

Geneforge — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Geneforge.

Write in the book, circle your answers, and check the Answer Key at the back.

1. DNA Structure & Function

Circle the correct answer

1. What does DNA stand for?

(A) Dynamic nuclear arrangement (B) Deoxyribonucleic acid (C) Double nucleotide assembly (D) Dinitrogen acid

2. What shape is a DNA molecule?

(A) A double helix (twisted ladder) (B) A single ring (C) A straight line (D) A flat sheet

3. What are the four chemical bases found in DNA?

(A) Actin, tubulin, gelatin, and collagen (B) Adenine, thymine, guanine, and cytosine (C) Alanine, tryptophan, glycine, and cysteine (D) Aluminum, titanium, gold, and carbon

4. Where is DNA found inside a eukaryotic cell?

(A) In the nucleus (B) In the mitochondria only (C) In the cell membrane (D) In the cytoplasm floating freely

5. Why is DNA sometimes called the 'blueprint of life'?

(A) Because it contains the instructions for building and running every living organism (B) Because it is blue in color under a microscope (C) Because it was discovered in a building (D) Because it is shaped like a building

6. How are nucleotides related to DNA?

(A) Nucleotides are separate molecules that float around DNA (B) Nucleotides are the building blocks that link together to form a DNA strand (C) Nucleotides are the same thing as chromosomes (D) Nucleotides destroy old DNA so new DNA can form

Write the answer

7. Explain the base pairing rule in DNA. Why can adenine only pair with thymine?

Answer: _____

8. What is the difference between a gene and a chromosome?

Answer: _____

9. How does the order of base pairs in DNA determine what an organism looks like?

Answer: _____

10. Why is it important that DNA can make exact copies of itself?

Answer: _____

Match each question to its answer

1. If one strand of DNA has the bases A-T-G-C-C-A, what would the matching strand read? →

2. A scientist analyzes a DNA sample and finds it contains 30% adenine. What percentage of the bases are cytosine? →

3. You are building a model of DNA using colored beads. Red beads represent adenine and blue beads represent thymine. If you place 8 red beads on one strand, how many blue beads must go on the opposite strand? →

4. A cell is about to divide. Describe what must happen to the DNA before the cell can split into two. →

5. Humans have 46 chromosomes in most body cells. If a skin cell divides to make two new skin cells, how many chromosomes will each new cell have? →

(A) The DNA double helix must unwind and each strand must be copied so both new cells get a complete set of DNA

(B) 8 blue beads, because every adenine must pair with a thymine

(C) 20%

(D) T-A-C-G-G-T

(E) 46 chromosomes each, because DNA is copied before the cell divides

2. Heredity Basics

Circle the correct answer

11. What is a trait?

(A) A characteristic or feature of an organism, such as eye color or height (B) A chemical found only in DNA (C) A disease that organisms can catch (D) A type of cell found in plants

12. What term describes a version of a gene that always shows its effect when present?

(A) Mutant (B) Recessive (C) Dominant (D) Hybrid

13. What is an allele?

(A) A different version of the same gene (B) A cell that carries traits (C) A protein that builds DNA (D) A type of chromosome

14. How many copies of each gene do humans typically inherit?

(A) One copy from the mother only (B) It varies randomly for each gene (C) Two copies, one from each parent (D) Four copies, two from each parent

15. What is the difference between a phenotype and a genotype?

(A) Genotype applies only to plants and phenotype only to animals (B) Genotype is the set of alleles an organism has, while phenotype is the physical appearance or observable trait (C) Phenotype is the DNA sequence and genotype is the appearance (D) They mean the same thing

16. Why do siblings from the same parents often look similar but not identical?

(A) Each sibling receives a different random combination of alleles from the same two parents (B) Only identical twins share any DNA at all (C) Siblings have completely different DNA from each other (D) The environment changes their DNA after birth

Write the answer

17. How can two brown-eyed parents have a blue-eyed child?

Answer: _____

18. Explain why a recessive trait can skip a generation and reappear in grandchildren.

Answer: _____

19. Why do you look more like your parents than like a random stranger?

Answer: _____

20. What does it mean when someone is described as heterozygous for a trait?

Answer: _____

Match each question to its answer

1. A mother has the genotype Bb for eye color (B = brown, b = blue) and the father has genotype Bb. What are the possible genotypes of their children? →

2. In a family, the father has attached earlobes (recessive trait, ee) and the mother has free earlobes (dominant trait, Ee). What is the chance their child will have attached earlobes? →

3. You notice that your friend can roll their tongue but neither of their parents can. Using your knowledge of heredity, is this possible? →

4. A farmer has a plant that produces red flowers (Rr) and crosses it with a white-flowered plant (rr). Predict the flower colors of the offspring. →

5. Your classmate says they have green eyes like their grandmother, even though both parents have brown eyes. Apply your knowledge of genetics to explain how this happened. →

(A) Tongue rolling is more complex than a single gene, and environmental factors or multiple genes may be involved, so yes this is possible

(B) BB, Bb, or bb

(C) About half the offspring will have red flowers (Rr) and half will have white flowers (rr)

(D) 50%, because half the possible combinations result in ee

(E) Both parents likely carry a recessive green-eye allele inherited from the grandmother, and the classmate received the recessive allele from each parent

3. Punnett Squares

Circle the correct answer

21. What is a Punnett square used for?

(A) To predict the possible genotypes and phenotypes of offspring from a genetic cross (B) To calculate the number of cells in an organism (C) To measure the size of chromosomes (D) To identify the location of genes on DNA

22. In a Punnett square, what do the letters on the top and left side represent?

(A) The alleles from each parent (B) The number of chromosomes (C) The names of the offspring (D) The size of the genes

23. What does 'homozygous dominant' mean?

(A) Having two copies of the recessive allele (B) Having no alleles for that trait (C) Having two copies of the dominant allele (like BB) (D) Having one dominant and one recessive allele

24. What is the genotype ratio from a cross between two heterozygous parents (Bb x Bb)?

(A) 4 BB : 0 Bb : 0 bb (B) 0 BB : 4 Bb : 0 bb (C) 1 BB : 2 Bb : 1 bb (D) 2 BB : 0 Bb : 2 bb

25. Explain why a Punnett square gives probabilities rather than guarantees about offspring.

(A) Because alleles change randomly after fertilization (B) Because which allele each parent passes on is random, like flipping a coin; the Punnett square shows all possibilities but cannot predict which one will actually happen (C) Because parents choose which alleles to pass on (D) Punnett squares are always wrong so they only give estimates, making this the most widely accepted explanation

26. What is the difference between a genotype ratio and a phenotype ratio?

(A) Genotype ratio counts the different allele combinations (like 1:2:1), while phenotype ratio counts the different physical appearances (like 3:1) (B) Phenotype ratio only applies to animals, and this is the standard approach used in most cases (C) Genotype ratio only applies to plants, and this principle applies across similar situations (D) They are the same thing expressed differently, as this is what research and standard practice suggests

Write the answer

27. Why does crossing a homozygous dominant parent (BB) with any other parent always produce offspring showing the dominant trait?

Answer: _____

28. How does a test cross help determine whether an organism with a dominant phenotype is homozygous or heterozygous?

Answer: _____

29. In incomplete dominance, what phenotype ratio would you expect from crossing two heterozygous parents (Rr x Rr) where R is red and r is white?

