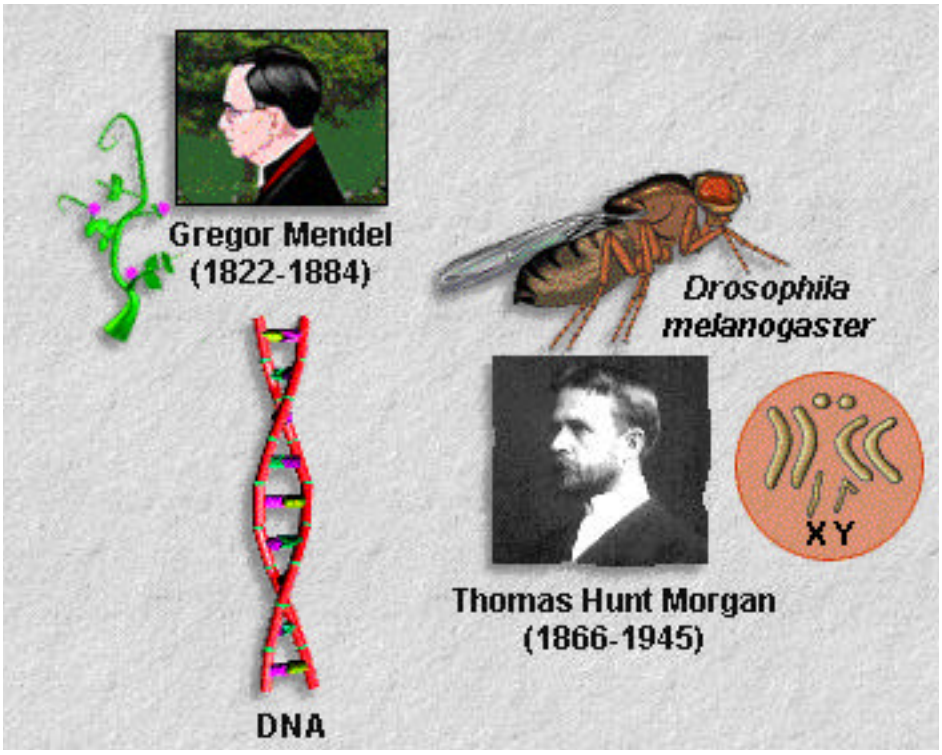
Interactive Biology Multimedia Courseware

Investigating Heredity
Program Supplement



Investigating Heredity
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Investigating Heredity
TEACHING OBJECTIVES

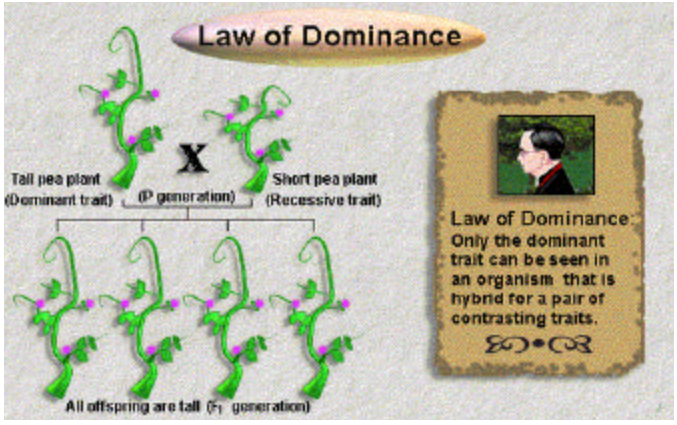
The following subject areas are illustrated throughout the Interactive Biology Multimedia Courseware program, *Investigating Heredity*. Ideally, these areas would be augmented with additional coursework outside of this program.

- Mendel's principles of heredity.
- The chromosome theory of inheritance and the genetic studies of Thomas Morgan.
- Patterns of heredity, including multiple gene inheritance, incomplete dominance, and codominance.
- Human genetic disorders and gene therapy.
- Common human chromosomal disorders.

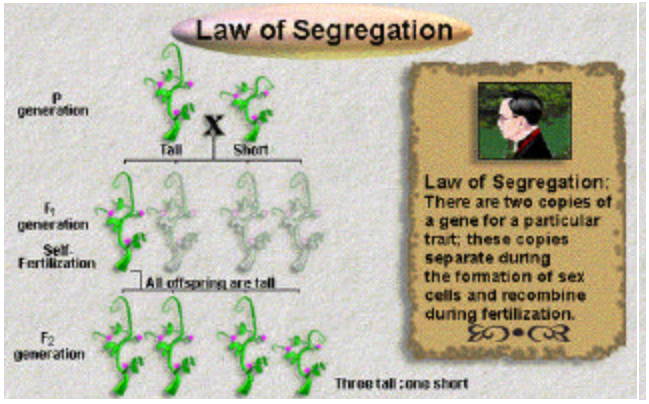
Study Guide #1
MENDEL'S PRINCIPLES OF HEREDITY

By simply looking at a family, whether it be your family, your neighbor's family, or your neighbor's dog's family, it is easy to see that children, or offspring, tend to look like their parents. The reason for this is that within a family, traits are passed from generation to generation. This is called heredity.

