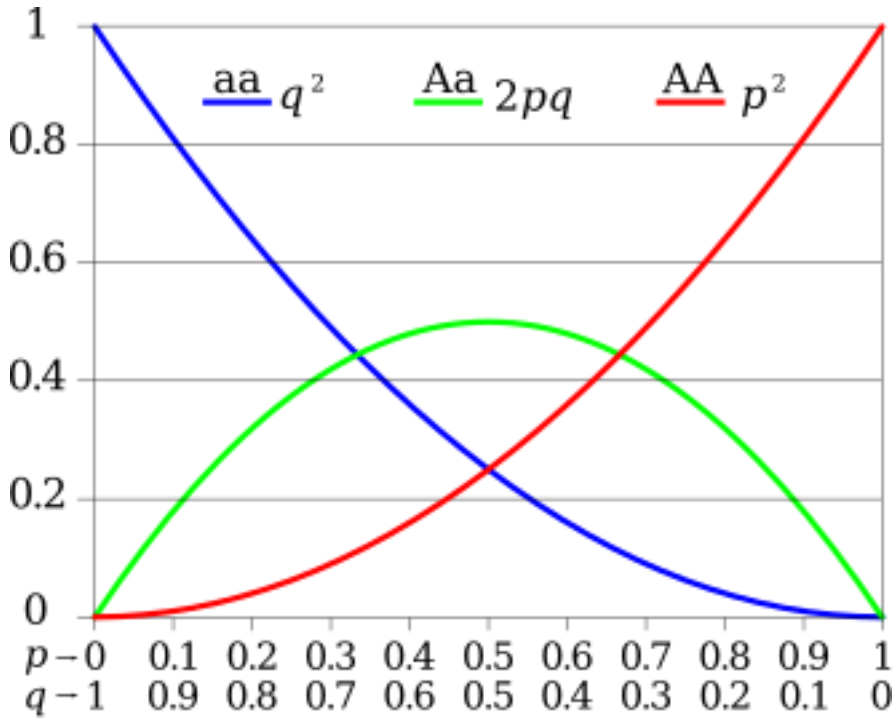
# Hardy-Weinberg Equilibrium

- **Allele frequencies stay constant between generations**

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

p=frequency of dominant allele
q=frequency of recessive allele
$p^2$=frequency of homozygous dominant
2pq=frequency of heterozygous
$q^2$=frequency of homozygous recessive



# Hardy-Weinberg Equilibrium

## Main Assumptions:

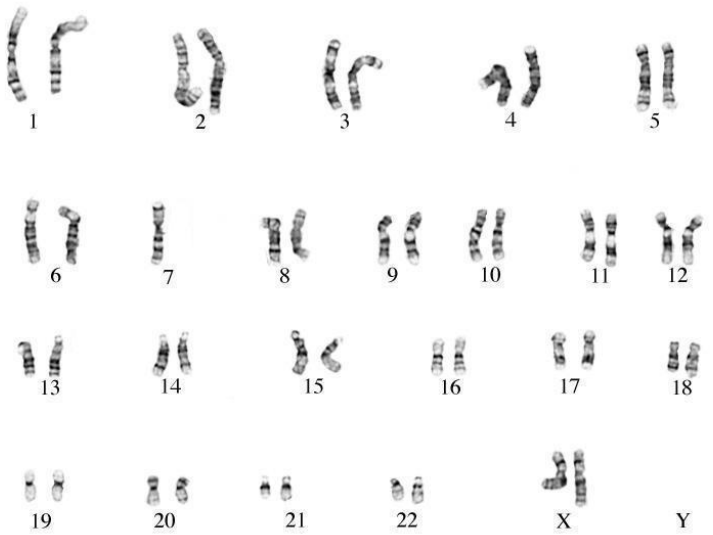
- Random mating
- Infinite population size
- No migration
- No mutation
- No selection

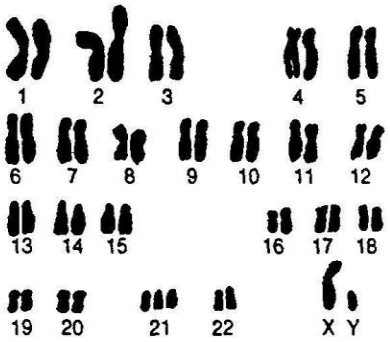
## Additional assumptions:

- Diploid
- Only sexual reproduction occurs
- Equal gene frequency between sexes
- Non-overlapping generations