Answer: _____

30. Why is a monohybrid cross called 'monohybrid'?

Answer: _____

Match each question to its answer

1. Complete this Punnett square: A father is heterozygous for dimples (Dd) and the mother is homozygous recessive (dd). What percentage of their children are expected to have dimples? →

2. Two pea plants that are both heterozygous for seed shape (Rr, where R = round, r = wrinkled) are crossed. Out of 100 offspring, approximately how many would you expect to have wrinkled seeds? →

3. A rabbit breeder has a black rabbit (Bb) and a white rabbit (bb). She wants to produce as many black rabbits as possible. What percentage of offspring from this cross will be black? →

4. In guinea pigs, black fur (B) is dominant over white fur (b). A pet store has a black guinea pig but does not know if it is BB or Bb. Design a cross that would help determine the guinea pig's genotype. →

5. A genetics problem states that both parents are Tt for tallness. You set up a Punnett square and find TT, Tt, Tt, and tt. Your friend says this means they will have exactly 3 tall children and 1 short child. Explain why your friend is not quite right. →

- (A) About 25, because the predicted ratio is 3 round : 1 wrinkled
 - (B) Cross the black guinea pig with a white guinea pig (bb); if any white offspring appear, the black parent must be Bb
 - (C) 50%, with genotypes Bb (black) and bb (white) in equal proportions
 - (D) The Punnett square shows probabilities, not guarantees; each child has a 75% chance of being tall and 25% chance of being short, but the actual results in a small family may not match exactly
 - (E) 50%, because half the offspring will be Dd (dimples) and half will be dd (no dimples)
-

4. Mutations & Genetic Variation

Circle the correct answer

31. What is a mutation?

- (A) A type of cell division
- (B) A change in the DNA sequence of an organism
- (C) A protein that helps cells grow
- (D) The process of DNA copying itself perfectly

32. Which type of mutation involves replacing one DNA base with a different base?

- (A) Duplication mutation
- (B) Substitution mutation
- (C) Insertion mutation
- (D) Deletion mutation

33. What is genetic variation?

- (A) The number of chromosomes in a cell
- (B) The process of DNA replication
- (C) Differences in DNA among individuals in a population
- (D) When all organisms in a population look the same

34. Which of the following can cause mutations in DNA?

- (A) Drinking clean water
- (B) Sleeping eight hours a night
- (C) Eating healthy food
- (D) Ultraviolet radiation from the sun

35. How does a substitution mutation differ from a deletion mutation in terms of what happens to the DNA sequence?

- (A) A substitution swaps one base for another while a deletion removes a base entirely
- (B) There is no difference between substitution and deletion mutations
- (C) A substitution removes a base while a deletion adds a base
- (D) A substitution adds extra bases while a deletion swaps bases

36. Why are most mutations considered neutral, meaning they have no effect on the organism?

- (A) Because DNA never actually changes during an organism's lifetime
- (B) Because all mutations are automatically repaired by the cell
- (C) Because they occur in DNA regions that do not code for important proteins
- (D) Because mutations only affect

plants, not animals

Write the answer

37. What does it mean when scientists say a mutation is 'harmful'?

Answer: _____

38. How do insertion mutations affect the reading of a DNA sequence?

Answer: _____

39. Why is genetic variation important for a population's survival?

Answer: _____

40. How does understanding the difference between inherited mutations and acquired mutations help explain why some mutations are passed to offspring?

Answer: _____

Match each question to its answer

1. A scientist discovers that a population of bacteria has developed resistance to an antibiotic. Which concept best explains how mutations contributed to this resistance?

→

2. The DNA sequence THE CAT ATE THE RAT becomes THE CAT ATT HER AT after a mutation. What type of mutation occurred? →

3. A farmer notices that one plant in a field produces larger fruit than all the others. If the farmer wants this trait in future crops, what should the farmer do? →

4. A student writes the sentence THE BIG RED FOX to represent a DNA sequence. If a substitution mutation occurs at the 8th letter, which result is possible? →

5. Two identical twin mice are raised in different environments. One is exposed to a chemical mutagen and develops spots on its fur, while the other does not. If both mice have offspring, what would you predict? →

(A) Deletion mutation

(B) Save and plant seeds from the large-fruited plant to pass on the mutation

(C) Random mutations gave some bacteria resistance, and those bacteria survived and reproduced more

(D) THE BIG RID FOX

(E) The spotted mouse's offspring would likely not have spots because the mutation was in body cells, not reproductive cells

5. Genetic Traits & Phenotypes

Circle the correct answer

41. What is a phenotype?

(A) The type of mutations an organism carries (B) The observable physical characteristics of an organism (C) The DNA sequence inside an organism's cells (D) The number of chromosomes an organism has

42. What is a genotype?

(A) The total number of genes in an organism (B) The combination of alleles an organism carries for a specific trait (C) The process by which cells divide (D) The physical appearance of an organism

43. What does it mean for an allele to be dominant?

(A) It is always the most common allele in a population (B) It masks the effect of the other allele and determines the phenotype even when only one copy is present (C) It only shows its effect when two copies are present (D) It is stronger and healthier than other alleles

44. What is the term for an organism that has two identical alleles for a trait, such as BB or bb?

(A) Heterozygous (B) Codominant (C) Polygenic (D) Homozygous

45. How does the genotype of an organism relate to its phenotype?

(A) The genotype and phenotype are the same thing (B) The genotype has no connection to the phenotype (C) The phenotype determines what genotype an organism will have (D) The genotype provides the genetic instructions that, together with the environment, produce the observable phenotype

46. Why can two organisms have the same phenotype but different genotypes?

(A) Because a dominant allele masks the recessive allele, so both BB and Bb produce the same phenotype (B) Because phenotype has nothing to do with genotype (C) Because all organisms with the same phenotype are clones (D) Because genotypes change to match the phenotype over time

Write the answer

47. What is incomplete dominance?

Answer: _____

48. How does codominance differ from incomplete dominance?

Answer: _____

49. Why is human skin color determined by multiple genes rather than a single gene?

Answer: _____

50. How can the environment affect an organism's phenotype even though the genotype stays the same?

Answer: _____

Match each question to its answer

1. In snapdragons, red flowers (RR) crossed with white flowers (WW) produce pink offspring (RW). If two pink snapdragons are crossed, what fraction of offspring would you expect to be pink? →

2. A cat has the genotype Bb for fur color, where B (black) is dominant over b (orange). What is this cat's phenotype? →

3. Two heterozygous tall pea plants (Tt) are crossed. What percentage of their offspring would you expect to show the short phenotype? →

4. A farmer has a brown-furred rabbit and wants to determine if its genotype is BB or Bb. How could the farmer figure this out? →

5. In a certain breed of cattle, red coat (R) and white coat (W) are codominant. A red bull (RR) is crossed with a white cow (WW). What will the offspring look like? →

(A) About 25% of the offspring would be short

(B) The cat has black fur because the dominant B allele determines the phenotype

(C) About one-half (50%) of the offspring would be pink

(D) The offspring will have a roan coat with distinct patches of both red and white hairs

(E) Cross the brown rabbit with a white (bb) rabbit and observe the offspring; if any offspring are white, the parent must be Bb

6. Biotechnology & Genetic Engineering

Circle the correct answer

51. What is selective breeding?

(A) The process of randomly mating organisms without any goal (B) The process of choosing organisms with desired traits to reproduce in order to produce offspring with those traits (C) A laboratory technique that directly edits DNA (D) A natural process that happens without human involvement

52. What does GMO stand for?

(A) Genetically Modified Organism (B) Genetic Mutation Operation (C) Generally Modified Offspring (D) Gene Mapping Organization

53. What is the basic goal of genetic engineering?

(A) To prevent all mutations from ever occurring (B) To directly modify an organism's DNA to introduce, remove, or change specific traits (C) To create entirely new species from scratch (D) To speed up natural evolution by millions of years

54. What is CRISPR-Cas9?

(A) A type of microscope used to view chromosomes (B) A computer program that predicts genetic diseases (C) A chemical that causes random mutations in DNA (D) A gene-editing tool that allows scientists to cut DNA at a specific location and make precise changes

55. How does genetic engineering differ from selective breeding in terms of speed and precision?

(A) Genetic engineering can make specific changes in one generation, while selective breeding takes many generations and is less precise (B) Both methods take the same amount of time and have equal precision (C) Genetic engineering is slower but more natural than selective breeding (D) Selective breeding is faster and more precise than genetic engineering

56. Why might scientists insert a gene from one species into a completely different species?

(A) To prove that all species are closely related (B) To give the receiving organism a useful trait it could not develop through its own genetics, such as pest resistance (C) To create a hybrid animal that is half of each species (D) To permanently merge the two species into one