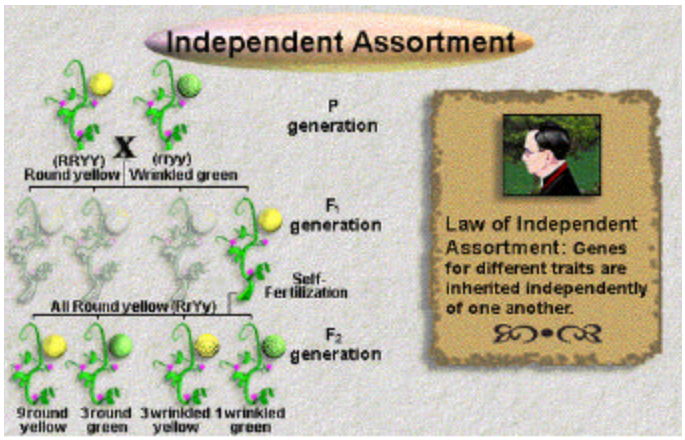
The first person to form some basic principles, or laws, of heredity was Gregor Mendel, the "Father of Genetics." During the mid-1800s, Mendel lived as a monk in what is now Czechoslovakia. There he conducted a series of genetic studies using pea plants. In many of his early experiments he experimented with only one pea plant trait such as plant height. In one study he pollinated a tall pea plant with pollen from a short pea plant. Both plants were pure breeding, meaning that each came from a strain of pea plant that grew to the same height generation after generation. Mendel found that all of the offspring were as tall as the tallest parent plant. He described the tall trait as **dominant** and the short trait as **recessive**. From this came Mendel's **law of dominance**; only the dominant trait can be seen in an organism that is produced from pure parents with contrasting traits.



In another experiment, Mendel found that when he allowed the tall offspring of the F1 generation (i.e. the first generation produced from the original cross) to self-pollinate, the resulting F2 generation contained both tall and short plants. In order to explain why the recessive trait for shortness disappeared in one generation and reappeared in the next, he hypothesized that for each trait there must be two forms of the hereditary "factor" for that trait. He reasoned that these factors separate from each other during the formation of sex cells and then recombine during fertilization. This idea became Mendel's **law of segregation**.



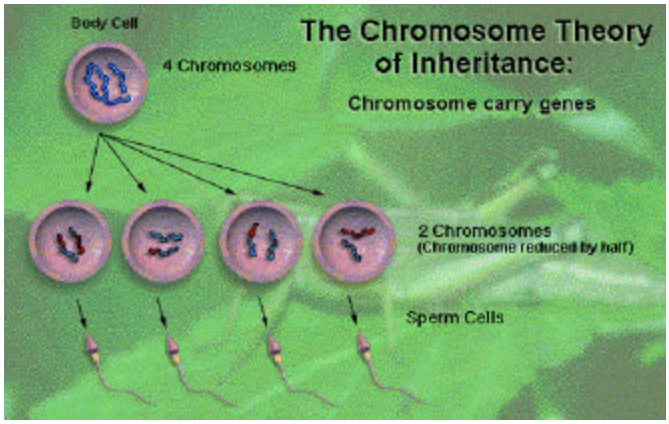
In modern genetics, the hereditary factors referred to by Mendel are called **genes**. Each of us receives two copies of a gene, one from each parent. Each copy of a gene is called an **allele**. When studying genetics, alleles are represented by letters. Dominant alleles are capitalized, while recessive alleles are written in lower case. An individual with two identical alleles for a particular gene is considered **homozygous** for that gene. An individual with one dominant allele and one recessive allele for a particular gene is **heterozygous**.



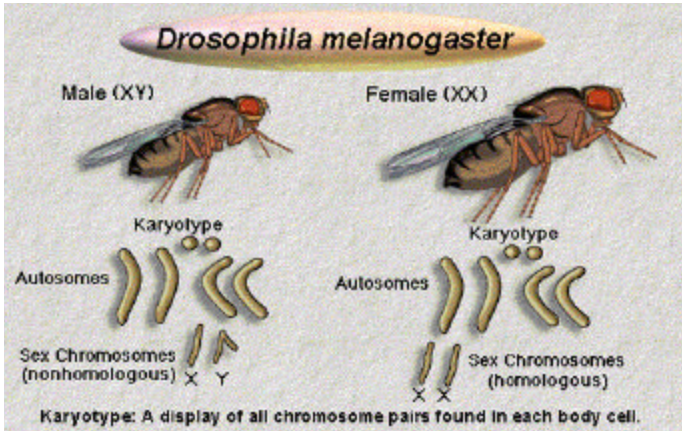
In another experiment with pea plants, Mendel studied the inheritance patterns of two traits. First, he crossed a pea plant that produced round, yellow seeds with one that produced green, wrinkled seeds. All of the offspring from this cross-produced round, yellow seeds. Self-pollination among the offspring produced pea plants with four different types of seeds. From these results, Mendel devised the **law of independent assortment**; genes for different traits, such as those for seed color and seed shape, must be inherited independently of one another.

Study Guide #2
THE CHROMOSOME THEORY OF INHERITANCE

In the early 1900s, about 35 years after Mendel's studies, an American graduate student named Walter Sutton was researching the formation of sperm cells in grasshoppers. He noted that the number of chromosomes found in each sperm cell was exactly half the number of chromosomes found in a grasshopper's body cells. Chromosomes, as you may already know, are the rod-like structures found in cells. They are made up of protein and DNA, an organism's hereditary substance. Recalling Mendel's law of segregation - two copies of a gene separate during formation of sex cells - Sutton suggested that chromosomes carry genes. This idea has since become known as the **chromosome theory of inheritance**.

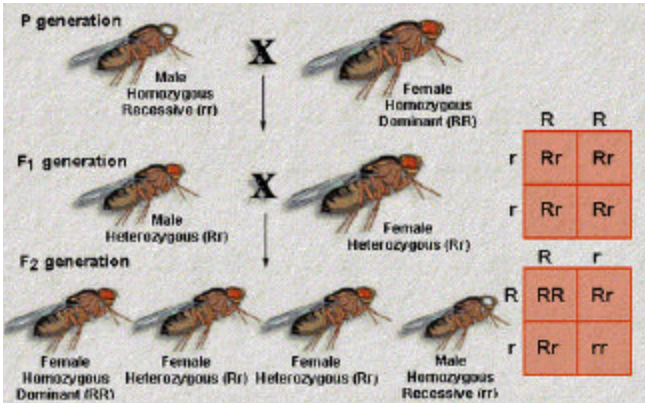


American geneticist Thomas Hunt Morgan gathered the first evidence that actually proved that genes were indeed carried by chromosomes in the early 1900s. Morgan used the fruit fly *Drosophila melanogaster* in his experiments. Fruit flies are ideal for genetic research because they are easily maintained in large numbers in laboratories due to their tiny size, they reproduce quickly, and they have only four pairs of chromosomes.