# Karyotypes

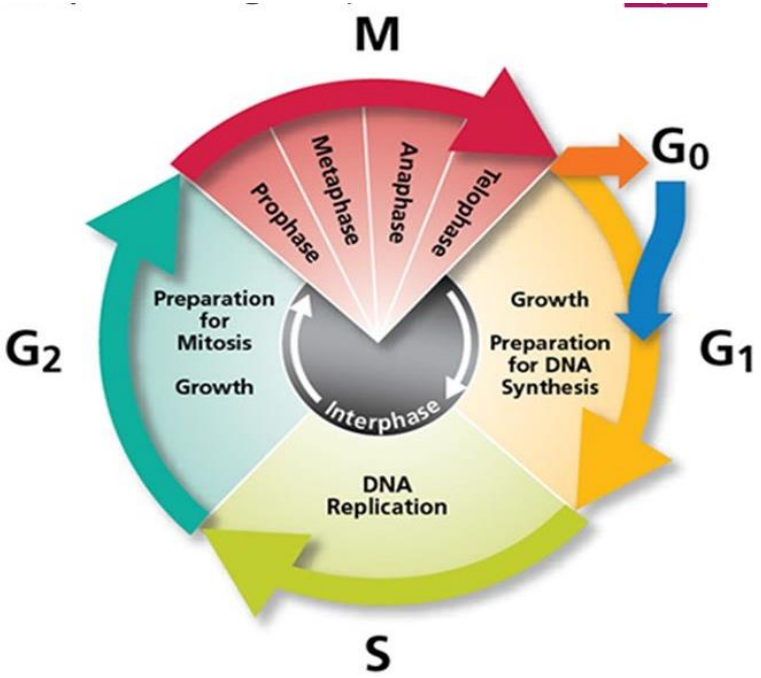
- **Pairs 1-22** = Autosomes
- **XY** = Sex chromosomes
- **Male** = X & Y
- **Female** = only X
- **Nondisjunction**
- **Extra chromosomes (Trisomy)**
- **Missing chromosomes (Monosomy)**



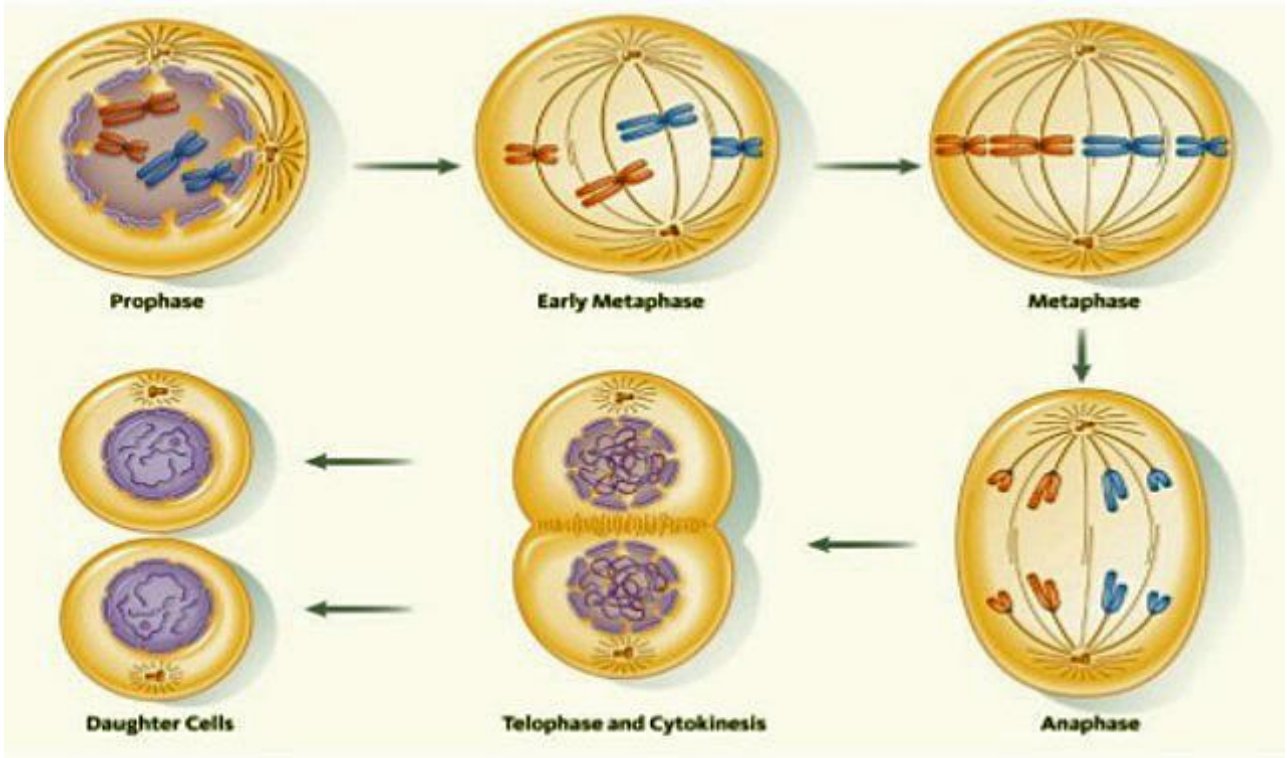



# Cell Cycle

- **Interphase**
  - G1
  - S – DNA replicates
  - G2
- **Mitosis**
  - Prophase
  - Metaphase
  - Anaphase
  - Telophase