Write the answer

57. What is gene therapy and what is its primary goal?

Answer: _____

58. How is cloning different from genetic engineering?

Answer: _____

59. Why do scientists use bacteria as tools in genetic engineering?

Answer: _____

60. What is a potential benefit of genetically modified crops for farmers in developing countries?

Answer: _____

Match each question to its answer

1. A scientist wants to produce large quantities of human insulin for diabetic patients. How could genetic engineering help accomplish this? →
2. A tomato variety spoils quickly after harvest, causing food waste. How might genetic engineering help solve this problem? →
3. Golden Rice is a genetically modified rice variety that produces beta-carotene, giving it a yellow-orange color. How could this help address a health problem in developing nations? →
4. A community is debating whether to allow GM crops in their farmland. One farmer says GM crops could harm local butterfly populations. Using your knowledge of Bt crops, explain how this could be a valid concern. →
5. If a scientist uses CRISPR to correct a genetic mutation that causes sickle cell disease in a patient's bone marrow cells, would this change be passed to the patient's children? Explain why or why not. →

(A) Insert the human insulin gene into bacteria so they produce insulin as they grow and multiply

(B) It provides vitamin A to populations that rely heavily on rice as a staple food and suffer from vitamin A deficiency

(C) Bt crops produce insecticidal proteins that target pest insects, but the pollen could drift to nearby plants eaten by non-target insects like butterflies

(D) Modify or silence the gene responsible for the ripening enzyme so the tomatoes stay firm longer after harvest

(E) No, because bone marrow cells are somatic cells; only changes to egg or sperm cells can be inherited by children

7. Evolution & Genetics Connection

Circle the correct answer

61. What is natural selection?

(A) The process by which organisms choose which traits they want to develop (B) The random elimination of organisms regardless of their traits (C) The process by which organisms with traits better suited to their environment are more likely to survive and reproduce (D) A type of selective breeding performed by scientists in a lab

62. What is an allele frequency?

(A) The speed at which DNA replicates during cell division (B) The number of chromosomes in an organism (C) The proportion of a specific allele compared to all alleles for that gene in a population (D) The total number of genes in an organism's genome

63. What is genetic drift?

(A) The process by which organisms adapt to their environment over time (B) The deliberate movement of genes from one population to another (C) The movement of organisms from one habitat to another (D) Random changes in allele frequencies in a population due to chance events rather than natural selection

64. What is gene flow?

(A) The transfer of alleles from one population to another when organisms migrate and interbreed (B) The movement of genes within a single chromosome during cell division (C) The flow of nutrients through an organism's digestive system (D) The process of genes being copied during DNA replication

65. How does genetic variation within a population relate to natural selection?

(A) Genetic variation prevents natural selection from occurring (B) Genetic variation has no connection to natural selection (C) Genetic variation provides the raw material for natural selection by creating differences in traits that affect survival and reproduction (D) Natural selection creates genetic variation by forcing organisms to mutate

66. Why is evolution sometimes described as a change in allele frequencies over time?

(A) Because evolution only involves changes to individual organisms' DNA during their lifetime (B) Because evolution only happens when new species are formed (C) Because when certain alleles become more or less common in a population across generations, the population's genetic makeup has changed, which is evolution (D) Because allele frequency never actually changes in real populations

Write the answer

67. How does sexual reproduction contribute to genetic variation in a population?

Answer: _____

68. What is the difference between adaptation and evolution?

Answer: _____

69. Why does natural selection act on phenotypes rather than directly on genotypes?

Answer: _____

70. How does the founder effect demonstrate the relationship between genetics and evolution?

Answer: _____

Match each question to its answer

1. In a population of lizards, those with longer legs can run faster and escape predators more easily. Over 50 generations, the average leg length in the population increases. Explain this outcome using the principles of genetics and natural selection.

→

2. A population of flowers exists in two colors: red and yellow. A new pollinator species arrives that is attracted only to red flowers. Apply your knowledge of genetics and natural selection to predict what will happen to allele frequencies over many generations. →

3. Two populations of squirrels are separated by a new highway. Apply your knowledge of gene flow to predict how this might affect the genetic diversity of each population over time. →

4. A volcanic eruption kills most of a rabbit population, leaving only 12 survivors. Using your knowledge of genetic drift, predict how this bottleneck event will affect the genetic diversity of the future population. →

5. Bacteria that are resistant to an antibiotic can share their resistance genes with non-resistant bacteria through a process called horizontal gene transfer. Apply this concept to explain why doctors warn against overusing antibiotics. →

(A) Overusing antibiotics selects for resistant bacteria, which can then share resistance genes with other bacteria, making more infections untreatable

(B) The frequency of red-color alleles will increase because red flowers will be pollinated more often and produce more offspring

(C) Lizards with alleles for longer legs survived and reproduced more, passing those alleles to offspring, increasing the frequency of long-leg alleles over generations

(D) Without gene flow between them, each population will become less genetically diverse over time and may evolve in different directions

(E) The surviving 12 rabbits carry only a fraction of the original genetic diversity, so the rebuilt population will have reduced genetic variation and may lack alleles that were present before

8. Human Genetics & Genetic Disorders

Circle the correct answer

71. How many chromosomes does a typical human body cell contain?

(A) 48 chromosomes arranged in 24 pairs (B) 23 individual chromosomes (C) 92 chromosomes arranged in 46 pairs (D) 46 chromosomes arranged in 23 pairs

72. What is a sex-linked trait?

(A) A trait that is inherited from only one parent (B) A trait controlled by a gene located on one of the sex chromosomes, usually the X chromosome (C) A trait that determines whether an organism is male or female (D) A trait that is only expressed in one sex and never in the other

73. What is a pedigree chart used for in genetics?

(A) To measure the DNA content of individual cells (B) To trace the inheritance pattern of a specific trait through multiple generations of a family (C) To map the physical location of all genes on a chromosome (D) To predict the weather patterns that affect genetic expression

74. What is a karyotype?

(A) A visual display of an individual's chromosomes arranged in pairs by size and shape (B) A type of microscope used to view genes (C) A blood test that measures protein levels (D) A map showing the location of every gene on DNA

75. Why are males more likely than females to express X-linked recessive disorders such as color blindness?

(A) Because males have only one X chromosome, so a single recessive allele on it will be expressed with no second X to mask it (B) Because females cannot carry alleles for color blindness (C) Because males have weaker immune systems than females (D) Because the Y chromosome causes recessive alleles to become dominant

76. How does Down syndrome differ from most genetic disorders in terms of its cause?

(A) Down syndrome is caused by a virus that attacks chromosomes (B) Down syndrome is caused by having an extra copy of chromosome 21 rather than by a mutation in a single gene (C) Down syndrome is caused by having too few chromosomes instead of too many (D) Down syndrome is caused by a single dominant gene mutation

Write the answer

77. What is a carrier in genetics?

Answer: _____

78. What is genetic counseling and why might someone seek it?

Answer: _____

79. How does cystic fibrosis illustrate the concept of autosomal recessive inheritance?

Answer: _____

80. What is the difference between a genetic disorder and a chromosomal disorder?

Answer: _____

Match each question to its answer

1. A woman who is a carrier for hemophilia ($X^H X^h$) has children with an unaffected man ($X^H Y$). What is the probability that their son will have hemophilia? →
2. Both parents are carriers for sickle cell disease (HbA HbS). They want to know the probability that their next child will be affected, a carrier, or unaffected. Calculate the probabilities. →
3. A couple learns through genetic testing that both carry one copy of the CFTR mutation for cystic fibrosis. They ask a genetic counselor to explain the risk. If they plan to have three children, what is the probability that all three will be unaffected? →
4. A pedigree shows that a genetic disorder appears in every generation, affects both males and females equally, and affected individuals always have at least one affected parent. Based on this pattern, what is the most likely inheritance pattern? →
5. Huntington's disease is caused by a dominant allele, meaning a person only needs one copy to develop the disease. However, it often does not show symptoms until age 30-50. Explain how a person could unknowingly pass this allele to their children before knowing they have it. →

(A) There is a 50% chance that a son will have hemophilia because he has a 50% chance of inheriting the X^h allele from his mother

(B) Autosomal dominant inheritance, because the trait appears in every generation and only requires one copy of the allele

(C) About 42% probability, calculated as $(3/4) \times (3/4) \times (3/4) = 27/64$

(D) 25% chance unaffected (HbA HbA), 50% chance carrier (HbA HbS), and 25% chance affected with sickle cell disease (HbS HbS)

(E) Because symptoms appear late in life, a person can carry and pass on the dominant allele during their reproductive years before they show any signs of the disease