One day, after a year of breeding flies and looking for unusual individuals, Morgan discovered a male fly with white eyes. This was a trait that he had never seen before, so he decided to mate the mutant white-eyed male with a normal red-eyed female. He found that all of the offspring had red eyes. Thus, he concluded that the allele for white eyes is recessive.

Next, Morgan crossed two flies from the red-eyed offspring. Among the resulting offspring, the F2 generation, approximately three-quarters of the flies had red eyes, while the remaining quarter had white eyes. Morgan noticed something peculiar about the white-eyed flies - all of them were male. What's more, all of the red-eyed flies of the F2 generation were female.



In his next experiment, Morgan mated the original white-eyed male with a red-eyed female from the first generation of offspring. Among the offspring from this cross, half of the females had red eyes, while the other half had white. The same ratio of red eyes to white was found among the males. Morgan knew that the Y chromosome is shorter than the X chromosome, so he thought the allele for eye color might be missing from the Y chromosome. This would explain the results of his latest cross.

To test his hypothesis further, Morgan crossed a white-eyed female with a red-eyed male. He predicted that all female offspring would have red eyes since the red-eye trait is dominant. All males, on the other hand, should have white eyes since they would only inherit a single white-eye allele should the allele for eye color be missing on the Y chromosome. The actual results matched Morgan's predictions, proving the existence of a **sex-linked trait**. A sex-linked trait is a trait determined by a gene found on a sex chromosome. The discovery of sex-linked traits also gave credibility to the earlier hypothesis that genes are located on chromosomes.

Each human cell contains about 100,000 genes. Since there are 46 chromosomes in a cell, each chromosome must contain thousands of genes. Genes located on the same chromosome are called **linked genes**. All of the genes on a single chromosome make up a **linkage group**.

Study Guide #3
PATTERNS OF HEREDITY

As mentioned in Study Guide #1, Gregor Mendel was the first person to describe the dominant-recessive relationship between alleles of a gene. Through his studies with pea plants, it became clear to Mendel that traits followed patterns of heredity. In the case of pea plant height a pattern of complete dominance was observed. The allele for tallness is dominant to the allele for shortness, so crossing a homozygous tall plant with a homozygous short plant always produced heterozygous tall plants.

When inheritance of a particular trait follows a pattern of incomplete dominance, the phenotype of the individual lies somewhere between the phenotypes of the homozygous dominant and homozygous recessive individuals. An example of incomplete dominance can be seen in the flowers of a snapdragon. If a snapdragon with red flowers is crossed with a snapdragon with white flowers, the resulting offspring will have neither red nor white flowers. Instead, the new snapdragon will have pink flowers, a color between red and white.

ABO Blood Group System	
Genotype	**Blood Type**
$I^A I^A$ or $I^A i$	A
$I^B I^B$ or $I^B i$	B
$I^A I^B$	AB
ii	O

Alleles of a gene may also be **codominant**. In this case both alleles show up in the phenotype. Evidence of codominance can be seen in the human ABO blood type system. A, B, and O are the three alleles that determine human blood type. The A and B alleles are dominant, while the O allele is recessive. If the A allele is paired with the O allele, the blood type is A. However, when a person inherits an A allele from one parent and a B allele from the other, his or her blood type is AB since both alleles are dominant.

Many traits in both animals and plants actually vary between extreme forms. For example, people are not just tall or short. Instead, the height of humans ranges from very short to very tall. A trait that ranges between two extremes is the single expression of two or more genes. This pattern of heredity, in which two or more genes result in a single characteristic is called **multiple-gene**, or **polygenic**, **inheritance**.

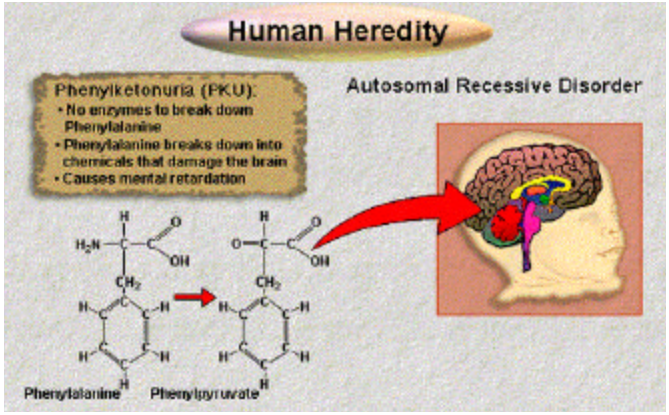
Study Guide #4
HUMAN GENETIC DISORDERS

Just as genes for hair and eye color are passed from parents to offspring, so to are genes for many diseases. Defective alleles may be dominant or recessive, sex-linked or autosomal. Genetic disorders also vary in severity from relatively harmless color blindness to life-threatening Huntington's disease.