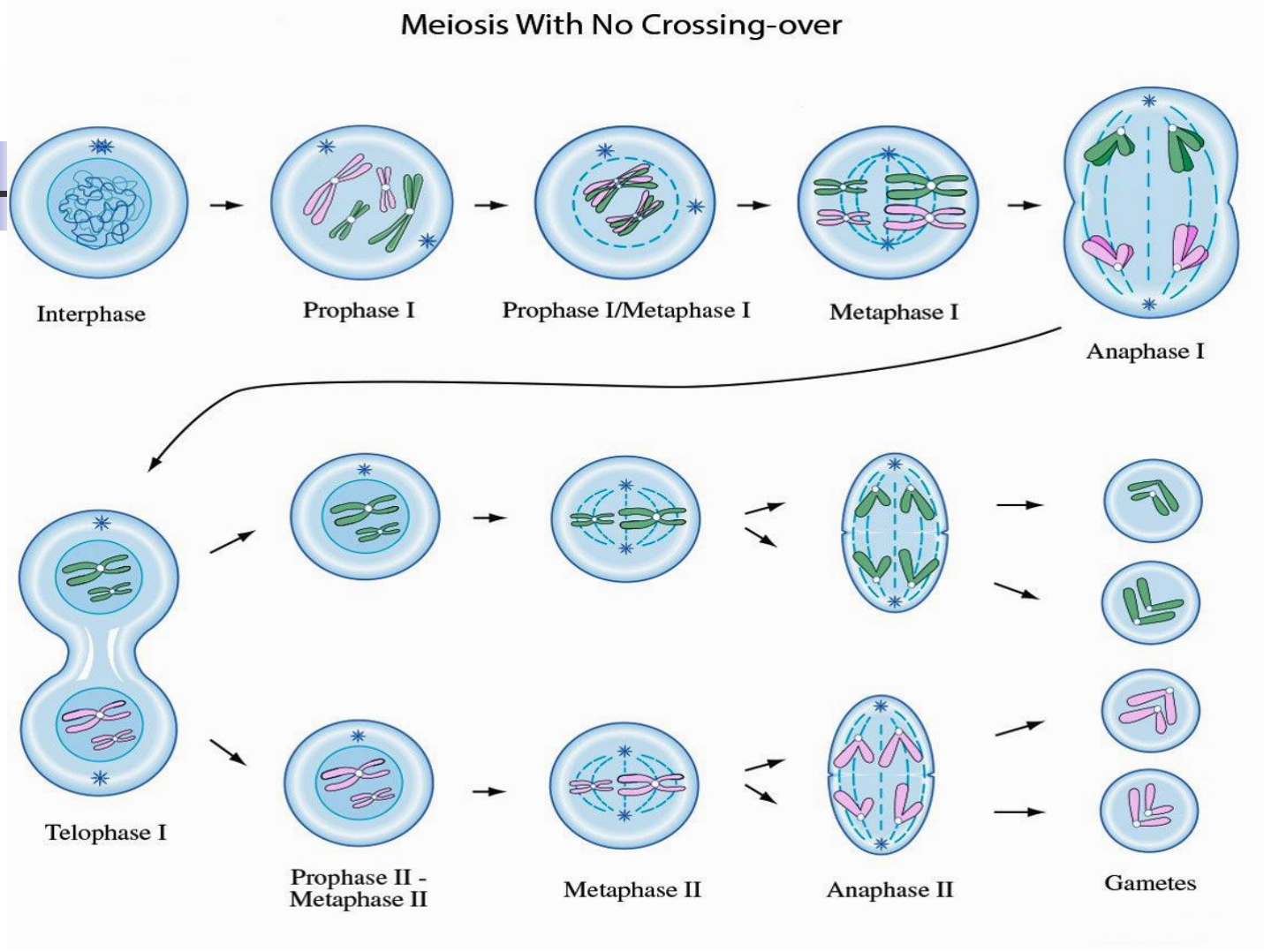


# Stages of Mitosis

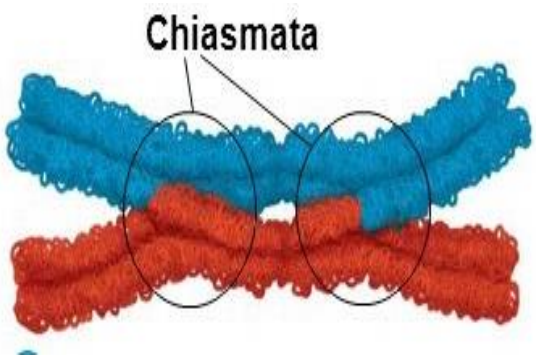


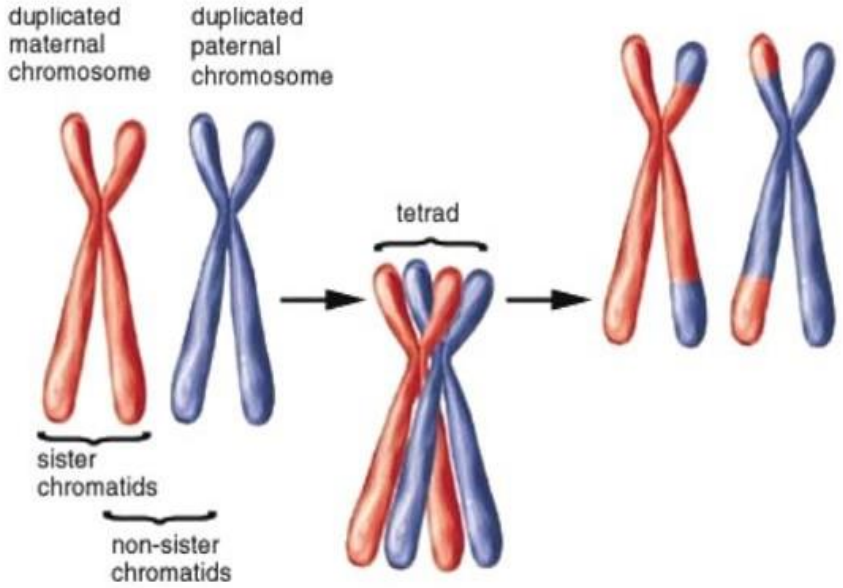
# Mitosis vs. Meiosis

- **Mitosis**
  - Growth and Asexual Reproduction
  - One division – 2 diploid cells
  - Genetically same as original
- **Meiosis**
  - Gametes for Sexual Reproduction
  - 2 divisions – 4 haploid cells

