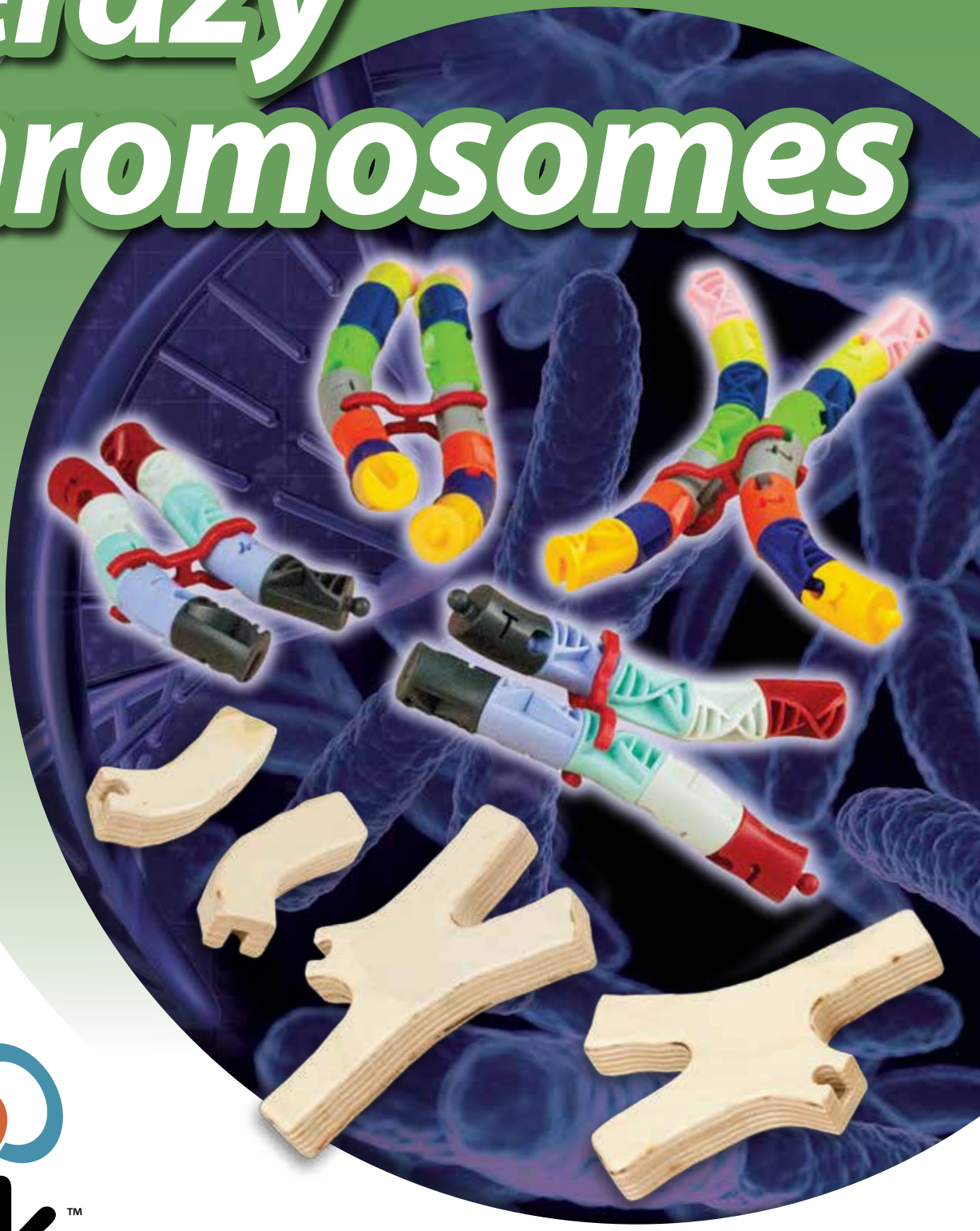
DNA, Inheritance, and Genetic Variation

Crazy Chromosomes



link™
CPO Science

Real Investigations in Science and Engineering

Overview Chart for Investigations–Crazy Chromosomes

	Investigation	Key Question	Summary	Learning Goals	Vocabulary
A1	**DNA Structure** Pages 1–6 50 minutes	What is the structure of the DNA molecule?	Students learn about the basic structure of DNA and the concept of base pairing. Later, they will discover why the structure of DNA is important to other processes such as reproduction, the expression of traits, and mutations.	• Explain the function of DNA in organisms. • Identify the components of a DNA molecule. • Model the structure of DNA.	base base pair base sequence DNA DNA strand double helix hydrogen bond nucleotide nucleus phosphate group
A2	**Genes and Chromosomes** Pages 7–12 50 minutes	How are DNA, genes, and chromosomes related?	Students explore the relationship between DNA, genes, and chromosomes. In the previous investigation, students built models of a DNA segment and learned about the importance of the base sequence and base-pairing. Now they apply what they learned to genes and chromosomes and begin to learn some of the language of genetics.	• Model the relationship between DNA, genes, and chromosomes. • Explain the concept of genome. • Understand the relationship between genes and traits.	allele chromosome diploid set eukaryotic cell gene genome homologous chromosomes karyotype sex chromosome
A3	**Creature Genome** Pages 13–20 50 minutes	What is a genome and how does it influence traits?	Students flip coins to determine the genotype of a fictional creature called a Crazy Creature. They first determine the creature's sex, then the genotypes of its 13 traits. Then, students "decode" their creature's genome by looking up its phenotypes for each trait based on the creature's genotypes.	• Explain how genes, alleles, and traits are related. • Model and interpret a diploid set of chromosomes. • Relate that an organism's genotype determines its phenotype.	dominant genetics genotype heredity heterozygous homozygous phenotype probability recessive trait

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	Investigation	Key Question	Summary	Learning Goals	Vocabulary
A4	**Modeling Mitosis** Pages 21–28 50 minutes	How does mitosis produce exact copies of cells?	Students model the process of mitosis. They begin by making a diploid set of chromosomes to represent a cell in interphase. Then, students double the chromosomes to prepare for mitosis. Next, students actually move the chromosomes through the stages of mitosis as they study a cell cycle diagram.	• Model the process of mitosis. • Describe the purpose of mitosis and where it occurs. • Explain why mitosis results in cells that are genetically identical to the original parent cell.	anaphase body cell cell division centromere chromatid chromatin cytokinesis daughter cells interphase metaphase mitosis parent cell prophase telophase
A5	**Modeling Meiosis** Pages 29–36 50 minutes	How does meiosis produce gametes?	Students model the process of meiosis. This time, however, because there are two meiotic divisions, students will observe that the gametes formed by meiosis have only half the number of chromosomes of the parent cell. They should also observe that there is some variation in alleles of the two gametes.	• Model the process of meiosis. • Compare and contrast mitosis and meiosis in terms of number of cells produced, diploid and haploid numbers, and genetic variation in the end products. • Explain the role of gametes in sexual reproduction.	asexual reproduction egg gamete haploid set homologous pair meiosis sexual reproduction sperm
