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Punnett square dihybrid cross worksheet answer key

Tutorial to help answer the question Which of the following genetic crosses would be predicted to give a phenotypic ratio of 9:3:3:1? Tutorial Determine all possible combinations of alleles in the gametes for each parent. Half of the gametes get a dominant S and a dominant Y allele; the other half of the gametes get a recessive s and a recessive y allele. Both parents produce 25% each of SY, Sy, sY, and sy. (Review the tutorials for problems #1 and problem #4 if necessary). Since each Parent produces 4 different combinations of alleles in the gametes, draw a 4 square by 4 square punnett square. List the gametes for Parent 1 along one edge of the punnett square. List the gametes for Parent 2 along one edge of the punnett square. Fill out the squares with the alleles of Parent 1. Fill out the squares with the alleles from Parent 2. The result is the prediction of all possible combinations of genotypes for the offspring of the dihybrid cross, SsYy x SsYy. There are 9 genotypes for spherical, yellow seeded plants. They are: SSYY (1/16) SSYy (2/16) SsYY (2/16) SsYy (4/16) Two recessive alleles result in green seeded plants. There are 2 genotypes for spherical, green seeded plants. They are: Ssyy (1/16) Ssyy (2/16) Two recessive s alleles result in dented seeded plants. There are 2 genotypes for dented, yellow seeded plants. They are: ssYY (1/16) ssYy (2/16) A ssyy plant would be recessive for both traits. There is only 1 genotypes for dented, green seeded plants. It is: ssyy (1/16) A phenotypic ratio of 9:3:3:1 is predicted for the offspring of a SsYy x SsYy dihybrid cross. 9 spherical, yellow 3 spherical, green 3 dented, yellow 1 dented, green The Biology Project University of Arizona Wednesday, August 14, 1996 Contact the Development Team All contents copyright © 1996. All rights reserved. Study Of Genetic Corn & Parakeets Chi Square Test For Dihybrid Cross 1. Introduction Introduction: This laboratory investigates a dihybrid cross as shown in the above photo of an ear of corn. The four different genes and grain types are identified in the following photo, and the complete cross is shown in Table 1 below. There are four grain phenotypes in the above ear of genetic corn: Purple & Smooth (A), Purple & Shrunken (B), Yellow & Smooth (C) and Yellow & Shrunken (D). These four grain phenotypes are produced by the following two pairs of heterozygous genes (P & p and S & s) located on two pairs of homologous chromosomes (each gene on a separate chromosome): Dominant Genes Recessive Genes P = Purple p = Yellow S = Smooth s = Shrunken The following Table 1 shows a dihybrid cross between two heterozygous parents (PpSs X PpSs). The four gametes of each parent are shown along the top and left sides of the table. This cross produced the ear of genetic corn shown at the top of this page. Table 1 is essentially a genetic checkboard called a Punnett square after R.C. Punnett, a colleague of William Bateson who devised this method. In 1900, English Geneticist William Bateson had Gregor Mendel's original 1865 paper on the genetics of garden peas translated into English and published. Thus Mendel became known to the entire scientific world. Bateson is also credited with the discovery of gene linkage in 1905. Gametes PS Ps pS ps PS PPS PPS PpSs PpSs PpSs PpSs Ppss pS PpSs PpSs ppSs ppSs ps PpSs Ppss ppSs pps Table 1. This table shows four different phenotypes with the following fractional ratios: 9/16 Purple & Smooth (blue), 3/16 Purple & Shrunken (red), 3/16 Yellow & Smooth (green), and 1/16 yellow and shrunken (pink). There are nine different genotypes in the table: PPSs (1), PPSs (2), PpSs (4), PPSs (4), PPSs (1), Ppss (2), ppSs (1), ppSs (2) and pps (1). You can easily calculate the number of different phenotypes and genotypes in a dihybrid cross using the following