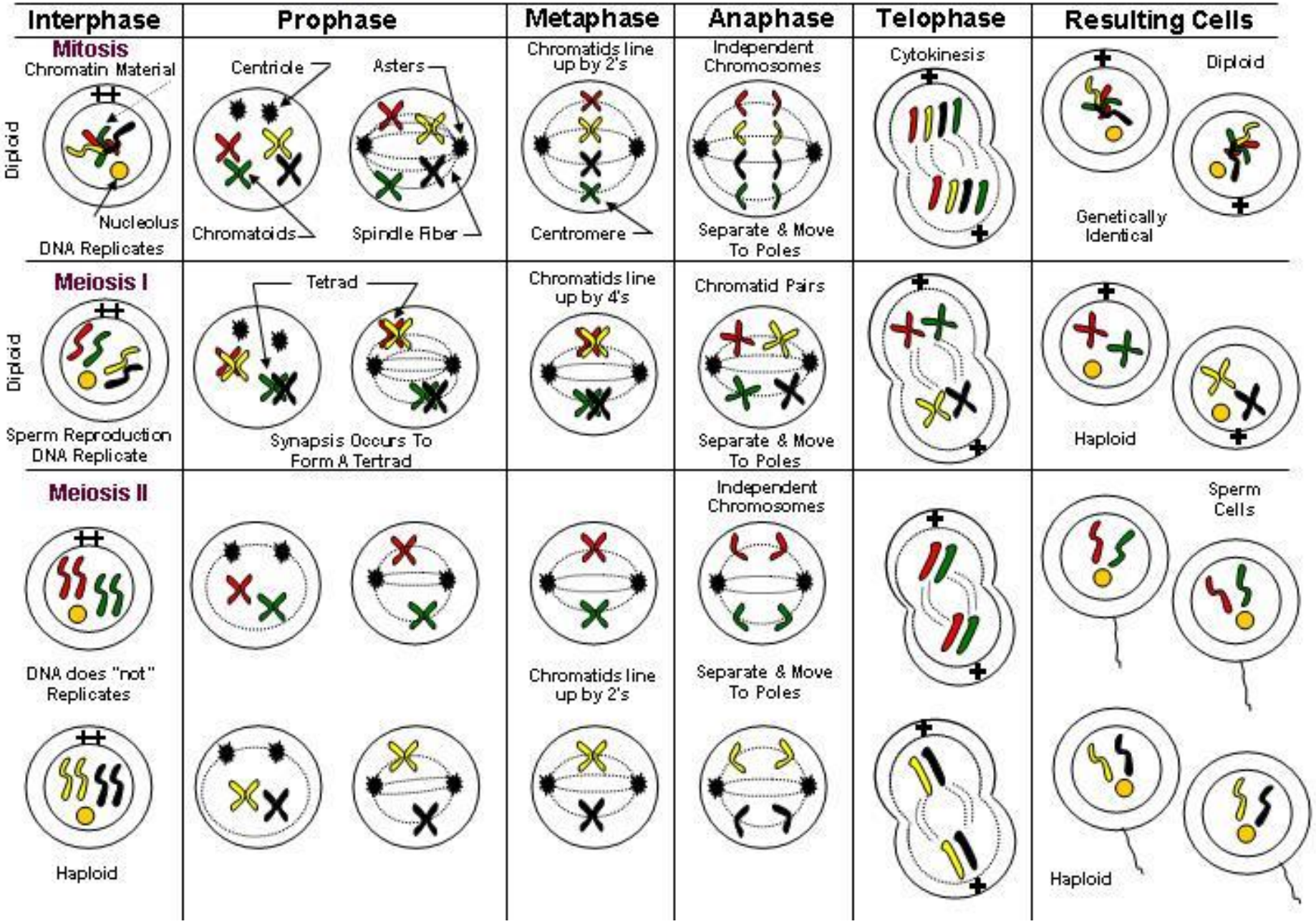

Meiosis With No Crossing-over
Interphase
Prophase I
Prophase I/Metaphase I
Metaphase I
Anaphase I
Telophase I
Prophase II -
Metaphase II
Metaphase II
Anaphase II
Gametes