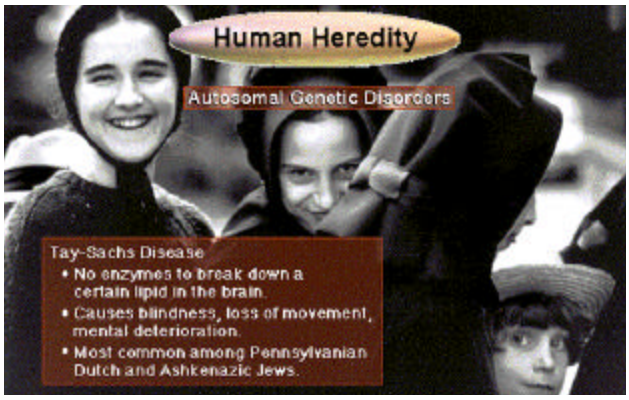
Two common sex-linked genetic disorders are **hemophilia** and **red-green color blindness**. Hemophilia is a blood disorder in which the blood cannot clot due to the absence of a clotting protein. Someone who inherits hemophilia, therefore, is in danger of bleeding to death from even a small cut. The allele is recessive and is found on the X chromosome. Since a male has only a single X chromosome, he has no chance of carrying a dominant allele that will mask the expression of the hemophilia trait should he inherit the recessive allele. Thus, many more males than females suffer from hemophilia. One in every 10,000 males is a hemophiliac, while only one in every 100 million females suffers from the disease.

As indicated by the name of the disease, a person with red-green color blindness cannot differentiate between the colors red and green. Like hemophilia, the allele for red-green color blindness is also recessive and found on the X chromosome, and is therefore much more frequent among males than females.

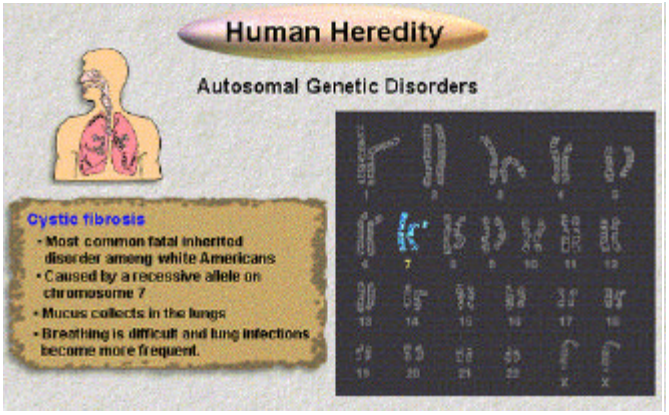
Many other human genetic disorders are caused by recessive alleles on non-sex chromosomes, or autosomes. One such disorder is **sickle-cell anemia**. Individuals with this disease have red blood cells that are shaped like sickles rather than disks. The sickle-shaped red blood cells carry less oxygen and have a shorter life span than the normal disk-shaped red blood cells. Furthermore, the sickle shape of the cells causes them to clump together and clog blood vessels, preventing the transport of oxygen and carbon dioxide to and from tissues. Sickle-cell anemia is most common among African-Americans.



Phenylketonuria, or PKU, is another autosomal recessive disease. A person with PKU lacks the enzyme necessary to properly breakdown the amino acid phenylalanine. Phenylalanine, therefore, breaks down into chemicals that can damage the brain and cause mental retardation. Infants with PKU can be diagnosed at birth with a simple biochemical test. To avoid brain damage, they must follow a special diet low in phenylalanine.

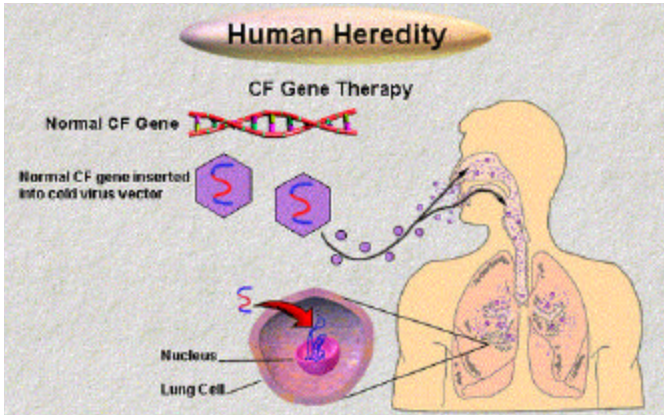


Like PKU, **Tay-Sachs disease** is an autosomal recessive disease characterized by damage to the brain. A person with Tay-Sachs disease lacks the enzyme that breaks down a certain lipid in the brain. The lipid accumulates in the brain, causing blindness, loss of movement, and mental deterioration. This disease is most common among Pennsylvania Dutch and Eastern European, or Ashkenazic, Jews. The symptoms of Tay-Sachs disease usually occur before the age of one and typically cause death by age five.



Among white Americans, **cystic fibrosis**, or CF, is the most common fatal inherited disorder. Researchers have discovered that the disease is caused by a recessive allele located on chromosome 7. The main symptom of CF is a build up of unusually thick mucus in the lungs. Breathing becomes more difficult and lung infections become more frequent. Although new drug therapies, special diets, and physical therapy have raised their life expectancy, most CF patients live only until early adulthood.

All of the genetic disorders mentioned above are caused by recessive alleles and therefore will not affect a person if he or she inherits a dominant allele. **Huntington's disease**, on the other hand, is caused by a dominant allele found on chromosome 4. Thus, any child born to a parent with Huntington's disease has a fifty percent chance of inheriting the disease. The disease causes a progressive breakdown of the nervous system, resulting in jerky movements of the head and limbs, mental deterioration, and eventually death. Huntington's disease usually appears between ages thirty and fifty.