formulae: Number of phenotypes: 2² = 4 Number of genotypes: 3² = 9 Testosterone or "Madre de Maiz": The Ancestor Of Corn 2. Sample Chi Square Problem Chi Square Problem: An ear of corn has a total of 381 grains, including 216 Purple & Smooth, 79 Purple & Shrunken, 65 Yellow & Smooth, and 21 Yellow & Shrunken. These phenotypes and numbers are entered in Columns 1 and 2 of the following Table 2. Your Tentative Hypothesis: This ear of corn was produced by a dihybrid cross (PpSs x PpSs) involving two pairs of heterozygous genes resulting in a theoretical (expected) ratio of 9:3:3:1. See dihybrid cross in Table 1. Objective: Test your hypothesis using chi square and probability values. In order to test your hypothesis you must fill in the columns in the following Table 2. 1. For the observed number (Column 2), enter the number of each grain phenotype counted on the ear of corn. 2. To calculate the observed ratio (Column 3), divide the number of each grain phenotype by 21 (the grain phenotype with the lowest number of grains). 3. For the expected ratio (Column 4), use 9:3:3:1, the theoretical ratio for a dihybrid cross. The fractional ratios for these four phenotypes are 9/16, 3/16, 3/16 and 1/16. 4. To calculate the expected number (Column 5), multiply the number of each grain phenotype by the expected fractional ratio for that grain phenotype. 5. In the last column (Column 6), for each grain phenotype take the observed number of grains (Column 2) and subtract the expected number (Column 5), square this difference, and then divide by the expected number (Column 5). Round off to three decimal places. 6. To calculate the chi square value, add up the four decimal values in the last column (Column 6). Grain Phenotype (Column 1) Observed Number (Column 2) Observed Ratio (Column 3) Expected Ratio (Column 4) Expected Number (Column 5) [Obs No. - Exp No.]² ÷ Expected No. (Column 6) Purple & Smooth 216 10.3 3 381 x 9/16 = 214 4 + 214 = 0.019 Purple & Shrunken 79 3.8 3 381 x 3/16 = 71 64/71 = 0.901 Yellow & Smooth 65 3.1 3 381 x 3/16 = 71 36/71 = 0.507 Yellow & Shrunken 21 1.0 1 381 x 1/16 = 24 9/24 = 0.375 Total Number: 381 ----- Chi Square Value: 1.80 Table 2. Chi Square Data 7. Degrees Of Freedom: Number of phenotypes - 1. In this problem the number of phenotypes is four; therefore, the degrees of freedom (df) is three (4 - 1 = 3). In the following Table 3 you need to locate the number in row three that is nearest to your chi square value of 1.80. 8. Probability Value: In the following Table 3, find the number in row three that is closest to your chi square value of 1.80. In this table 1.85 (shaded in yellow) is the closest number; then go to the top of the column and locate your probability value. In this case the probability value that lines up with 1.85 is .60 (shaded in yellow). This number means that the probability that your hypothesis is correct is 0.60 or 60 percent. The probability that your hypothesis is incorrect is 0.40 or 40 percent. Good Fit Between Ear & Data Poor Fit df .90 .70 .60 .50 .20 .10 .05 .01 1 .02 .15 .31 .46 1.64 2.71 3.85 6.64 2 .21 .71 1.05 1.39 3.22 4.60 5.99 9.21 3 .58 1.42 1.85 2.37 4.64 6.25 7.82 11.34 4 1.06 2.20 2.78 3.36 5.99 7.78 9.49 13.28 Table 3. Probability Values 3. A Chi Square Problem For Credit Chi Square Problem: A large ear of corn has a total of 433 grains, including 271 Purple & Smooth, 73 Purple & Shrunken, 63 Yellow & Smooth, and 26 Yellow & Shrunken. These numbers are entered in Columns 1 and 2 of the following Table 4. Your Tentative Hypothesis: This ear of corn was produced by a dihybrid cross (PpSs x PpSs) involving two pairs of heterozygous genes resulting in a theoretical (expected) ratio of 9:3:3:1. See dihybrid cross in Table 1. Objective: Test your hypothesis using chi square and probability values. In order to test your hypothesis you must fill in the columns in the following Table 4. 