# CROSSING OVER IN MEIOSIS I

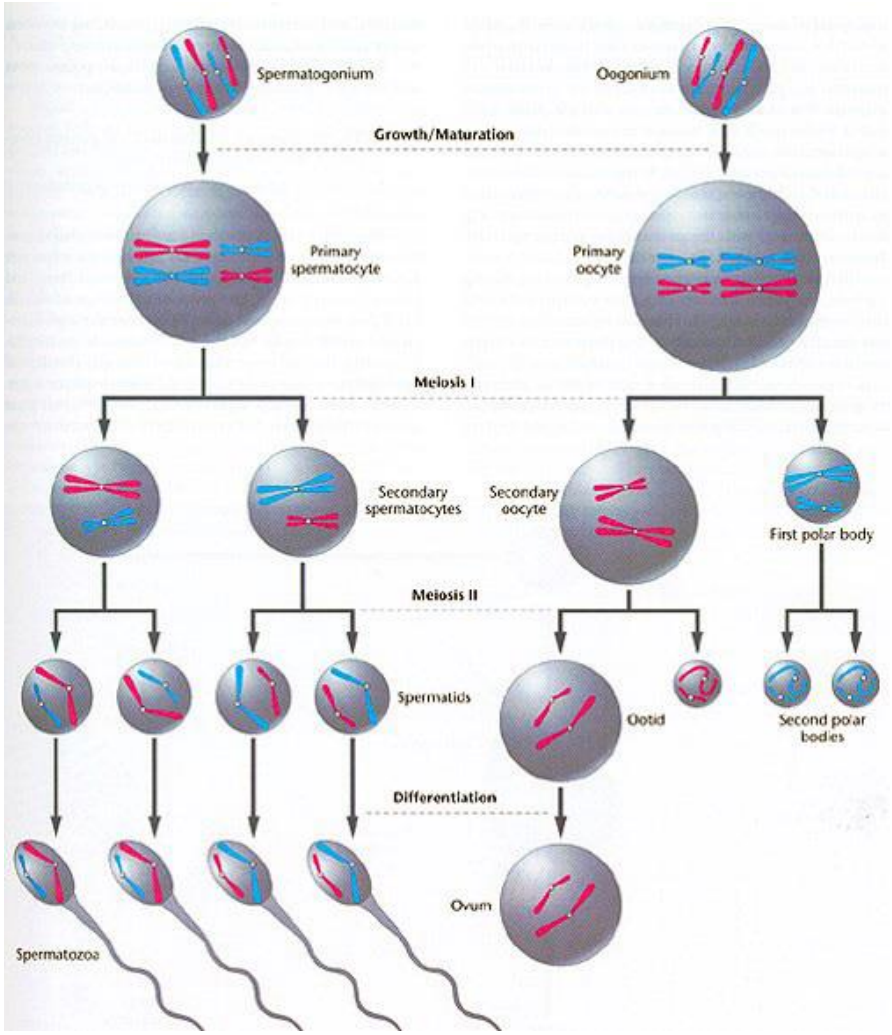


# Comparison of Mitosis and Meiosis

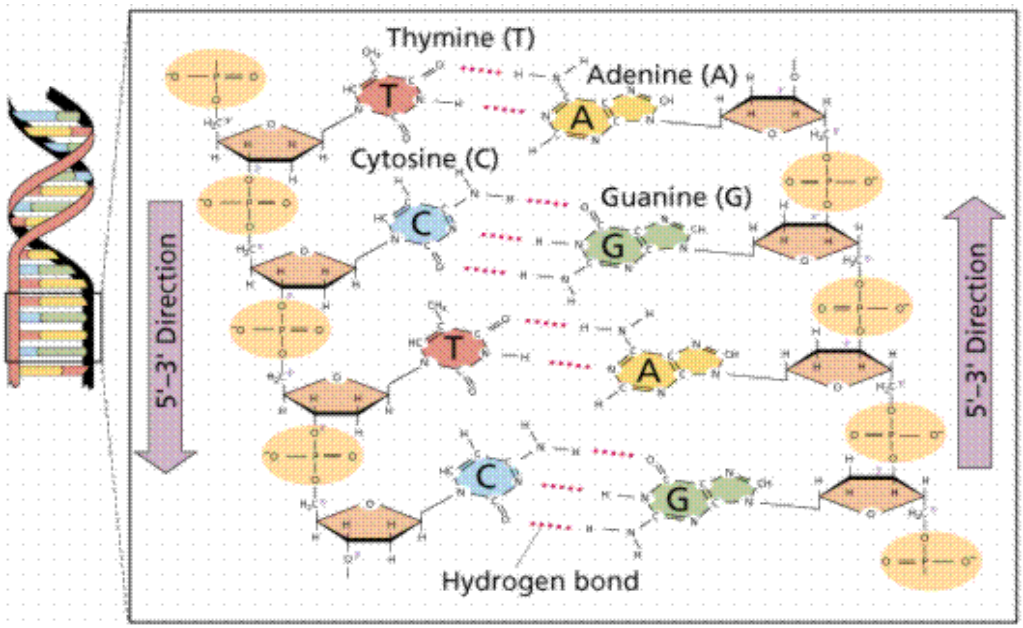


# Gamete Formation



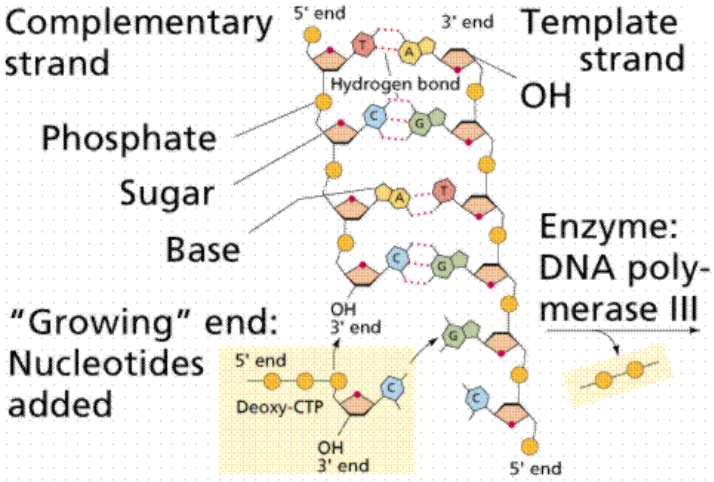