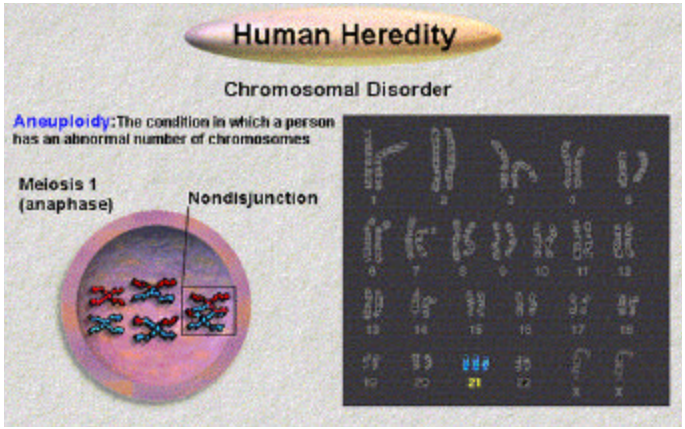


In the past, the concept of altering one's genetic code to correct genetic disorders was the stuff of science fiction. Today, however, **gene therapy** - the insertion of normal genes into human cells to correct genetic disorders - is already undergoing trials at the world's leading research hospitals. Cystic fibrosis is one of the diseases involved in these trials. A normal CF gene is taken from a cell of a person who doesn't have the disease. This gene is then inserted into the DNA of a cold virus. The cold virus is then introduced into the lungs of the CF patient, where it is hoped that the cold virus DNA, which contains the normal CF gene, will integrate in the DNA of the lung cells and eliminate the disease.

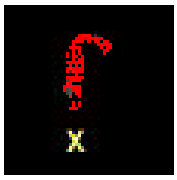
Study Guide #5
HUMAN CHROMOSOMAL DISORDERS

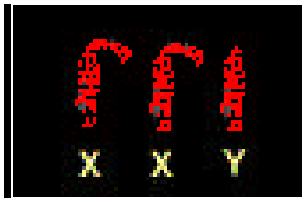
As mentioned previously, humans have 46 chromosomes - 22 pairs of autosomes and 2 sex chromosomes. Aneuploidy is the condition in which a person has an abnormal number of chromosomes. This is usually the result of **nondisjunction**, when paired homologous chromosomes fail to separate during meiosis.

Down syndrome is caused by an aneuploidy of chromosome 21. A person with Down Syndrome has three copies of chromosome 21, a condition known as a trisomy. Symptoms include a short stature, a large, thick tongue, and at least mild mental retardation. The probability that a mother will give birth to a child with Down syndrome is higher among older mothers, particularly those over the age of 40.



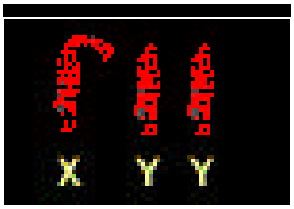
Aneuploidy of the sex chromosomes is known to cause several other chromosomal disorders including **Turner syndrome**, **Klinefelter's syndrome**, and an extra Y chromosome in males. Turner syndrome occurs when an individual has only a single X chromosome and no Y chromosome. A person with Turner syndrome is a female, since she has an X chromosome, but she has no ovaries and her sex characteristics are underdeveloped. This disorder is common, occurring once in every 2,000 births.





Klinefelter's syndrome is a condition in which a male is born with an extra X chromosome. Such a person is indeed a male because of the presence of the Y chromosome. A man with Klinefelter's often displays some female characteristics and is usually taller than average, has unusually long limbs, is sterile, and suffers from some degree of mental retardation.

As many as one per thousand males has an extra Y chromosome. **XYY** males are fertile and appear normal, although they are usually taller than average. It was once believed that males with an extra Y chromosome had criminal tendencies, but further studies have shown that only a minimal correlation exists, if any.



Investigating Heredity
QUIZ PACK

The following quizzes are meant to test student understanding of specific topic areas covered in the Interactive Biology Multimedia Courseware program, *Investigating Heredity*. Many, but not all, of these questions have been addressed directly in the study guides designed to strengthen student understanding of these topics.

QUIZ #1	Mendel's Principles of Genetics
QUIZ #2	The Chromosome Theory of Inheritance
QUIZ #3	Patterns of Heredity
QUIZ #4	Human Genetic Disorders
QUIZ #5	Human Chromosomal Disorders

Quiz #1
MENDEL'S PRINCIPLES OF HEREDITY

1. The "Father of Genetics" is _____.

   A. James Watson
   B. Francis Crick
   C. Gregor Mendel
   D. Albert Einstein

2. Each copy of a gene is called a(n) _____.

   A. chromosome
   B. allele
   C. DNA
   D. protein

3. An individual with two identical alleles for a particular gene is _____ for that gene.

   A. homozygous
   B. dominant
   C. heterozygous
   D. recessive

4. When Mendel crossed a pure breeding tall pea plant with a pure breeding short pea plant, all of the resulting plants were tall. In this case, the tall gene was _____ and the short gene _____.

   A. recessive, dominant
   B. homozygous, heterozygous
   C. dominant, recessive
   D. none of the above

5. The genetic principle that states that only the dominant trait can be seen in an organism produced from pure breeding parents with contrasting traits, is called _____.

   A. Mendel's law of segregation
   B. Mendel's law of independent assortment
   C. Mendel's law of dominance
   D. none of the above

6. The genetic principle that states that genes for different traits must be inherited independently of one another is called _____.

   A. Mendel's law of segregation
   B. Mendel's law of independent assortment
   C. Mendel's law of dominance
   D. none of the above

7. The genetic principle that states that hereditary factors (i.e. alleles) separate from each other during the formation of sex cells and then recombine during fertilization is called _____.

   A. Mendel's law of segregation
   B. Mendel's law of independent assortment
   C. Mendel's law of dominance
   D. none of the above

Quiz #2
THE CHROMOSOME THEORY OF INHERITANCE

1. The chromosome theory of inheritance states that _____.

   A. genes carry chromosomes
   B. chromosomes are made up of DNA and protein
   C. chromosomes are rod-like structures found in the nucleus of a cell
   D. chromosomes carry genes

2. The first person to propose the chromosome theory of inheritance was _____.

   A. Walter Sutton
   B. Thomas Hunt Morgan
   C. Gregor Mendel
   D. Francis Crick

3. _____ proved that chromosomes carry genes by conducting experiments with _____.