A6	**Fertilization and Offspring** Pages 37–44 50 minutes	How are offspring produced in sexual reproduction?	Students model the process of fertilization, when a sperm and egg unite. They use the gametes they produced through meiosis and work with another team to pair up the chromosomes from the gametes. Students model how half the chromosomes come from the mother in the egg and half come from the father in the sperm. They also discover that sexual reproduction produces diverse offspring.	• Explain how haploid gametes join to create a diploid zygote during fertilization. • Model how offspring produced by sexual reproduction receive half their chromosomes from the mother in the egg and half from the father in the sperm. • Compare and contrast asexual and sexual reproduction.	egg fertilization sperm zygote
A7	**DNA Function** Pages 45–52 50 minutes	How is DNA's structure related to its function?	Students use pop beads to model DNA function. First, they model the process of DNA replication and learn how the structure of DNA lends itself to making two identical daughter molecules. Next, they model how the base sequences along a DNA strand act as a code for directing the production of proteins.	• Describe the importance of DNA replication. • Explain how the structure of DNA leads to its function. • Model how a gene works.	amino acids base sequence DNA polymerase DNA replication hemoglobin proteins protein synthesis

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A8	**Mutations and Genetic Variation** Pages 53–60 50 minutes	What are mutations and how do they affect organisms?	Students use pop beads to model how a gene mutation happens when a mistake is made during DNA replication. They discover that sometimes the mistake can lead to the formation of a different protein because one of the amino acids is different after the mutation. They develop a model for how mutations lead to genetic variation, and can sometimes be harmful, helpful, or have no effect on a population.	• Develop a model for how mutations happen at the molecular level. • Describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. • Explain the relationship between mutations and adaptations.	adaptation dominant allele genetic disorder genetic variation mutation recessive allele
B1	**Genes and Traits** Pages 61–68 50 minutes	How are DNA, genes, and chromosomes related to traits?	Students explore the relationship between DNA, genes, chromosomes, and traits. In the last investigation, students built models of a DNA segment and learned about the importance of the base sequence and base-pairing. Now they apply what they learned to genes and chromosomes and begin to learn some of the language of genetics.	• Understand the relationship between DNA, genes, and chromosomes. • Explain the concept of genome. • Model and interpret a diploid set of chromosomes. • Relate that an organism's genotype determines its phenotype.	allele chromosome diploid set DNA eukaryotic cell gene genetics genotype genome heredity heterozygous homologous chromosomes homozygous karyotype phenotype sex chromosome trait