# DNA Structure

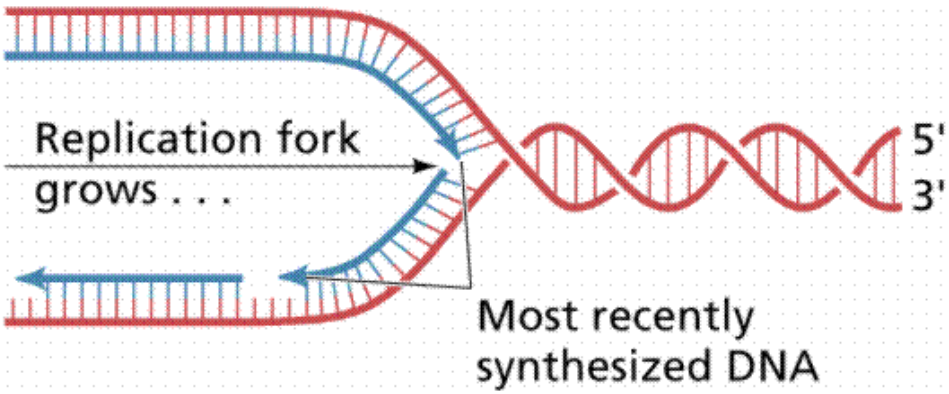
- Double helix
- Antiparallel – 3′ to 5′
- Nucleotide
  - Deoxyribose sugar
  - Phosphate
  - Nitrogen bases
    - Adenine
    - Thymine
    - Guanine
    - Cytosine