   A. Walter Sutton, rats
   B. Walter Sutton, fruit flies
   C. Thomas Hunt Morgan, fruit flies
   D. Thomas Hunt Morgan, pea plants

4. A trait that is determined by a gene located on a sex chromosome is called a(n)_____.

   A. autosomal trait
   B. dominant trait
   C. linkage group
   D. sex-linked trait

5. A chromosome may carry thousands of genes.

   A. True
   B. False

6. Linked genes are _____.

   A. genes located on separate chromosomes that interact with each other
   B. genes located on the same chromosome
   C. genes on separate chromosomes that affect the same trait
   D. all of the above

7. All of the genes on a single chromosome form a(n) _____.

   A. genome
   B. allele
   C. linkage group
   D. aneuploidy

8. In fruit flies, the allele for white eyes is recessive and found only on the X chromosome. If a white-eyed male is crossed with a homozygous red-eye female, which of the following describes the eye-color(s) of the offspring?

   A. red-eyed females, white-eyed males
   B. white-eyed females, red-eyed males
   C. all offspring have white eyes
   D. all offspring have red eyes

Quiz #3
PATTERNS OF HEREDITY

1. Mendel crossed a homozygous tall pea plant with a homozygous short pea plant and all of the offspring were tall heterozygotes. This was an example of _____.

   A. incomplete dominance
   B. complete dominance
   C. codominance
   D. polygenic inheritance

2. The AB blood type is an example of _____.

   A. incomplete dominance
   B. complete dominance
   C. codominance
   D. polygenic inheritance

3. A trait controlled by more than one gene and is an example of _____.

   A. incomplete dominance
   B. complete dominance
   C. codominance
   D. polygenic inheritance

4. If a red-flowered snapdragon is crossed with a white-flowered snapdragon all of the offspring will have pink flowers. This is an example of _____.

   A. incomplete dominance
   B. complete dominance
   C. codominance
   D. polygenic inheritance

5. Human height ranges from very short to very tall and is controlled by a single gene.

   A. True
   B. False

Quiz #4
HUMAN GENETIC DISORDERS

1. Red-green color blindness is an autosomal genetic disorder.

   A. True
   B. False

2. _____ is a blood disorder in which the blood cannot clot due to the absence of a clotting protein.

   A. Sickle-cell anemia
   B. Anemia
   C. Phenylketonuria
   D. Hemophilia

3. Genetic disorders caused by genes located only on the X chromosome are much more common among males than females.

   A. True
   B. False

4. Hemophilia is _____.

   A. sex-linked
   B. caused by a gene located on the X chromosome
   C. a recessive disorder
   D. all of the above

5. Sickle-cell anemia is a(n) _____ disorder.

   A. sex-linked
   B. autosomal
   C. recessive
   D. B and C

6. Sickle-cell anemia is most common among African-Americans.

   A. True

B. False

7. A person who lacks the enzyme to properly breakdown the amino acid phenylalanine suffers from _____.

   A. Tay-Sachs disease
   B. cystic fibrosis
   C. phenylketonuria
   D. Huntington's disease

8. Phenylketonuria, or PKU, is a(n) _____ disorder.

   A. autosomal recessive
   B. autosomal dominant
   C. sex-linked dominant
   D. sex-linked recessive

9. _____ is an autosomal recessive disorder in which a person lacks an enzyme necessary to breakdown a certain lipid in the brain.

   A. Tay-Sachs disease
   B. cystic fibrosis
   C. phenylketonuria
   D. Huntington's disease

10. Tay-Sachs disease is most common among _____.

    A. Ashkenazic Jews
    B. African-Americans
    C. Pennsylvania Dutch
    D. A and C

11. The most common fatal inherited disorder is _____.

    A. Tay-Sachs disease
    B. cystic fibrosis
    C. phenylketonuria
    D. Huntington's disease

12. Which of the following is caused by a dominant allele?

    A. Tay-Sachs disease
    B. cystic fibrosis
    C. phenylketonuria
    D. Huntington's disease

13. Any child born to a parent with Huntington's disease has at least a fifty percent chance of inheriting the disease.

    A. True
    B. False

14. In gene therapy, normal genes are often transferred to the cells of a diseased individual through viral infection of the cells.

    A. True
    B. False

15. All of the following are typical symptoms of Huntington's disease **except** _____.

    A. breakdown of the nervous system
    B. inability to breakdown phenylalanine
    C. mental deterioration
    D. jerky movements of the head and limbs

Quiz #5
HUMAN CHROMOSOMAL DISORDERS

1. The condition in which a person has an abnormal number of chromosomes is called _____.

   A. anemia
   B. cystic fibrosis
   C. phenylketonuria
   D. aneuploidy

2. Humans normally have ___ pairs of autosomes, or non-sex chromosomes, and ___ sex chromosomes.

   A. 44, 2
   B. 22, 2
   C. 22, 4
   D. 23, 2

3. A person with _____ has three copies of chromosome 21.

   A. Down syndrome
   B. Klinefelter's syndrome
   C. Turner syndrome
   D. Tay-Sachs disease

4. The probability that a mother will give birth to a child with Down syndrome is higher among older mothers, particularly those over the age of 40.

   A. True
   B. False

5. A woman with only one X chromosome has _____.

   A. Klinefelter's syndrome
   B. Murdoch syndrome
   C. Redstone syndrome
   D. Turner syndrome

6. A male with an extra X chromosome has _____.

   A. Klinefelter's syndrome
   B. Murdoch syndrome
   C. Redstone syndrome
   D. Turner syndrome

7. Males with an extra Y chromosome were once thought to have criminal tendencies.

   A. True
   B. False

8. A man with Klinefelter's syndrome is likely to display some female characteristics.

   A. True
   B. False

Investigating Heredity
COMPREHENSIVE EXAM

The following exam is based on the Interactive Biology Multimedia Courseware program, *Investigating Heredity.* Most, but not all, of these questions have been addressed directly in the study guides. All of the questions on this exam, however, are based on information put forth in the program.