Overview Chart for Investigations–Crazy Chromosomes

	Investigation	Key Question	Summary	Learning Goals	Vocabulary
B2	**DNA Structure and Function** Pages 69–78 100 minutes	How is DNA's structure related to its function?	Students use pop beads to build a model of a gene and learn about DNA structure. Using this model, they simulate the processes of DNA replication and protein synthesis. First, they model how one DNA molecule copies itself during DNA replication to produce two identical daughter molecules. Next, they explore how a gene works and model the process of protein synthesis.	• Model the process of DNA replication. • Relate the structure of DNA to its function. • Explain how a gene works.	amino acids base base pair base sequence codon DNA DNA polymerase DNA replication DNA strand double helix hemoglobin hydrogen bond nucleotide nucleus phosphate group proteins protein synthesis
B3	**Chromosomes and Cell Division** Pages 79–86 50 minutes	How do cells divide to produce more cells with exact copies of an organism's genome?	Students model the process of mitosis. They begin by making a diploid set of chromosomes to represent a cell in interphase. Then, students double the chromosomes to prepare for mitosis. Next, students actually move the chromosomes through the stages of mitosis as they study a cell cycle diagram.	• Model the process of mitosis. • Explain why mitosis results in cells that are genetically identical to the original, parent cell. • Describe the purpose of mitosis and where it occurs.	anaphase asexual reproduction body cell cell division centromere chromatid chromatin cytokinesis daughter cells interphase metaphase mitosis parent cell prophase telophase

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	Investigation	Key Question	Summary	Learning Goals	Vocabulary
B4	**Inheritance of Traits** Pages 87–96 100 minutes	How are traits passed on to offspring?	Students model the process of meiosis. They observe that there is some variation in the alleles between the gametes. Then, students model the process of fertilization. Groups team up in gender pairs to share information about their parent creatures, exchange gametes, and pair up chromosomes.	• Model the process of meiosis. • Explain how haploid gametes join to create a diploid zygote during fertilization. • Model how offspring produced by sexual reproduction receive half of their chromosomes from the mother's egg and half from the father's sperm. • Explain why offspring produced by sexual reproduction are genetically diverse.	diploid set egg fertilization gamete haploid set meiosis sexual reproduction sperm zygote
B5	**Traits and Probability** Pages 97–106 50 minutes	How can you predict phenotypes for some traits in offspring?	Students recreate Mendel's famous pea plant experiments using the Crazy Chromosomes set. Students build the chromosomes for a parent generation focusing on the gene for hands on the second chromosome. Students will see how Punnett squares show possible allele combinations while also gaining an appreciation of the role of probability in genetics.	• Understand how Mendel's experiments with true-breeding parent plants produced 100% dominant allele offspring in F1 and a 3:1 ratio in dominant-to-recessive allele offspring in F2. • Learn to use Punnett squares to show the possible allele combinations in offspring. • Understand how probability plays an important role in genetics, for though parents produce gametes that have both of their alleles, they can only pass on one allele in the gamete that is fertilized.	cross dominant allele F1 generation F2 generation P1 generation probability Punnett square ratio recessive allele true-breeding
B6	**Independent Assortment** Pages 107–118 50 minutes	How do two genes on separate chromosome pairs segregate during gamete formation?	Students explore how alleles of genes separate into gametes independently if they are on different chromosomes. Students are introduced to dihybrid crosses, or crosses involving two genes, and use a Punnett square to predict the possible allele combinations for those two genes.	• Describe the laws of inheritance. • Model how two genes on different chromosomes are transmitted to offspring. • Calculate ratios and use them to make predictions or explain the results of a dihybrid cross.	chromosome map dihybrid cross law of dominance law of independent assortment laws of inheritance law of segregation phenotypic ratio ratio segregate sister chromatids

