Heredity - Patterns of Inheritance

Genes and Alleles

A. Genes
1. A sequence of nucleotides that codes for a special functional product
   a. Transfer RNA
   b. Enzyme
   c. Structural protein
   d. Pigments
2. Genes control development and function of organisms

B. Alleles
1. Different forms of the same gene
2. Alleles create the possibility for inherited variations within a species

Organization of Genes on Chromosomes

A. Chromosomes
1. DNA molecules with large quantities of histone proteins associated

B. Genes on DNA
1. About 1% of Eukaryotic chromosome DNA codes for expressed protein

C. Prokaryotic Chromosomes
1. Little protein associated
2. Most of DNA codes for expressed protein

Techniques for Studying Chromosomes

A. Identifying Homologs
1. Similar size
2. Same centromere location
3. Staining
   a. Similar banding pattern

B. Karyotype
1. Pairing of homologs from enlarged photo of the chromosomes
2. Can be used to identify certain anomalies in a developing fetus

Sex Determination

A. XY System (Humans)
1. All ova carry one X chromosome
2. 1/2 of sperm carry an X, the other half carry a Y
3. Sex of embryo is determined by sperm
   a. XX = female
   b. XY = male

B. XO System (Some insects)
1. Females have two X chromosomes
2. Males have one X chromosome

C. ZW System (Birds, some fish, some insects)
1. ZZ = male
2. ZW = female
Mendel's Work
A. Gregor Mendel (1822-1884)
   1. Monk who made some of the initial studies of inheritance patterns
   2. Did most of his work with pea plants
B. Developing “True Breeding” varieties
   1. Isolated plants and self bred to be sure they carried only the
      traits he desired
C. Cross Breeding
   1. Breeding two different true breeding plants

Principles of Segregation and Independent Assortment
A. Hybrids
   1. Offspring of parents with different traits
   2. Monohybrids
      a. Crosses between parents that differ in only one trait
B. Green pod/Yellow pod Crosses
   1. F₁ (first filial) generation
      a. All pods were green
   2. F₂ (second filial) generation
      a. 3:1 ratio of green to yellow pods
C. Dominant/Recessive
   1. Dominant trait
      a. Only trait visible in the F₁ generation
   2. Recessive trait
      a. Hidden in F₁ but reappears in F₂
D. Punnett Squares
   1. Representation of hybrid crosses

\[ F₁ = GG \times gg \quad F₂ = Gg \times Gg \]

E. Genotype - Alleles carried by an organism
   1. Heterozygous (Gg)
      a. The two alleles for a gene are different
   2. Homozygous
      a. The two alleles for a gene are the same
         (1) Homozygous dominant - GG
         (2) Homzygous recessive - gg
F. Phenotype
   1. Appearance of observable characteristics
      a. GG and Gg show the same phenotype, though they
         are different genotypes
G. Principle of Independent Assortment
   1. Alleles for one characteristic behave independently of other alleles
      during gamete formation
Probability and Genetics

A. Probability
1. Branch of math that predicts the probability that a certain event will happen

B. Examples from genetics
1. Male/Female Offspring
   a. 1/2 or 50% probability for each birth
   b. Probability of 5 offspring all being the same sex

\[
\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{32}
\]

2. Inherited disease - Cystic Fibrosis
   a. 1/20 people are carriers
   b. Marriages between two carriers

\[
\frac{1}{20} \times \frac{1}{20} = \frac{1}{400}
\]

c. Trait is recessive, so 1/4 of offspring will be affected

\[
\frac{1}{4} \times \frac{1}{400} = \frac{1}{1600}
\] children born will have CF

Codominance and Multiple Alleles

A. Codominance
1. Both alleles contribute to the phenotype
   a. Red flower x white flower = pink flower

\[F_1 = RR \times rr\]

\[F_2 = Rr \times Rr\]

B. Multiple Alleles
1. More than two alleles for the same gene
   a. Blood types ABO
      (1) A & B are codominant
      (2) O is recessive

Multifactorial Inheritance

A. Multifactorial Traits
1. Traits controlled by more than one gene
   a. Environment may also contribute
2. Most human traits are multifactorial
   a. Height
   b. Weight
   c. Intelligence
   d. Hair color
   e. Skin color
   f. metabolic processes
B. Distribution of Multifactorial traits
   1. Graph is a bell curve
      e.g. extremes of height and weight are rare, most people
      would be found somewhere in the middle

Linked Genes
A. Definition
   1. Genes located on the same chromosome
      a. Not all genes assort independently
B. Crossing Over
   1. Linked genes may become "unlinked" by crossing over
   2. Frequency of separation in directly proportional to the distance
      between the genes
      a. Used in chromosome mapping

X-Linked Traits
A. Fruit Fly Studies
   1. White eye trait showed up only in male fruit flies
B. Explanation
   1. Gene for white eyes is carried on the X chromosome, with no
      complementary allele on the Y chromosome
      a. Female has normal X to cover the trait
      b. Male has only affected X and a Y chromosome

Nondisjunction
A. Definition
   1. Failure of homologous chromosomes to separate during meiosis
B. Nondisjunction of Sex Chromosomes
1. **XO** - Turner's Syndrome  
   a. Short, underdeveloped, sterile females
2. **XXX**  
   a. Limited fertility, intellectual impairment
3. **XXY** - Klinefelter's Syndrome  
   a. Tall, pear shaped, sexually underdeveloped, slight intellectual impairment

C. Nondisjunction of Autosomes  
1. Most produce a non-viable embryo  
2. Trisomy 21 - Down Syndrome  
   a. Three copies of chromosome 21  
   b. 1/700 live births in the U.S.  
   c. Karyotype of fetus can detect Down Syndrome

**X** Inactivation  
A. Inactivation  
1. One X chromosome in each cell of a female becomes inactive  
2. Inactivation in random, varies from cell to cell  
B. Barr Body  
1. Present only in females  
2. Two Barr bodies in XXX females  
3. Explains why nondisjunction of sex chromosomes tends to be less harmful than nondisjunction of autosomes

Genotype - Environment Interaction  
A. Siamese Cats  
   1. Genotype is for dark fur  
      a. Pigment enzyme is most active at slightly low temperatures  
      b. Only extremities are darkly colored  
B. Studies of Identical Twins  
   1. Allows determination of influence of inheritance vs. environment