9. Genetics & DNA

Circle the correct answer

81. What does GMO stand for?

(A) Gene Mutation Outcome (B) Genetic Material Origin (C) Genetically Modified Organism (D) Growth Modified Organism

82. What is the name of the gene-editing tool that uses a guide RNA to cut DNA at a specific location?

(A) PCR (B) CRISPR-Cas9 (C) Restriction enzyme (D) Gel electrophoresis

- 83.** What is the process of making identical copies of a gene or organism called?
(A) Transcription (B) Hybridization (C) Mutation (D) Cloning
- 84.** What type of organism is commonly used as a model in genetic engineering experiments due to its rapid reproduction?
(A) Reptiles (B) Mammals (C) Bacteria (D) Fungi
- 85.** What is a small circular piece of DNA found in bacteria that scientists use to insert new genes?
(A) Plasmid (B) Ribosome (C) Chromosome (D) Vacuole
- 86.** What is the first genetically modified food crop approved for sale in the United States?
(A) Flavr Savr tomato (B) Bt corn (C) Roundup Ready soybean (D) Golden Rice

Write the answer

- 87.** Why is CRISPR-Cas9 considered more useful than older gene-editing methods?
Answer: _____
- 88.** How does the Bt gene help crops resist insects?
Answer: _____
- 89.** Why do scientists use restriction enzymes in genetic engineering?
Answer: _____
- 90.** What is the purpose of Golden Rice?
Answer: _____

Match each question to its answer

1. How does selective breeding differ from genetic engineering? →
 2. A farmer wants to grow corn that is resistant to a specific pest. Which approach would give the fastest and most targeted result? →
 3. Scientists want to produce human insulin using bacteria. What must they do first? →
 4. A scientist uses gel electrophoresis after cutting DNA with restriction enzymes. What is gel electrophoresis used for in this process? →
 5. If you were developing a drought-resistant crop, which step would come after identifying the gene responsible for drought tolerance in a desert plant? →
- (A) Separating DNA fragments by size
(B) Insert the human insulin gene into a bacterial plasmid
(C) Cutting out the gene and inserting it into the crop plant's DNA
(D) Inserting a pest-resistance gene using genetic engineering

(E) Selective breeding uses natural mating while genetic engineering directly changes DNA in a lab

10. Genetics & DNA

Circle the correct answer

91. How many chromosomes does a normal human body cell contain?

(A) 23 (B) 44 (C) 48 (D) 46

92. What is a karyotype?

(A) An organized image of all the chromosomes in a cell arranged by size and shape
(B) A type of genetic disease, as this is what research and standard practice suggests
(C) A tool used to cut DNA, as this is what research and standard practice suggests (D)
A diagram of a family tree, and this principle applies across similar situations

93. What is the name of the genetic disorder caused by having an extra copy of chromosome 21?

(A) Down syndrome (B) Cystic fibrosis (C) Sickle cell disease (D) Turner syndrome

94. What sex chromosomes does a typical human male have?

(A) XO (B) XX (C) XY (D) YY

95. What type of genetic disorder is sickle cell disease?

(A) A single-gene disorder caused by a mutation in the hemoglobin gene (B) A disorder caused by too few chromosomes (C) A disease caused by a virus (D) A chromosomal disorder with extra chromosomes

96. What is a genetic carrier?

(A) A doctor who treats genetic conditions (B) An organism that spreads disease to others (C) A person who has one copy of a recessive allele for a disorder but does not show symptoms (D) A person who has a genetic disease

Write the answer

97. Why are males more likely than females to have color blindness?

Answer: _____

98. How can two parents who do not have cystic fibrosis have a child with the disease?

Answer: _____

99. What does a genetic counselor do?

Answer: _____

100. Why is a pedigree chart useful in studying human genetics?

Answer: _____

Match each question to its answer

1. How does nondisjunction lead to conditions like Down syndrome? →
2. Two parents are both carriers for sickle cell disease (Ss). Using a Punnett square, what percentage of their children would you expect to have sickle cell disease? →
3. A doctor examines a patient's karyotype and finds 47 chromosomes with an extra chromosome 18. What condition does this suggest? →
4. A woman who is a carrier for hemophilia ($X^H X^h$) has children with a man who does not have hemophilia ($X^H Y$). What is the probability that their son will have hemophilia? →
5. A newborn screening test detects that a baby has phenylketonuria (PKU). What dietary change must be made? →

- (A) The baby must follow a diet low in the amino acid phenylalanine
 - (B) Chromosomes fail to separate properly during cell division, resulting in cells with an extra or missing chromosome
 - (C) 25%
 - (D) 50%
 - (E) Edwards syndrome (trisomy 18)
-

11. Genetics & DNA

Circle the correct answer

101. What is natural selection?

- (A) The movement of organisms from one area to another (B) The process where organisms with traits better suited to their environment are more likely to survive and reproduce (C) The process of humans choosing which animals to breed (D) Random changes in DNA that occur during replication

102. What is genetic drift?

- (A) A purposeful change in genes by scientists (B) A type of genetic mutation caused by radiation (C) The movement of animals during migration (D) A random change in allele frequencies in a small population due to chance events

103. What is an adaptation?

- (A) A disease caused by a genetic mutation (B) The process of organisms moving to a new habitat (C) A trait that helps an organism survive and reproduce in its environment (D) A chemical used to modify DNA

104. What term describes two or more different forms of a gene that exist in a population?

(A) Chromosomes (B) Organelles (C) Ribosomes (D) Alleles

105. What is a gene pool?

(A) The total collection of all alleles in a population (B) A single organism's complete set of genes (C) A swimming pool made for genetic research (D) The place where genes are stored in a cell

106. Who is known as the father of evolution by natural selection?

(A) Louis Pasteur (B) Charles Darwin (C) Gregor Mendel (D) James Watson

Write the answer

107. Why does natural selection require genetic variation in a population?

Answer: _____

108. How does geographic isolation lead to the formation of new species?

Answer: _____

109. Why is the bottleneck effect a concern for endangered species?

Answer: _____

110. How does antibiotic resistance in bacteria illustrate natural selection?

Answer: _____

Match each question to its answer

1. What is the difference between genetic drift and natural selection? →

2. A population of beetles has two color variations: green and brown. Birds eat the green beetles more easily because they are visible on brown tree bark. Predict what will happen to the beetle population over many generations. →

3. A small island population of 20 birds is hit by a hurricane, and only 5 survive. The 5 survivors all happen to have red feathers. What evolutionary concept does this illustrate? →

4. Farmers use antibiotics on their livestock. Over several years, they notice that some bacterial infections in the animals are no longer cured by the same antibiotic. Apply your knowledge of natural selection to explain why. →

5. Two populations of squirrels are separated by a newly formed canyon. After thousands of years, the populations on each side look very different. Apply your understanding of speciation to explain this. →

- (A) Genetic drift is driven by random chance, while natural selection is driven by which traits help organisms survive
 - (B) The population will have more brown beetles because they survive and reproduce more than green beetles
 - (C) Bacteria with natural resistance survived the antibiotic, reproduced, and their resistant offspring became the dominant population
 - (D) The bottleneck effect (a form of genetic drift)
 - (E) Geographic isolation prevented interbreeding, and each population adapted to its own environment through natural selection and genetic drift
-

12. Genetics & DNA

Circle the correct answer

111. What is gene expression?

- (A) A method for editing DNA sequences, which is why this approach is recommended by experts
- (B) The process of copying entire chromosomes, and this principle applies across similar situations
- (C) The process by which the information in a gene is used to make a functional product, usually a protein
- (D) The total number of genes in an organism, making this the most widely accepted explanation

112. What is epigenetics?

- (A) The study of how genes are edited with CRISPR
- (B) The study of how DNA is inherited from parents
- (C) The study of how new genes are created
- (D) The study of changes in gene activity that do not involve changes to the DNA sequence itself

113. What is DNA methylation?

- (A) The addition of a methyl group to DNA that typically silences gene expression
- (B) The removal of nucleotides from a DNA strand
- (C) The process of DNA replication
- (D) The joining of two DNA molecules together

114. What are histones?

- (A) Enzymes that cut DNA at specific sites
- (B) Proteins that DNA wraps around to help package and organize chromosomes
- (C) The sugar molecules in the DNA backbone
- (D) Small RNA molecules that regulate genes