Please determine if the following statements are true or false.

1. Human height ranges from very short to very tall and is controlled by a single gene.

   A. True
   B. False

2. The gene for red-green color blindness is located on a non-sex chromosome.

   A. True
   B. False

3. A chromosome may carry thousands of genes.

   A. True
   B. False

4. Genetic disorders caused by genes located only on the X chromosome are much more common among males than females.

   A. True
   B. False

5. Sickle-cell anemia is most common among African-Americans.

   A. True
   B. False

6. Any child born to a parent with Huntington's disease has at least a fifty percent chance of inheriting the disease.

   A. True
   B. False

7. In gene therapy, normal genes are often transferred to the cells of a diseased individual through viral infection of the cells.

   A. True
   B. False

8. The probability that a mother will give birth to a child with Down syndrome is higher among older mothers, particularly those over the age of 40.

   A. True
   B. False

9. Males with an extra Y chromosome were once thought to have criminal tendencies.

   A. True
   B. False

10. A man with Klinefelter's syndrome is likely to display some female characteristics.

    A. True
    B. False

In the following portion of the exam, please select the letter next to the word of phrase that best completes each sentence.

11. The "Father of Genetics" is _____.

    A. James Watson
    B. Francis Crick
    C. Gregor Mendel
    D. Albert Einstein

12. Each copy of a gene is called a(n) _____.

A. chromosome
B. allele
C. DNA
D. protein

13. An individual with two identical alleles for a particular gene is _____ for that gene.

A. homozygous
B. dominant
C. heterozygous
D. recessive

14. When Mendel crossed a pure breeding tall pea plant with a pure breeding short pea plant, all of the resulting plants were tall. In this case, the tall gene was _____ and the short gene _____.

A. recessive, dominant
B. homozygous, heterozygous
C. dominant, recessive
D. none of the above

15. The genetic principle that states that only the dominant trait can be seen in an organism produced from pure breeding parents with contrasting traits, is called _____.

A. Mendel's law of segregation
B. Mendel's law of independent assortment
C. Mendel's law of dominance
D. none of the above

16. The genetic principle that states that genes for different traits must be inherited independently of one another is called _____.

A. Mendel's law of segregation
B. Mendel's law of independent assortment
C. Mendel's law of dominance
D. none of the above

17. The genetic principle that states that hereditary factors (i.e. genes) separate from each other during the formation of sex cells and then recombine during fertilization is called _____.

A. Mendel's law of segregation
B. Mendel's law of independent assortment
C. Mendel's law of dominance
D. none of the above

18. Mendel crossed a homozygous tall pea plant with a homozygous short pea plant and all of the offspring were tall heterozygotes. This was an example of _____.

A. incomplete dominance
B. complete dominance
C. codominance
D. polygenic inheritance

19. The AB blood type is an example of _____.

A. incomplete dominance
B. complete dominance
C. codominance
D. polygenic inheritance

20. A trait controlled by more than one gene and is an example of _____.

A. incomplete dominance
B. complete dominance
C. codominance
D. polygenic inheritance

21. If a red-flowered snapdragon is crossed with a white-flowered snapdragon all of the offspring will have pink flowers. This is an example of _____.

A. incomplete dominance
B. complete dominance
C. codominance
D. polygenic inheritance

22. The chromosome theory of inheritance states that _____.

A. genes carry chromosomes
B. chromosomes are made up of DNA and protein
C. chromosomes are rod-like structures found in the nucleus of a cell
D. chromosomes carry genes

23. The first person to propose the chromosome theory of inheritance was _____.

A. Walter Sutton
B. Thomas Hunt Morgan
C. Gregor Mendel
D. Francis Crick

24. _____ proved that chromosomes carry genes by conducting experiments with _____.

A. Walter Sutton, rats
B. Walter Sutton, fruit flies
C. Thomas Hunt Morgan, fruit flies
D. Thomas Hunt Morgan, pea plants

25. A trait that is determined by a gene located on a sex chromosome is called a(n)_____.

A. autosomal trait
B. dominant trait
C. linkage group
D. sex-linked trait

26. Linked genes are _____.

A. genes located on separate chromosomes that interact with each other
B. genes located on the same chromosome
C. genes on separate chromosomes that affect the same trait
D. all of the above

27. All of the genes on a single chromosome form a(n) _____.

A. genome
B. allele
C. linkage group
D. aneuploidy

28. In fruit flies, the allele for white eyes is recessive and found only on the X chromosome. If a white-eyed male is crossed with a homozygous red-eyed female, which of the following describes the eye-color(s) of the offspring?

A. red-eyed females, white-eyed males
B. white-eyed females, red-eyed males
C. all offspring have white eyes
D. all offspring have red eyes

29. The condition in which a person has an abnormal number of chromosomes is called _____.

A. anemia
B. cystic fibrosis
C. phenylketonuria
D. aneuploidy

30. Humans normally have ___ pairs of autosomes, or non-sex chromosomes, and ___ sex chromosomes.

A. 44, 2
B. 22, 2
C. 22, 4
D. 23, 2

31. A person with _____ has three copies of chromosome 21.

A. Down syndrome
B. Klinefelter's syndrome
C. Turner syndrome
D. Tay-Sachs disease

32. A woman with only one X chromosome has _____.

A. Klinefelter's syndrome
B. Murdoch syndrome
C. Redstone syndrome
D. Turner syndrome

33. A male with an extra X chromosome has _____.

A. Klinefelter's syndrome
B. Murdoch syndrome
C. Redstone syndrome
D. Turner syndrome

34. _____ is a blood disorder in which the blood cannot clot due to the absence of a clotting protein.