1. For the observed number (Column 2), enter the number of each grain phenotype counted on the ear of corn. [Note: These numbers are already entered in Table 4.] 2. To calculate the observed ratio (Column 3), divide the number of each grain phenotype by 26 (the grain phenotype with the lowest number of grains). 3. For the expected ratio (Column 4), use 9:3:3:1, the theoretical ratio for a dihybrid cross. 4. To calculate the expected number (Column 5), multiply the number of each grain type by the expected fractional ratio for that grain phenotype. The fractional ratios for these four phenotypes are 9/16, 3/16, 3/16 and 1/16. 5. In the last column (Column 6), for each grain phenotype take the observed number of grains (Column 2) and subtract the expected number (Column 5), square this difference, and then divide by the expected number (Column 5). Round off to three decimal places. 6. To calculate the chi square value, add up the four decimal values in the last column (Column 6). Grain Phenotype (Column 1) Observed Number (Column 2) Observed Ratio (Column 3) Expected Ratio (Column 4) Expected Number (Column 5) [Obs No. - Exp No.]² ÷ Expected No. (Column 6) Purple & Smooth 271 ? 9/16 433 x 9/16 = ? Purple & Shrunken 73 ? 3/16 433 x 3/16 = ? Yellow & Smooth 63 ? 3/16 433 x 3/16 = ? Yellow & Shrunken 26 1.0 1/16 433 x 1/16 = ? Total Number: 433 ----- Chi Square Value: ? Table 4. Chi Square Data Go To An Automated Version Of Table 4.7. Degrees Of Freedom: Number of phenotypes - 1. In this problem the number of phenotypes is four; therefore, the degrees of freedom (df) is three (4 - 1 = 3). In the following Table 5 you need to locate the number in row three that is nearest to your chi square value. 8. Probability Value: In the following Table 5, find the number in row three that is closest to your chi square value. For an explanation of how to find and interpret the probability value, go back to the previous example. 4. Chi Square Table Of Probabilities Good Fit Between Ear & Data Poor Fit df .90 .70 .60 .50 .20 .10 .05 .01 1 .02 .15 .31 .46 1.64 2.71 3.85 6.64 2 .21 .71 1.05 1.39 3.22 4.60 5.99 9.21 3 .58 1.42 1.85 2.37 4.64 6.25 7.82 11.34 4 1.06 2.20 2.78 3.36 5.99 7.78 9.49 13.28 Table 5. Probability Values 5. Chi Square Quiz # 1 Scantron Questions 1. What is the chi square value? [Use Chi Square Choices] 2. What is the probability value? [Use Probability Decimal Choices] 3. Is there a GOOD or POOR fit between your hypothesis and your data? I.e. is the probability value within acceptable limits? (a) Good Fit (b) Poor Fit 4. What is the percent probability that your hypothesis is correct? I.e. the observed ratio of grains in the ear of corn represents a dihybrid cross involving two pairs of heterozygous genes (PpSs X PpSs). [Use The Percent Probability Choices] 5. What is the percent probability that the observed ratio of grains in the ear of corn deviates from the expected 9:3:3:1 due to an incorrect hypothesis? I.e. your ear of corn does NOT represent a dihybrid cross involving two pairs of heterozygous genes (PpSs X PpSs). [Use The Percent Probability Choices] 6. The following question refers to a cross involving linkage, where the genes P & s are linked to the same chromosome, and the genes p & S are linked to the homologous chromosome. Refer to Section 7 below. What percent of the grains from this cross will be purple and smooth? [Use The Percent Probability Choices] 6. Chi Square Quiz # 1 Scantron Choices Chi Square Choices (Choose Number Closest To You Chi Square Value) (a) 0.58 (a) 2.20 (a) 6.65 (a) 11.34 (b) 1.01 (b) 2.37 (b) 7.78 (b) 11.79 (c) 1.06 (c) 3.36 (c) 7.82 (c) 12.26 (d) 1.42 (d) 4.64 (d) 9.49 (d) 13.28 (e) 1.80 (e) 5.99 (e) 9.98 (e) 14.13 Probability Value Decimal Choices (a) < .01 (a) 0.05 (a) 0.50 (a) 1.00 (b) 0.01 (b) 0.10 (b) 0.60 (b) 1.10 (c) 0.02 (c) 0.20 (c) 0.70 (c) 1.20 (d) 0.03 (d) 0.30 (d) 0.80 (d) 1.30 (e) 0.04 (e) 0.40 (e) 0.90 (e) 1.40 Percent