# DNA Replication

- **Replication (in nucleus)**
- **DNA uncoils & splits**
- **Reads 3′ to 5′**
- **Assembles 5′ to 3′**
- **4 types of nucleotides**
- **Okazaki fragments**



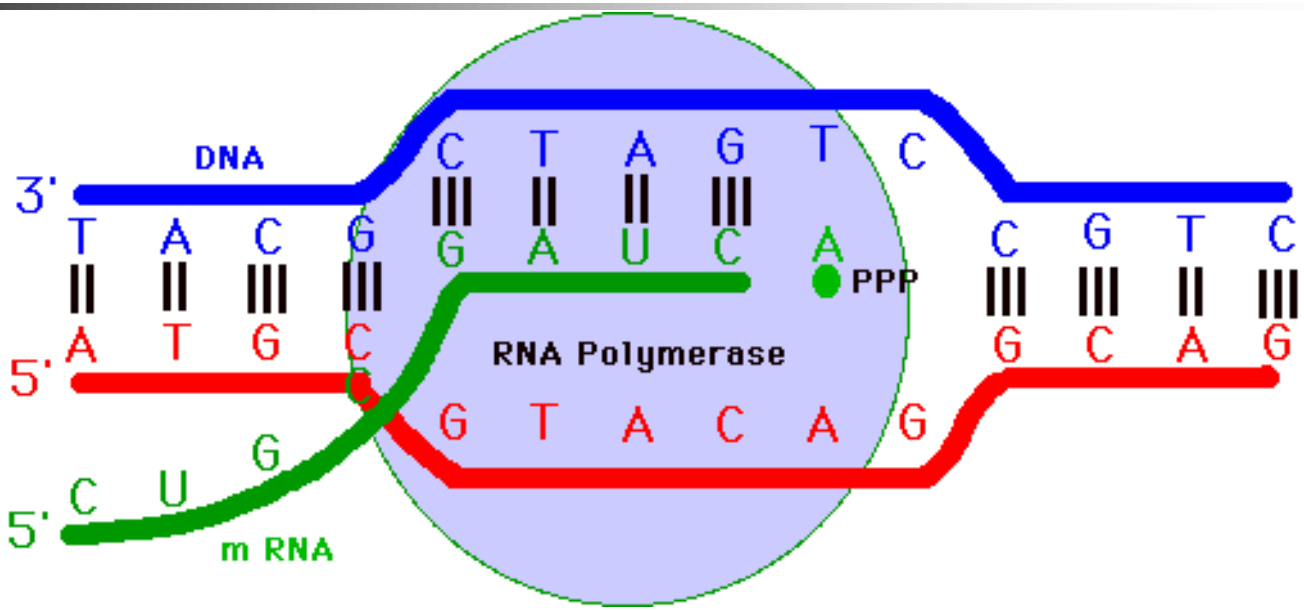
# Types of RNA

- **Differences between DNA & RNA**
  - Single strand
  - Ribose instead of Deoxyribose
  - Uracil instead of Thymine
- **Messenger RNA (m-RNA) – carries blueprint**
- **Transfer RNA (t-RNA) – brings amino acids**
- **Ribosomal RNA (r-RNA) – reads code**

