5.4 Non-Mendelian Genetics

IST-1.J Explain deviations from Mendel’s model of the inheritance of traits.

- Patterns of inheritance of many traits do not follow ratios predicted by Mendel’s laws and can be identified by quantitative analysis, where observed phenotypic ratios statistically differ from the predicted ratios.

Genes Are Linked

- Linked genes can show the distance between genes on the chromosomes.
- Percentage of recombinant phenotypes measures distance between genes to map the chromosomes.
  - If 1% of crossing-over equals one map unit, then 6.4% recombinants of BC reveal 6.4 map units between genes BC.
  - If crosses are performed for three alleles on a chromosome, only one map order explains map units.

ENDURING UNDERSTANDING

IST-1 Heritable information provides for continuity of life.

Genes Are Linked

- Determine the sequence of genes along a chromosome based on the following recombination frequencies:
  - A-B 8%
  - A-C 28%
  - A-D 25%
  - B-C 20%
  - B-D 33%
IST-1.J Explain deviations from Mendel’s model of the inheritance of traits.

- Some traits are determined by genes on sex chromosomes and are known as sex-linked traits. The pattern of inheritance of sex-linked traits can often be predicted from data, including pedigree, indicating the parent genotype/phenotype and the offspring genotypes/phenotypes.

Sex-Linked Traits

- Thomas Hunt Morgan
  - Work with fruit flies showed XY system similar to mammals.
  - Newly discovered mutant male fruit fly had white eyes.
  - Cross of F1 male with F1 female
    - Yields 3:1 red-to-white ratio
    - All white-eyed flies were males
  - An allele for eye color on the X but not Y chromosome supports the results of the cross.

Pedigree Charts

- Show pattern of inheritance within a family.
  - Males are designated by squares, females by circles
  - Shaded individuals are affected
  - A carrier has no apparent abnormality but can pass on an allele for a recessively inherited genetic disorder.
  - Autosomal dominant and autosomal recessive alleles have different patterns of inheritance.

Sex-Linked Traits

- In certain species, the chromosomal basis of sex determination is not based on X and Y chromosomes
  - ZW in birds
  - Haplodiploidy in bees

Pedigree Charts

- Characteristics of autosomal dominant disorders
  - Affected children must have one affected parent.
  - Heterozygotes are affected
  - Two unaffected parents can produce only unaffected child
- Characteristics of autosomal recessive disorders
  - Affected children can have normal parents
  - Two affected parents always produce an affected child.
  - Close relatives who reproduce together are more likely to have affected children.
IST-1.J Explain deviations from Mendel's model of the inheritance of traits.

- Many traits are the product of multiple genes and/or physiological processes acting in combination; these traits therefore do not segregate in Mendelian patterns.

Polygenic Inheritance

- Trait is controlled by several allelic pairs at different loci.
- Allele can be at different loci on a chromosome or on different chromosomes.
- Examples include skin color, eye color, and height in humans.

Dominance Has Degrees

- Incomplete dominance
  - Offspring intermediate between two parental phenotypes.
  - Blending
- Codominance
  - Both alleles of a gene are expressed.
  - F₁ hybrid is different from both parents and not a blending of traits.

Physiological Effects

- Pleiotropy - one gene many effects
  - Marfan syndrome
  - Failure to produce the protein fibrillin
  - Inability to produce normal connective tissue.
  - Individuals tend to be tall and thin with long legs, arms, and fingers, are near-sighted, and the wall of their aorta is weak (Lincoln?)

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Sex Limited/Influenced Traits

- Male Pattern Baldness
  - X Linked Codominance
  - Hormones affect expression (high testosterone)
IST-1.J Explain deviations from Mendel’s model of the inheritance of traits.

- Some traits result from non-nuclear inheritance
  - Chloroplasts and mitochondria are randomly assorted to gametes and daughter cells; thus, traits determined by chloroplast and mitochondrial DNA do not follow simple Mendelian rules.
  - In animals, mitochondria are transmitted by the egg and not by sperm; as such, traits determined by the mitochondrial DNA are maternally inherited.
    - Ex: Leber optic atrophy (gradual vision loss)
  - In plants, mitochondria and chloroplasts are transmitted in the ovule and not in the pollen; as such, mitochondria-determined and chloroplast-determined traits are maternally inherited.