115. What is the difference between a gene being 'turned on' and 'turned off'?

- (A) Turned-off genes are removed from the cell, making this the most widely accepted explanation
- (B) Turned-on genes are deleted from DNA, as this is what research and standard practice suggests
- (C) All genes are always turned on in every cell, and this has been consistently demonstrated in practice
- (D) A gene that is turned on is actively being used to make a protein, while a turned-off gene is not

producing its protein

116. What is the role of transcription factors in gene expression?

(A) They transport proteins out of the cell (B) They are proteins that bind to DNA and help control whether a gene is turned on or off (C) They copy entire chromosomes during cell division (D) They break down old DNA that is no longer needed

Write the answer

117. Why do skin cells and muscle cells look and function differently even though they contain the same DNA?

Answer: _____

118. How can a mother's diet during pregnancy affect the gene expression of her child?

Answer: _____

119. Why might identical twins develop different traits or diseases as they age, even though they share the same DNA?

Answer: _____

120. How does histone modification affect gene expression?

Answer: _____

Match each question to its answer

1. What does it mean for epigenetic changes to be potentially heritable? →

2. A scientist discovers that a gene for flower color is heavily methylated in one plant but not in another of the same species. Predict how flower color might differ between the two plants. →

3. Researchers find that children who experienced severe famine in early life have different epigenetic patterns than those who did not. Apply your knowledge of epigenetics to explain this finding. →

4. A queen bee and a worker bee have the same DNA but very different bodies and roles. The difference is determined by diet—queens are fed royal jelly. Apply epigenetics to explain how diet causes these differences. →

5. A doctor notices that a patient has a gene for a hereditary disease, but the patient shows no symptoms. Using your knowledge of gene expression, explain how this is possible. →

- (A) The nutritional stress caused epigenetic changes (altered methylation patterns) that modified gene expression related to metabolism and growth
 - (B) Royal jelly triggers epigenetic changes that turn on genes for queen development, while the normal diet keeps those genes silenced in workers
 - (C) The plant with the methylated gene will likely not express the flower color, so its flowers may be a different color or white
 - (D) Some epigenetic modifications can be passed from parent to offspring without changing the DNA sequence
 - (E) The disease gene may be silenced by epigenetic modifications, preventing it from being expressed
-

13. DNA Structure & Function

Circle the correct answer

121. You are building a model of DNA using colored beads. Red beads represent adenine and blue beads represent thymine. If you place 8 red beads on one strand, how many blue beads must go on the opposite strand?

- (A) 0 blue beads, because adenine pairs with guanine (B) 8 blue beads, because every adenine must pair with a thymine (C) 4 blue beads, because only half need to pair (D) 16 blue beads, because each adenine needs two partners

122. In a family, the father has attached earlobes (recessive trait, ee) and the mother has free earlobes (dominant trait, Ee). What is the chance their child will have attached earlobes?

- (A) 0%, because the mother has the dominant allele (B) 100%, because the father is homozygous recessive (C) 50%, because half the possible combinations result in ee (D) 25%, because only one in four outcomes is recessive

123. Why is a monohybrid cross called 'monohybrid'?

- (A) Because it tracks the inheritance of only one trait at a time (B) Because it uses only one allele (C) Because it involves only one parent (D) Because it produces only one offspring

124. A researcher finds that a certain mutation in fruit flies causes shorter wings. In a lab with no predators and plenty of food, the mutation has no effect on survival. In the wild, however, fruit flies with shorter wings are eaten more often. What does this tell us about mutations?

- (A) Short wings are always beneficial because they save energy (B) All mutations are harmful regardless of the environment (C) Whether a mutation is harmful or neutral depends on the environment the organism lives in (D) Mutations only affect organisms in laboratories

125. In snapdragons, red flowers (RR) crossed with white flowers (WW) produce pink offspring (RW). If two pink snapdragons are crossed, what fraction of offspring would you expect to be pink?

(A) About one-quarter (25%) would be pink (B) None of the offspring would be pink
(C) All offspring would be pink (D) About one-half (50%) of the offspring would be pink

126. A pharmaceutical company is using genetically engineered goats that produce a human blood-clotting protein in their milk. Analyze why goats were chosen instead of bacteria for this particular application.

(A) Because bacteria cannot have foreign DNA inserted into them (B) Because complex human proteins often need modifications that bacteria cannot perform, while goat mammary cells can properly fold and modify the protein (C) Because goat milk is the only liquid that can dissolve proteins (D) Because goats are cheaper to buy than bacteria

Write the answer

127. How does the founder effect demonstrate the relationship between genetics and evolution?

Answer: _____

128. A woman who is a carrier for hemophilia ($X^H X^h$) has children with an unaffected man ($X^H Y$). What is the probability that their son will have hemophilia?

Answer: _____

129. Why is it important that DNA can make exact copies of itself?

Answer: _____

130. What term describes a version of a gene that always shows its effect when present?

Answer: _____

Match each question to its answer

1. Complete this Punnett square: A father is heterozygous for dimples (Dd) and the mother is homozygous recessive (dd). What percentage of their children are expected to have dimples? →

2. A classmate says that identical twins have zero genetic differences because they come from the same fertilized egg. Evaluate this claim based on what you know about mutations. →

3. How can the environment affect an organism's phenotype even though the genotype stays the same? →

4. A community is debating whether to allow GM crops in their farmland. One farmer

says GM crops could harm local butterfly populations. Using your knowledge of Bt crops, explain how this could be a valid concern. →

5. A population of mice lives in a forest. Some mice carry alleles for dark fur and others for light fur. A fire destroys half the forest, turning it to ash. Which allele frequency would you expect to change and in which direction? →

(A) This claim is mostly but not entirely true; identical twins start with the same DNA but can develop small differences due to random mutations that occur during development

(B) Environmental factors like nutrition, sunlight, and temperature can influence how genes are expressed without changing the DNA

(C) 50%, because half the offspring will be Dd (dimples) and half will be dd (no dimples)

(D) The frequency of dark-fur alleles would likely increase because dark mice would be better camouflaged on the ash-covered ground and survive predation more often

(E) Bt crops produce insecticidal proteins that target pest insects, but the pollen could drift to nearby plants eaten by non-target insects like butterflies

14. DNA Structure & Function

Circle the correct answer

131. What are the four chemical bases found in DNA?

(A) Actin, tubulin, gelatin, and collagen (B) Aluminum, titanium, gold, and carbon
(C) Alanine, tryptophan, glycine, and cysteine (D) Adenine, thymine, guanine, and cytosine

132. A mother has the genotype Bb for eye color (B = brown, b = blue) and the father has genotype Bb. What are the possible genotypes of their children?

(A) Only BB (B) Only bb (C) BB, Bb, or bb (D) Only Bb

133. Create a genetics problem involving Punnett squares for a fictional animal called a 'Grizzlion' where fur color shows incomplete dominance. Red (RR) x White (WW) = Pink (RW). Show the cross RW x RW and describe the expected offspring.

(A) The result is unpredictable with incomplete dominance, as this is what research and standard practice suggests (B) 75% would be red and 25% white, as this is what research and standard practice suggests (C) The Punnett square gives 1 RR (red) : 2 RW (pink) : 1 WW (white), so expect about 25% red, 50% pink, and 25% white Grizzlions (D) All offspring would be pink, which is the most common explanation for this phenomenon

134. Which of the following can cause mutations in DNA?

(A) Eating healthy food (B) Ultraviolet radiation from the sun (C) Sleeping eight hours a night (D) Drinking clean water

135. A breeder notices that coat color in a dog breed has three patterns: solid dark, solid light, and spotted. When two spotted dogs are crossed, they produce puppies in all three patterns. Analyze what inheritance pattern this most likely represents.

(A) This represents incomplete dominance because spotted is a blend of dark and light (B) This represents simple dominance because spotted is dominant over both solid colors (C) This means coat color is not genetic and is caused by random chance (D) This likely represents codominance, where the spotted pattern is the heterozygous phenotype showing both dark and light alleles expressed separately

136. Golden Rice is a genetically modified rice variety that produces beta-carotene, giving it a yellow-orange color. How could this help address a health problem in developing nations?