A. Sickle-cell anemia
B. Anemia
C. Phenylketonuria
D. Hemophilia

35. Hemophilia is _____.

A. sex-linked
B. caused by a gene located on the X chromosome
C. a recessive disorder
D. all of the above

36. Sickle-cell anemia is a(n) _____ disorder.

A. sex-linked
B. autosomal
C. recessive
D. B and C

37. A person who lacks the enzyme to properly breakdown the amino acid phenylalanine suffers from _____.

A. Tay-Sachs disease
B. cystic fibrosis
C. phenylketonuria
D. Huntington's disease

38. Phenylketonuria, or PKU, is a(n) _____ disorder.

A. autosomal recessive
B. autosomal dominant
C. sex-linked dominant
D. sex-linked recessive

39. _____ is an autosomal recessive disorder in which a person lacks an enzyme necessary to breakdown a certain lipid in the brain.

A. Tay-Sachs disease
B. cystic fibrosis
C. phenylketonuria
D. Huntington's disease

40. Tay-Sachs disease is most common among _____.

A. Ashkenazic Jews
B. African-Americans
C. Pennsylvania Dutch
D. A and C

41. The most common fatal inherited disorder is _____.

A. Tay-Sachs disease
B. cystic fibrosis
C. phenylketonuria
D. Huntington's disease

42. Which of the following is caused by a dominant allele?

A. Tay-Sachs disease
B. cystic fibrosis
C. phenylketonuria
D. Huntington's disease

43. All of the following are typical symptoms of Huntington's disease **except** _____.

A. breakdown of the nervous system
B. inability to breakdown phenylalanine
C. mental deterioration
D. jerky movements of the head and limbs

Investigating Heredity
ANSWER GUIDE

QUIZ PACK

QUIZ #1	QUIZ #2	QUIZ #3	QUIZ #4	QUIZ #5
1. C	1. D	1. B	1. B	1. D
2. B	2. A	2. C	2. D	2. B
3. A	3. C	3. D	3. A	3. A
4. C	4. D	4. A	4. D	4. A
5. C	5. A	5. B	5. D	5. D
6. B	6. B		6. A	6. A
7. A	7. C		7. C	7. A
	8. D		8. A	8. A
			9. A	
			10. D	
			11. B	
			12. D	
			13. A	
			14. A	
			15. B	

COMPREHENSIVE EXAM

1. A	11. C	21. A	31. A	41. B
2. A	12. B	22. D	32. D	42. D
3. A	13. A	23. A	33. A	43. B
4. A	14. C	24. C	34. D	
5. A	15. C	25. D	35. D	
6. A	16. B	26. B	36. D	
7. A	17. A	27. C	37. C	
8. A	18. B	28. D	38. A	
9. A	19. C	29. D	39. A	
10. A	20. D	30. B	40. D	

Investigating Heredity
GLOSSARY

allele: one of two copies of an allele.

autosome: a non-sex chromosome.

chromosome: in eukaryotic cells, a rod-like structure made-up of DNA and protein.

chromosome theory of inheritance: the idea proposed by Walter Sutton that chromosomes carry genes.

codominance: a pattern of heredity in which two different dominant alleles are expressed in the phenotype as in the case of AB blood type.

complete dominance: a pattern of heredity in which the dominant allele of a heterozygous pair of alleles is always expressed.

cystic fibrosis: an autosomal, recessive genetic disorder characterized by the build up of thick mucus in the lungs.

Down syndrome: a chromosomal disorder characterized by an extra chromosome 21.

gene: a single hereditary unit.

gene therapy: the treatment of a genetic disorder by inserting the normal gene for the disorder into an individual's genome.

hemophilia: a sex-linked, recessive genetic disorder characterized by the inability of the blood to clot due to the absence of a clotting protein.

heterozygous: the condition when two non-identical alleles for a particular trait are present.

homozygous: the condition when two identical alleles for a particular trait are present.

Huntington's disease: an autosomal, dominant genetic disorder characterized by a progressive breakdown of the nervous system.

incomplete dominance: a pattern of heredity in which the phenotype of a heterozygous individual lies somewhere between the contrasting phenotypes of the homozygous parents.

Klinefelter's syndrome: a chromosomal disorder in males characterized by an extra X chromosome.

law of dominance: in genetics, a law put forth by Gregor Mendel that states that only the dominant trait can be seen in an organism that is produced from pure parents with contrasting traits.

law of independent assortment: in genetics, a law put forth by Gregor Mendel that states that genes for different traits must be inherited independently of one another.

law of segregation: in genetics, a law put forth by Gregor Mendel that states that hereditary factors (i.e. alleles) separate from each other during the formation of sex cells and then recombine during fertilization.

linkage group: all of the genes on a single chromosome.

linked genes: genes located on the same chromosome.

multiple-gene inheritance: also polygenic inheritance; the pattern of heredity in which two or more genes result in a single trait.

nondisjunction: the failure of paired homologous chromosomes to separate during meiosis.

phenotype: a physical characteristic, or trait, determined by one or more genes.

phenylketonuria: an autosomal, recessive genetic disorder characterized by the absence of the enzyme that breaks down the amino acid phenylalanine.

red-green color blindness: a sex-linked, recessive genetic disorder characterized by the inability to distinguish between the colors red and green.

sex chromosome: an X or Y chromosome; a chromosome that helps determine the sex of an individual.

sex-linked trait: a trait determined by a gene located on a sex chromosome.

sickle-cell anemia: an autosomal, recessive genetic disorder characterized by sickle-shaped red blood cells; most common among African-Americans.

Tay-Sachs disease: an autosomal, recessive genetic disorder characterized by the absence of an enzyme that breaks down a certain lipid in the brain; common among Pennsylvania Dutch and Ashkenazic Jews.

Turner syndrome: a chromosomal disorder in females characterized by only one X chromosome.

XYY: a chromosomal disorder in males characterized by an extra Y chromosome.