Probability Choices (a) 1% (a) 7% (b) 2% (b) 10% (b) 60% (b) 93% (c) 3% (c) 15% (c) 70% (c) 94% (d) 4% (d) 20% (d) 80% (d) 95% (e) 5% (e) 35% (e) 90% (e) 98% 7. Possible Reasons For Incorrect Hypothesis Reasons For Incorrect Hypothesis: If your probability value is .05 (5%) or less, then your ear of corn deviates significantly from the theoretical (expected) ratio of 9:3:3:1 for a dihybrid cross. A probability value of 5% or less is considered to be a poor fit. One possible reason for a poor fit is that your original ear of corn was not produced by a dihybrid cross (PpSs X PpSs). The original parents may have had different genotypes, such as PpSS or PPSs. These genotypes when crossed together will not produce a 9:3:3:1 ratio typical of a true dihybrid cross. Another reason for an incorrect hypothesis might be due to linkage (autosomal linkage), where more than one gene is linked to the same chromosome. For example, what if the genes P & s are linked to a maternal chromosome and the genes p & S are linked to the homologous paternal chromosome. Since they occur on the same chromosomes, these linked genes will also appear together in the same gametes. They will not be assorted independently as in dihybrid cross shown in Table 1 above. The following Table 7 shows a genetic corn cross involving linkage: Gametes Ps pS Ps PPS PpSs pS PpSs ppSs Table 7. A Genetic Corn Cross Involving Linkage. There are three different phenotypes in the offspring from this cross: 1/4 Purple & Shrunken (blue), 2/4 Purple & Smooth (red) and 1/4 Yellow & Smooth (green). There are also three different genotypes: 1/4 PPSs (blue), 2/4 PpSs (red) and 1/4 ppSs (green). Compare the phenotypes and genotypes in this table with the original 9:3:3:1 dihybrid cross shown above in Table 1. When Gregor Mendel completed his research on genetic crosses with garden peas in 1865, he assumed that the individual traits were assorted independently of each other. One of his hypotheses became known as the Law of Independent Assortment. Today we can explain this law because the traits Mendel studied just happened to occur on separate chromosomes. This law also explains the assortment of the four different gametes from each heterozygous parent (PpSs) in the 9:3:3:1 dihybrid cross shown in Table 1: Ps, Pp, pS and ps. Linkage of P & s and p & S on one pair of homologous chromosomes would give only two gametes from a heterozygous parent (PpSs): Ps and pS. Additional gametes (pS and ps) could be produced by crossing over between the homologous chromosomes during synapsis of meiosis, but the resulting four gametes would not be in equal proportions as in a cross in which all four genes occur on separate chromosomes. So the neat ratios of offspring described in Mendel's monohybrid (3:1) and dihybrid (9:3:3:1) crosses only occur when all the genes occur on separate chromosomes and are segregated and assorted independently of each other. Whether Mendel encountered linkage in his experiments has been debated by geneticists for decades, but one thing for sure, he primarily concentrated on traits that just happened to be on the seven pairs of separate chromosomes in the garden pea (Pisum sativum). 9. Dihybrid Cross Between Two Green Parakeets Gametes BC Bc bC bc BC BBCC BBcc BbCC BbCc Bc BBCC BBcc BbCc Bbcc bC BbCc Bbcc bbCc bbcc Table 8. A dihybrid cross between two green parakeets (BbCc X BbCc). This cross involves codominance and gene interaction resulting in a 9:3:3:1 phenotypic ratio of offspring. Codominant alleles B & C together = Green (neither gene is completely dominant over the other). Homozygous or heterozygous dominant C alleles with recessive c alleles = Blue. Homozygous or heterozygous dominant B alleles with recessive b alleles = yellow. All recessive alleles (bbcc) = white. All text material & images on these pages copyright © W.P. Armstrong

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