(A) It produces a natural pesticide that keeps rice fields free of insects (B) The golden color makes the rice taste better so people eat more (C) It provides vitamin A to populations that rely heavily on rice as a staple food and suffer from vitamin A deficiency (D) It allows rice to grow in cold climates where it normally cannot survive

Write the answer

137. What is gene flow?

Answer: _____

138. Both parents are carriers for sickle cell disease (HbA HbS). They want to know the probability that their next child will be affected, a carrier, or unaffected. Calculate the probabilities.

Answer: _____

139. A scientist claims that changing a single base pair in a gene could completely change the protein it produces. Another scientist says one small change probably would not matter. Analyze which position is more accurate.

Answer: _____

140. Why do you look more like your parents than like a random stranger?

Answer: _____

Match each question to its answer

1. What does it mean when scientists say a mutation is 'harmful'? →
 2. What is the basic goal of genetic engineering? →
 3. In a population of lizards, those with longer legs can run faster and escape predators more easily. Over 50 generations, the average leg length in the population increases. Explain this outcome using the principles of genetics and natural selection.
→
 4. How does cystic fibrosis illustrate the concept of autosomal recessive inheritance?
→
 5. Some people think that eating genetically modified food will change your own DNA. Based on what you know about DNA and digestion, is this a reasonable concern? →
 - (A) No, because your digestive system breaks down all food DNA into individual nucleotides, which cannot change your own genes
 - (B) To directly modify an organism's DNA to introduce, remove, or change specific traits
 - (C) The mutation causes a change that reduces the organism's ability to survive or reproduce
 - (D) Lizards with alleles for longer legs survived and reproduced more, passing those alleles to offspring, increasing the frequency of long-leg alleles over generations
 - (E) Cystic fibrosis occurs only when a person inherits two copies of the defective CFTR gene, one from each parent, regardless of sex
-

15. DNA Structure & Function

Circle the correct answer

141. How are nucleotides related to DNA?

- (A) Nucleotides destroy old DNA so new DNA can form (B) Nucleotides are separate molecules that float around DNA (C) Nucleotides are the building blocks that link together to form a DNA strand (D) Nucleotides are the same thing as chromosomes

142. Your classmate says they have green eyes like their grandmother, even though both parents have brown eyes. Apply your knowledge of genetics to explain how this happened.

- (A) Both parents likely carry a recessive green-eye allele inherited from the grandmother, and the classmate received the recessive allele from each parent (B) Green eyes are caused by the environment, not genetics, and this has been consistently demonstrated in practice (C) This is impossible and the classmate must be mistaken, which is the most common explanation for this phenomenon (D) The classmate's eyes changed color after birth due to sunlight, and this principle applies across similar situations

143. In a Punnett square, what do the letters on the top and left side represent?

(A) The size of the genes (B) The alleles from each parent (C) The number of chromosomes (D) The names of the offspring

144. Why are most mutations considered neutral, meaning they have no effect on the organism?

(A) Because mutations only affect plants, not animals (B) Because they occur in DNA regions that do not code for important proteins (C) Because DNA never actually changes during an organism's lifetime (D) Because all mutations are automatically repaired by the cell

145. Some people claim that dominant traits are always more common in a population than recessive traits. Evaluate whether this claim is scientifically accurate.

(A) This claim is incorrect because recessive traits are actually always more common (B) This claim is incorrect; a trait being dominant does not mean it is more common, as allele frequency depends on population history, not dominance (C) This claim is correct because recessive alleles disappear over time (D) This claim is correct because dominant alleles always outcompete recessive ones

146. Analyze why consanguineous marriages (marriages between close relatives) increase the risk of children having autosomal recessive genetic disorders.

(A) Because relatives share the same blood type, which always causes genetic disorders (B) Because children of relatives have fewer chromosomes than other children (C) Close relatives are more likely to carry the same recessive alleles inherited from a common ancestor, increasing the chance that a child inherits two copies of a harmful recessive allele (D) Because marriage between relatives creates new harmful mutations that did not exist before

Write the answer

147. Some traits like human height are influenced by many genes rather than just one. How does this explain why height does not follow simple dominant/recessive patterns?

Answer: _____

148. A classmate says that because both of their parents have straight hair, it is impossible for them to have curly hair. Using your knowledge of genetics, evaluate this claim.

Answer: _____

149. Compare the development of modern corn from its wild ancestor teosinte through selective breeding with the development of Bt corn through genetic engineering. What does this comparison reveal about the two methods?

Answer: _____

150. Bacteria that are resistant to an antibiotic can share their resistance genes with non-resistant bacteria through a process called horizontal gene transfer. Apply this concept to explain why doctors warn against overusing antibiotics.

Answer: _____

Match each question to its answer

1. If one strand of DNA has the bases A-T-G-C-C-A, what would the matching strand read? →
2. In a class experiment, 20 out of 30 students can taste a bitter chemical on a test strip, while 10 cannot. Analyze what this tells you about the genetics of the class. →
3. A breeder crosses two organisms and all 20 offspring show the dominant trait. Can the breeder be certain that one parent is homozygous dominant? Analyze the possibilities. →
4. A scientist discovers that a population of bacteria has developed resistance to an antibiotic. Which concept best explains how mutations contributed to this resistance? →
5. A cat has the genotype Bb for fur color, where B (black) is dominant over b (orange). What is this cat's phenotype? →

(A) The ability to taste the chemical is likely a dominant trait; the 10 non-tasters are likely homozygous recessive, while the 20 tasters are either homozygous dominant or heterozygous

(B) T-A-C-G-G-T

(C) The cat has black fur because the dominant B allele determines the phenotype

(D) Not certain, but it is very likely; if both parents were Bb, there is only a very small probability that all 20 offspring would show dominant traits by chance

(E) Random mutations gave some bacteria resistance, and those bacteria survived and reproduced more

16. DNA Structure & Function

Circle the correct answer

151. A scientist analyzes a DNA sample and finds it contains 30% adenine. What percentage of the bases are cytosine?

(A) 10% (B) 30% (C) 25% (D) 20%

152. Why do siblings from the same parents often look similar but not identical?

(A) Each sibling receives a different random combination of alleles from the same two parents (B) Siblings have completely different DNA from each other (C) Only identical twins share any DNA at all (D) The environment changes their DNA after

birth

153. In guinea pigs, black fur (B) is dominant over white fur (b). A pet store has a black guinea pig but does not know if it is BB or Bb. Design a cross that would help determine the guinea pig's genotype.

(A) Check if the guinea pig has other dominant traits, which is the most common explanation for this phenomenon (B) Cross the black guinea pig with a white guinea pig (bb); if any white offspring appear, the black parent must be Bb (C) Cross it with another black guinea pig, which is why this approach is recommended by experts (D) Look at the guinea pig's parents, and this principle applies across similar situations

154. Why might scientists insert a gene from one species into a completely different species?

(A) To permanently merge the two species into one (B) To prove that all species are closely related (C) To give the receiving organism a useful trait it could not develop through its own genetics, such as pest resistance (D) To create a hybrid animal that is half of each species

155. Two islands near each other have populations of the same bird species. Island A has abundant food and few predators. Island B has scarce food and many predators. After 500 generations, scientists notice the birds on the two islands look quite different. Analyze how different selection pressures led to this divergence.

(A) Different environmental pressures on each island selected for different traits — Island B favored birds better at finding food and escaping predators, while Island A had weaker selection pressures, allowing more trait variation to persist (B) The birds only look different because of their diet, not their genes (C) The birds look different because they decided to change their appearance to match their island (D) The birds are different because Island B birds mutated intentionally to survive

156. Sickle cell disease is caused by a single nucleotide change in the hemoglobin gene. Analyze how one small change in DNA can cause such widespread effects throughout the body, affecting multiple organ systems.

(A) The single nucleotide change alters the hemoglobin protein shape, causing red blood cells to sickle and block blood vessels, which deprives organs of oxygen and causes damage throughout the body (B) The small DNA change is amplified by the immune system into a larger mutation, and this principle applies across similar situations (C) The mutation only affects blood cells and has no impact on other organs, making this the most widely accepted explanation (D) The nucleotide change affects every gene in the body simultaneously, and this principle applies across similar situations

Write the answer

157. Why is DNA sometimes called the 'blueprint of life'?

Answer: _____

158. Identical twins share 100% of their DNA, yet they can have different fingerprints and sometimes different heights. What does this reveal about the role of environment in shaping traits?