# Gene Expression - Transcription & Translation

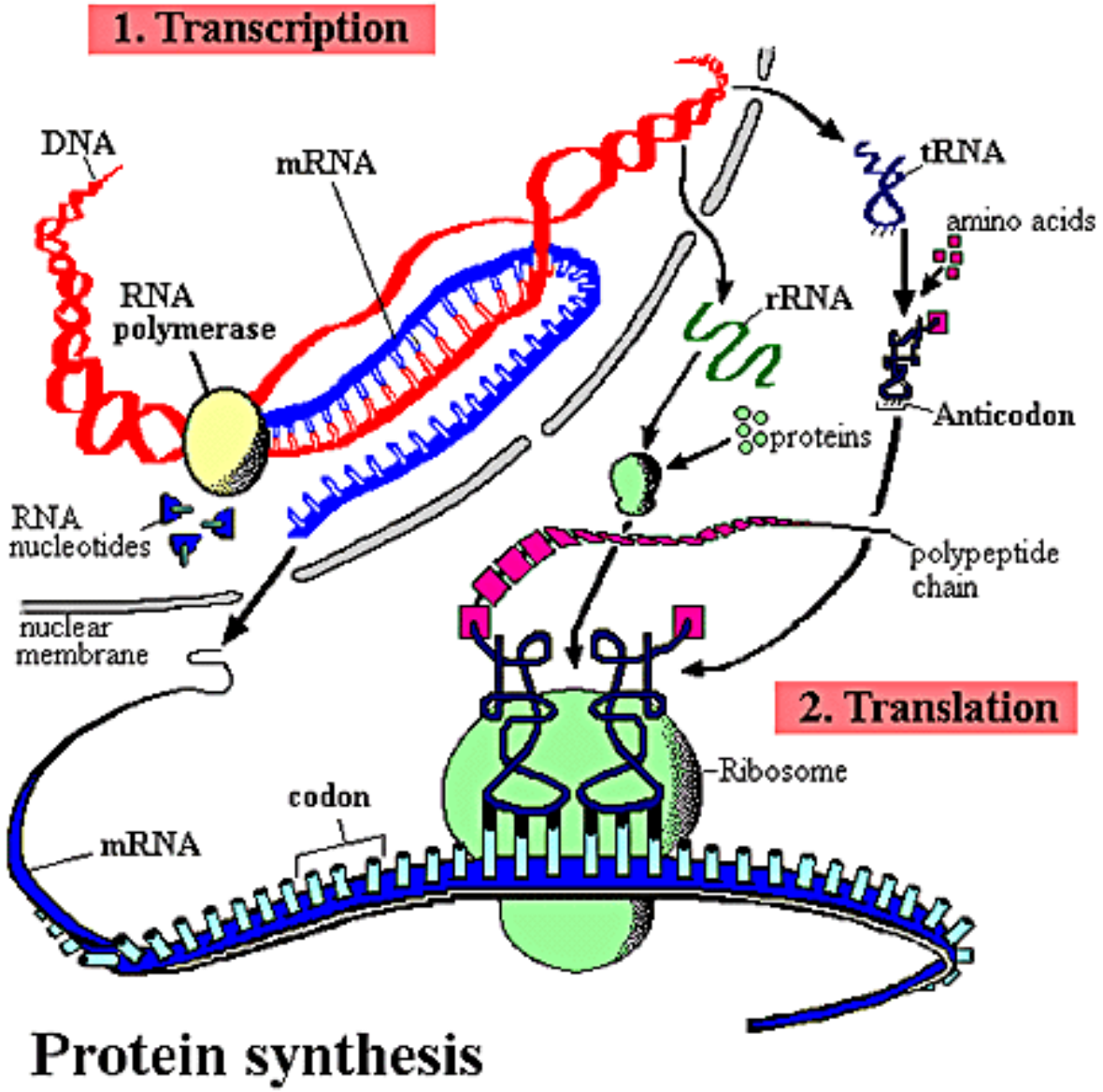
- **Transcription** – makes RNA (in nucleus)
- **Translation (protein synthesis)** -Reads blueprint and makes protein or part of protein (in cytoplasm at the ribosome)

# Transcription of RNA from DNA




- **Transcription:** Synthesis of RNA from a DNA Template.
- Requires DNA-dependent RNA polymerase plus the four nucleotides (ATP, GTP. CTP and UTP).
- Synthesis begins at a the initiation site on DNA
- The template strand is read 3' to 5' and the mRNA is synthesized 5' to 3'

# Translation – Protein Synthesis



# Mutations

- **Mutation – any change in the DNA**
- **Gene mutation**
- **Chromosomal mutation**
- **Agents causing mutations – radiation, chemicals, excess heat**

# Genetic Disorders

- **Causes of mutations –** chemicals, radiation, temperature, viruses
- **Nondisjunction** – chromatids do not separate properly during meiosis. Individual formed from such gametes have extra or missing chromosomes. as Down's Syndrome
- **Trinucleotide repeats –** sequences of 3 nucleotides is repeated, often several times in a gene when too many repeats are formed – cause genetic disorders triplet nucleotides -repeated too often as Huntington's
- **Defective genes** – does not produce correct protein as sickle cell anemia (A & T traded places)
- **Genetic disorders and their causes** as nondisjunction (Down's syndrome), trinucleotide repeats (fragile X and Huntington's), defective genes (sickle cell anemia, hemophilia)
- **Human genetic disorders –** can be dominant, recessive, sex-linked, epistatic, variable expressed
- **Crossover frequency –** during meiosis, pieces trade places – determining frequency

# Polymerase Chain Reaction (PCR)

- **Technique for quickly making an unlimited number of copies of any piece of DNA**
- **Sometimes called "molecular photocopying"**