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	Investigation	Key Question	Summary	Learning Goals	Vocabulary
B7	**Linked Genes and Recombination** Pages 119–126 50 minutes	What happens when genes are linked on the same chromosome?	Students build on what they learned about independent assortment from the previous investigation. Here they are presented with another pair of genes, but this time the genes are linked on the same chromosome. Students model how the process of crossover increases genetic diversity.	• Identify ways in which recombination can occur. • Model crossover and explain how it contributes to genetic diversity in offspring. • Calculate phenotypic ratios to analyze and compare data.	crossover linked genes non-linked genes recombination test cross
B8	**Genetic Variation and Adaptations** Pages 127–136 100 minutes	How do mutations contribute to genetic variation?	Students discover how mutations happen and how those mutations can be passed on to offspring. They study a fictional scenario involving Crazy Creatures and explore the concept of natural selection. They analyze how mutations, if favorable, can be passed on to offspring and then increase in the population over generations.	• Develop a model for how mutations happen at the molecular level. • Describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. • Explain the relationship between mutations and adaptations.	adaptation fitness gene mutation genetic disorder genetic variation mutation natural selection
C1	**Sex-Linked Genes** Pages 137–144 50 minutes	What are sex-linked genes and how are they passed on to offspring?	Students explore how sex-linked genes are passed on from parent to offspring. They learn about a sex-linked gene with a recessive allele that causes hemophilia, a genetic blood disorder. They also learn how to make pedigree charts and other tools used by genetic counselors to discuss genetic disorders with patients.	• Model how sex-linked genes are inherited. • Map the inheritance of a genetic disorder using a pedigree chart. • Describe the tools used in genetic counseling to advise patients about genetic disorders.	autosome genetic counseling genetic disorder hemophilia pedigree chart sex chromosome sex-linked gene
C2	**Allele Frequency and Evolution** Pages 145–154 150 minutes	What happens to the frequency of an allele in a population over time?	Students learn to use a mathematical model used by scientists to track how alleles change over time in populations of the same species. They model how favorable alleles are passed on to offspring and how allele frequencies within one of the populations change over time. Finally, they compare the allele frequencies for the two traits in each population.	• Explain how changes in allele frequency over time are an indication that evolution is occurring. • Calculate allele frequencies for populations given the frequency of homozygous recessive individuals. • Evaluate the importance of genetic variation to the survival of a species when changes in the environment occur.	adaptation allele frequency crossover evolution fitness genetic variation Hardy-Weinberg formulas linked genes mutation natural selection non-linked genes recombination

Next Generation Science Standards Correlation

CPO Science *Link* investigations are designed for successful implementation of the Next Generation Science Standards. The following chart shows the NGSS Performance Expectations and dimensions that align to the investigations in this title.

NGSS Performance Expectations	Crazy Chromosomes Investigations
MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.	A1, A2, A3, A7, A8
MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.	A4, A5, A6
MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.	A7, A8
HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.	B1, B2, B4, B5, C1
HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.	B3, B6, B7
HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.	B8, C2

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Next Generation Science Standards Correlation (cont'd)

NGSS Science and Engineering Practices	Crazy Chromosomes Investigations
Analyzing and Interpreting Data	B8, C2
Asking Questions and Defining Problems	B1, B2, B3, B4, B5, B6, C1
Developing and Using Models	A1, A2, A3, A4, A5, A6, A7, A8
Engaging in Argument from Evidence	B7

NGSS Disciplinary Core Ideas	Crazy Chromosomes Investigations
LS1.A: Structure and Function	B1, B2, B3, B4, B5, B6, C1
LS1.B: Growth and Development of Organisms	A4, A5, A6, B3, B4
LS3.A: Inheritance of Traits	A4, A5, A6, B1, B2, B3, B4, B5, B6, C1
LS3.B: Variation of Traits	A1, A2, A3, A4, A5, A6, A7, A8, B7
LS4.B: Natural Selection	B8, C2
LS4.C: Adaptation	B8, C2

NGSS Crosscutting Concepts	Crazy Chromosomes Investigations
Cause and Effect	A4, A5, A6, B1, B2, B3, B4, B5, B6, B7, C1
Structure and Function	A1, A2, A3, A7, A8
Patterns	B8, C2

Common Core State Standards Correlation

CCSS-Mathematics		Crazy Chromosomes Investigations
MP.2	Reason abstractly and quantitatively.	B3, B6, B7, B8, C2
MP.4	Model with mathematics.	A4, A5, A6
6.SP.B 5	Summarize numerical data sets in relation to their context.	A4, A5, A6

CCSS-English Language Arts & Literacy		Crazy Chromosomes Investigations
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.	A1, A2, A3, A4, A5, A6, A7, A8
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.	A1, A2, A3, A4, A5, A6, A7, A8
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.	A1, A2, A3, A4, A5, A6, A7, A8
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	A1, A2, A3, A4, A5, A6, A7, A8
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	B1, B2, B3, B4, B5, B6, B7, B8, C1, C2
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	B1, B2, B4, B5, C1
WHST.9-12.1	Write arguments focused on discipline-specific content.	B3, B6, B7
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	B8, C2
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.	B8, C2