Answer: _____

159. Two pea plants that are both heterozygous for seed shape (Rr , where R = round, r = wrinkled) are crossed. Out of 100 offspring, approximately how many would you expect to have wrinkled seeds?

Answer: _____

160. Two identical twin mice are raised in different environments. One is exposed to a chemical mutagen and develops spots on its fur, while the other does not. If both mice have offspring, what would you predict?

Answer: _____

Match each question to its answer

1. What is a genotype? →

2. How does genetic variation within a population relate to natural selection? →

3. A company offers direct-to-consumer genetic tests that report your risk for dozens of diseases based on your DNA. Some doctors are concerned about patients misinterpreting these results. Evaluate the potential benefits and limitations of these tests. →

4. Scientists found that two organisms have very similar DNA sequences. What can you conclude about the relationship between these organisms? →

5. Design a simple investigation to determine whether a trait in a group of plants follows simple dominance, incomplete dominance, or codominance. →

(A) Genetic variation provides the raw material for natural selection by creating differences in traits that affect survival and reproduction

(B) The tests can identify certain genetic risk factors and motivate preventive care, but they often test only a few variants per disease and cannot account for environmental factors, leading to potential misinterpretation of risk

(C) The combination of alleles an organism carries for a specific trait

(D) They are likely closely related and share a recent common ancestor

(E) Cross a homozygous dominant plant with a homozygous recessive plant and observe the offspring: if they show only the dominant trait it is simple dominance, if blended it is incomplete dominance, if both traits appear separately it is codominance

Riddle & Joke Break

Guess the answer, then check the key!

- 161. Why did the gene go to school?
 - 162. What did the DNA say to the RNA?
 - 163. Why was the recessive allele so quiet at parties?
 - 164. What did the chromosome say during cell division?
 - 165. Why did the Punnett square feel boxed in?
 - 166. What do geneticists wear to look sharp?
-

Answer Key

- 1. B — Deoxyribonucleic acid
- 2. A — A double helix (twisted ladder)
- 3. B — Adenine, thymine, guanine, and cytosine
- 4. A — In the nucleus
- 5. A — Because it contains the instructions for building and running every living organism
- 6. B — Nucleotides are the building blocks that link together to form a DNA strand
- 7. Adenine and thymine form two hydrogen bonds that fit together perfectly, while guanine and cytosine form three; mismatched pairs do not fit
- 8. A gene is a short section of DNA that codes for one trait, while a chromosome is a long, coiled-up strand of DNA containing many genes
- 9. The specific sequence of bases acts as a code that tells cells which proteins to make, and proteins determine traits like eye color and height
- 10. So that when cells divide, each new cell receives a complete and accurate set of genetic instructions
Matching (DNA Structure & Function): 1→D, 2→C, 3→B, 4→A, 5→E
- 11. A — A characteristic or feature of an organism, such as eye color or height
- 12. C — Dominant

13. A — A different version of the same gene
14. C — Two copies, one from each parent
15. B — Genotype is the set of alleles an organism has, while phenotype is the physical appearance or observable trait
16. A — Each sibling receives a different random combination of alleles from the same two parents
17. Both parents can be carriers of the recessive blue-eye allele, and the child can inherit the recessive allele from each parent
18. The recessive allele can be carried and hidden by a dominant allele in the parent generation, then expressed when two carriers have a child who inherits both recessive alleles
19. You share approximately 50% of your DNA with each parent, while you share much less with unrelated people
20. They have two different alleles for that gene, one dominant and one recessive
Matching (Heredity Basics): 1→B, 2→D, 3→A, 4→C, 5→E
21. A — To predict the possible genotypes and phenotypes of offspring from a genetic cross
22. A — The alleles from each parent
23. C — Having two copies of the dominant allele (like BB)
24. C — 1 BB : 2 Bb : 1 bb
25. B — Because which allele each parent passes on is random, like flipping a coin; the Punnett square shows all possibilities but cannot predict which one will actually happen
26. A — Genotype ratio counts the different allele combinations (like 1:2:1), while phenotype ratio counts the different physical appearances (like 3:1)
27. Because the BB parent can only pass on a B allele, and one dominant allele is enough to produce the dominant phenotype
28. By crossing the unknown organism with a homozygous recessive individual; if any offspring show the recessive trait, the unknown parent must be heterozygous
29. 1 red (RR) : 2 pink (Rr) : 1 white (rr)
30. Because it tracks the inheritance of only one trait at a time
Matching (Punnett Squares): 1→E, 2→A, 3→C, 4→B, 5→D

31. B — A change in the DNA sequence of an organism
 32. B — Substitution mutation
 33. C — Differences in DNA among individuals in a population
 34. D — Ultraviolet radiation from the sun
 35. A — A substitution swaps one base for another while a deletion removes a base entirely
 36. C — Because they occur in DNA regions that do not code for important proteins
 37. The mutation causes a change that reduces the organism's ability to survive or reproduce
 38. They shift all the bases that come after the insertion, changing how the code is read
 39. It increases the chance that some individuals can survive if the environment changes
 40. Only mutations in reproductive cells (eggs and sperm) can be inherited, while mutations in body cells cannot
- Matching (Mutations & Genetic Variation): 1→C, 2→A, 3→B, 4→D, 5→E
41. B — The observable physical characteristics of an organism
 42. B — The combination of alleles an organism carries for a specific trait
 43. B — It masks the effect of the other allele and determines the phenotype even when only one copy is present
 44. D — Homozygous
 45. D — The genotype provides the genetic instructions that, together with the environment, produce the observable phenotype
 46. A — Because a dominant allele masks the recessive allele, so both BB and Bb produce the same phenotype
 47. A pattern where the heterozygous phenotype is a blend between the two homozygous phenotypes
 48. In codominance both alleles are fully and separately expressed rather than blended together
 49. Because skin color is a polygenic trait, meaning several genes each contribute a small amount to the final phenotype

50. Environmental factors like nutrition, sunlight, and temperature can influence how genes are expressed without changing the DNA

Matching (Genetic Traits & Phenotypes): 1→C, 2→B, 3→A, 4→E, 5→D

51. B — The process of choosing organisms with desired traits to reproduce in order to produce offspring with those traits
52. A — Genetically Modified Organism
53. B — To directly modify an organism's DNA to introduce, remove, or change specific traits
54. D — A gene-editing tool that allows scientists to cut DNA at a specific location and make precise changes
55. A — Genetic engineering can make specific changes in one generation, while selective breeding takes many generations and is less precise
56. B — To give the receiving organism a useful trait it could not develop through its own genetics, such as pest resistance
57. A medical technique that introduces, alters, or replaces genes in a patient's cells to treat or prevent genetic diseases
58. Cloning creates a genetically identical copy of an organism without changing its DNA, while genetic engineering modifies the DNA itself
59. Because bacteria reproduce quickly, are easy to grow, and can take up and express foreign DNA in their cells
60. GM crops can be engineered to resist drought, pests, or disease, increasing food production where resources are limited
- Matching (Biotechnology & Genetic Engineering): 1→A, 2→D, 3→B, 4→C, 5→E
61. C — The process by which organisms with traits better suited to their environment are more likely to survive and reproduce
62. C — The proportion of a specific allele compared to all alleles for that gene in a population
63. D — Random changes in allele frequencies in a population due to chance events rather than natural selection
64. A — The transfer of alleles from one population to another when organisms migrate and interbreed
65. C — Genetic variation provides the raw material for natural selection by creating differences in traits that affect survival and reproduction

66. C — Because when certain alleles become more or less common in a population across generations, the population's genetic makeup has changed, which is evolution
67. It shuffles alleles through independent assortment and crossing over, creating unique combinations of traits in each offspring
68. Adaptation is a specific trait that improves survival in an environment, while evolution is the broader process of change in a population's genetic makeup over time
69. Because the environment interacts with an organism's observable traits, not directly with its DNA sequences
70. When a small group starts a new population, their limited genetic diversity represents only a fraction of the original population's alleles, causing the new population to evolve differently
Matching (Evolution & Genetics Connection): 1→C, 2→B, 3→D, 4→E, 5→A
71. D — 46 chromosomes arranged in 23 pairs
72. B — A trait controlled by a gene located on one of the sex chromosomes, usually the X chromosome
73. B — To trace the inheritance pattern of a specific trait through multiple generations of a family
74. A — A visual display of an individual's chromosomes arranged in pairs by size and shape
75. A — Because males have only one X chromosome, so a single recessive allele on it will be expressed with no second X to mask it
76. B — Down syndrome is caused by having an extra copy of chromosome 21 rather than by a mutation in a single gene
77. An individual who has one copy of a recessive allele for a disorder and can pass it to offspring without showing symptoms themselves
78. A healthcare service that helps individuals and families understand genetic risks, test results, and the probability of passing genetic conditions to their children
79. Cystic fibrosis occurs only when a person inherits two copies of the defective CFTR gene, one from each parent, regardless of sex
80. A genetic disorder is caused by a mutation in one or a few genes, while a chromosomal disorder involves changes in the number or structure of entire chromosomes

Matching (Human Genetics & Genetic Disorders): 1→A, 2→D, 3→C, 4→B, 5→E

81. C — Genetically Modified Organism

82. B — CRISPR-Cas9

83. D — Cloning

84. C — Bacteria

85. A — Plasmid

86. A — Flavr Savr tomato

87. It is faster, cheaper, and more precise

88. It produces a protein that is toxic to certain insects

89. To cut DNA at specific sequences

90. To provide vitamin A to people in developing countries

Matching (Genetics & DNA): 1→E, 2→D, 3→B, 4→A, 5→C

91. D — 46

92. A — An organized image of all the chromosomes in a cell arranged by size and shape

93. A — Down syndrome

94. C — XY

95. A — A single-gene disorder caused by a mutation in the hemoglobin gene

96. C — A person who has one copy of a recessive allele for a disorder but does not show symptoms

97. The gene for color vision is on the X chromosome, and males have only one X

98. Both parents are carriers with one recessive allele each, and the child inherits both recessive alleles

99. Helps families understand their risk of inherited conditions and make informed decisions

100. It shows how a trait is passed through multiple generations of a family

Matching (Genetics & DNA): 1→B, 2→C, 3→E, 4→D, 5→A

101. B — The process where organisms with traits better suited to their environment are more likely to survive and reproduce

102. D — A random change in allele frequencies in a small population due to chance

events

- 103. C — A trait that helps an organism survive and reproduce in its environment
- 104. D — Alleles
- 105. A — The total collection of all alleles in a population
- 106. B — Charles Darwin
- 107. Without different traits to select from, all organisms respond the same way to environmental pressures
- 108. Separated populations cannot interbreed, so they accumulate different mutations and adaptations over time
- 109. A drastic reduction in population size reduces genetic diversity, making the species more vulnerable
- 110. Bacteria with resistance genes survive antibiotic treatment and reproduce, passing resistance to the next generation
Matching (Genetics & DNA): 1→A, 2→B, 3→D, 4→C, 5→E
- 111. C — The process by which the information in a gene is used to make a functional product, usually a protein
- 112. D — The study of changes in gene activity that do not involve changes to the DNA sequence itself
- 113. A — The addition of a methyl group to DNA that typically silences gene expression
- 114. B — Proteins that DNA wraps around to help package and organize chromosomes
- 115. D — A gene that is turned on is actively being used to make a protein, while a turned-off gene is not producing its protein
- 116. B — They are proteins that bind to DNA and help control whether a gene is turned on or off
- 117. Different genes are turned on and off in each cell type, producing different proteins
- 118. Nutrients in the mother's diet can add or remove epigenetic tags on the baby's DNA, turning certain genes on or off
- 119. Their epigenetic patterns diverge over time due to different environmental exposures, diets, and lifestyles
- 120. Chemical changes to histone proteins can make DNA more or less accessible,

turning genes on or off

Matching (Genetics & DNA): 1→D, 2→C, 3→A, 4→B, 5→E

121. B — 8 blue beads, because every adenine must pair with a thymine
122. C — 50%, because half the possible combinations result in ee
123. A — Because it tracks the inheritance of only one trait at a time
124. C — Whether a mutation is harmful or neutral depends on the environment the organism lives in
125. D — About one-half (50%) of the offspring would be pink
126. B — Because complex human proteins often need modifications that bacteria cannot perform, while goat mammary cells can properly fold and modify the protein
127. When a small group starts a new population, their limited genetic diversity represents only a fraction of the original population's alleles, causing the new population to evolve differently
128. There is a 50% chance that a son will have hemophilia because he has a 50% chance of inheriting the X^h allele from his mother
129. So that when cells divide, each new cell receives a complete and accurate set of genetic instructions
130. Dominant
Matching (DNA Structure & Function): 1→C, 2→A, 3→B, 4→E, 5→D
131. D — Adenine, thymine, guanine, and cytosine
132. C — BB, Bb, or bb
133. C — The Punnett square gives 1 RR (red) : 2 RW (pink) : 1 WW (white), so expect about 25% red, 50% pink, and 25% white Grizzlies
134. B — Ultraviolet radiation from the sun
135. D — This likely represents codominance, where the spotted pattern is the heterozygous phenotype showing both dark and light alleles expressed separately
136. C — It provides vitamin A to populations that rely heavily on rice as a staple food and suffer from vitamin A deficiency
137. The transfer of alleles from one population to another when organisms migrate and interbreed

138. 25% chance unaffected (HbA HbA), 50% chance carrier (HbA HbS), and 25% chance affected with sickle cell disease (HbS HbS)
139. Both can be correct depending on where the change occurs; a change in a critical part of the gene can drastically alter the protein, while a change elsewhere may have little or no effect
140. You share approximately 50% of your DNA with each parent, while you share much less with unrelated people
Matching (DNA Structure & Function): 1→C, 2→B, 3→D, 4→E, 5→A
141. C — Nucleotides are the building blocks that link together to form a DNA strand
142. A — Both parents likely carry a recessive green-eye allele inherited from the grandmother, and the classmate received the recessive allele from each parent
143. B — The alleles from each parent
144. B — Because they occur in DNA regions that do not code for important proteins
145. B — This claim is incorrect; a trait being dominant does not mean it is more common, as allele frequency depends on population history, not dominance
146. C — Close relatives are more likely to carry the same recessive alleles inherited from a common ancestor, increasing the chance that a child inherits two copies of a harmful recessive allele
147. With many genes each contributing a small effect, there is a wide range of possible heights rather than just two or three categories
148. This claim may be incorrect because if curly hair is polygenic, the parents could carry alleles that combine in the child to produce curly hair
149. Selective breeding transformed teosinte into corn over thousands of years by gradually accumulating small changes, while Bt corn was created in a few years by directly inserting a specific gene
150. Overusing antibiotics selects for resistant bacteria, which can then share resistance genes with other bacteria, making more infections untreatable
Matching (DNA Structure & Function): 1→B, 2→A, 3→D, 4→E, 5→C
151. D — 20%
152. A — Each sibling receives a different random combination of alleles from the same two parents
153. B — Cross the black guinea pig with a white guinea pig (bb); if any white offspring appear, the black parent must be Bb

154. C — To give the receiving organism a useful trait it could not develop through its own genetics, such as pest resistance
155. A — Different environmental pressures on each island selected for different traits — Island B favored birds better at finding food and escaping predators, while Island A had weaker selection pressures, allowing more trait variation to persist
156. A — The single nucleotide change alters the hemoglobin protein shape, causing red blood cells to sickle and block blood vessels, which deprives organs of oxygen and causes damage throughout the body
157. Because it contains the instructions for building and running every living organism
158. The environment plays a significant role alongside genetics; factors like nutrition, physical activity, and random development affect traits even when DNA is identical
159. About 25, because the predicted ratio is 3 round : 1 wrinkled
160. The spotted mouse's offspring would likely not have spots because the mutation was in body cells, not reproductive cells
Matching (DNA Structure & Function): 1→C, 2→A, 3→B, 4→D, 5→E
161. To improve its expression!
162. "Stop copying me!"
163. It could never express itself when the dominant one was around!
164. "I'm splitting up -- it's not you, it's mitosis!"
165. Because it was always stuck in a grid!
166. Designer genes!

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