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Gene Rummy: A Card Game About Mendelian Genetics

Katrin Becker

Mount Royal University, Department of Computer Science and Information Systems, 4825 Mount Royal Gate SW, Calgary AB T3E 6K6 CAN
(kbecker@mtroyal.ca)

Many people struggle with the fundamental concepts underlying Mendelian genetics. The classic examples are fine, but additional resources can be helpful. Here's a visual way to learn the jargon and the basic principles of Mendelian inheritance while playing a fast-paced card game using rabbit coat color genetics. Coat color in rabbits demonstrates dominance/recessive traits, differences in pheno- vs genotypes, epistatis, and multiple alleles - all of which blend together to form the color we see. This workshop is a demonstration of our prototype card game and participants will have an opportunity to examine the cards, see how the games are played, and try a few hands themselves.

Keywords: Mendelian genetics, genotype, phenotype

Introduction

Many people struggle with the fundamental concepts underlying Mendelian genetics(Lewis & Kattmann, 2004; Richards, 1996). As soon as we involve more than two traits, things get complicated! The classic examples such as blood types and fruit flies (*Drosophila*) are fine, but additional resources can be useful in helping students understand the fundamental concepts. The approach introduced in this workshop provides a visual way to learn the jargon and the basic principles of Mendelian inheritance while playing a fast-paced card game using rabbit coat color genetics. Domestic rabbits (*Oryctolagus cuniculus*) are popular small livestock-raised both commercially (meat & fur) and as a hobby, and as a result considerable effort has been put into identifying and understanding the genes that have a major influence on coat color. Coat color in domestic rabbits demonstrates typical dominant and recessive traits as well as partial dominance. It also demonstrates differences in phenotypes and genotypes, epistasis, and includes several gene series that contain multiple alleles - all of which blend together to form the color we see in the coat.

Gene Rummy consists of a set of 56 - 78 cards (depending on which variant is used) and uses a form of gameplay that is a variation of Gin Rummy. The workshop that was presented was a demonstration of the prototype card game and participants had an opportunity to examine the cards, see how the games are played, and try a few hands for themselves.

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Materials

The game cards are in production and hopefully will be available sometime later this year. Please contact the author if you are interested in purchasing Gene Rummy.

Notes for the Instructor

This game is intended to be played as "open hands" where all players get to see each other's cards during gameplay. Once the players are familiar with the game (which normally takes 15-20 minutes), rounds typically take 5-10 minutes to complete, with another 5-10 minutes taken to tally the score. The game can be used in a single class period or it can be used in multiple sessions, either consecutively or interspersed with other classes and activities.

Briefly, gin rummy involves players attempting to build sets of cards according to specific criteria, and then placing those cards that meet the criteria on the table. The main objective of the game is to be the first player to lay down all of their cards. In Gene Rummy, the goal is to build sets of cards that could represent a viable breeding. In other words, identify two parents whose known color genotype could have produced the rabbit chosen as the offspring.

Three variants of the card game exist:

1. **Novice:** This set includes only the B- and D-series of alleles (see Fig. 2) and consists of 7 identical copies of each of the four major shades as males and females, for a total of 56 cards. This version is intended to be used when first introducing the game, or with learners who are just beginning to study Mendelian genetics. Gameplay for this variation is the same as for **Production** except that the scoring is different.
2. **Production**: This set includes 36 cards showing distinct genotypes in each sex as well as 2 male and 2 female albino genotypes for a total of 78 cards. During play, once 8 cards have been dealt, the gameplay for this variant consists of picking a rabbit from the *Gene Pool*(stock pile of cards) and trying to find two parents (one male and one female) from the player's hand who could produce this color. If the player succeeds, she lays her cards on the table, and discards an additional rabbit from her hand to the *Retirement Pile.*
3. **Families:** This variant is the most complex and here the goal is to attempt to form families from the rabbits in the player's hands by choosing a sire and dam and up to four babies that this mating could produce.

Figure 1. This figure shows each of the major *shades* (black, chocolate, blue, and lilac) along with the albino. The **P** in the top left indicates that these are from the production set (as opposed to the novice set). The name at the top is the commonly accepted name for the phenotype, while the term below the image is the commonly accepted genotype name. The table shows the four gene series used in the game. The top row shows the known alleles for this genotype, and the codes below the genotype list all possible alleles for that series. A dash (-) in the genotype indicates that the allele is unknown, and the alleles shown in the column below that pair indicate which alleles are possible, in decreasing order of dominance. Those shown in grey are not possible choices for this genotype.

While a portion of the instructional goals are met by playing the game, additional concepts can be reinforced through the manner in which the game is scored. The score in all games is tallied by assigning a point value to each of the possible alleles, with the most dominant alleles having the lowest point values and the most recessive alleles having the highest point values. In the **Novice** game a dominant allele earns 5 points and a recessive earns 10 points. Further, it is often the case that unknown alleles in either the parents or the offspring can be determined once the "mating" is complete. For example, if a black buck (male) having a genotype of *B- D-* is paired with a black doe (female) and they produce a lilac offspring, which has a genotype of *bb dd*, then it is possible to resolve the unknown alleles in both parents, as the only way they could have produced the lilac kit would have been if both parents had the genotype *Bb Dd*.

Since four gene series are used in the **Production** game, there are many more alleles to consider, and the point allocation is different. Dominant alleles are worth 1 point, and then each successive allele is worth double the points. For example the C-series consists of the following four alleles (there are, in fact, five known alleles in this series but one was omitted as it does not yield sufficiently visually distinct phenotypes, thereby eliminating the visual cues that are instrumental to the learning aspect of this game.): C (full color), c^{chd}(dark chinchilla), c^{h} (himalayan), c (albino), and so points would be allocated as follows: C = 1 pt, c^{chd}= 2 pts, c^{h}=4 pts, c = 8 pts.

Both the color genetics and the scoring rules are fairly complex, making this game unsuitable for students who have just begun to learn about Mendelian genetics and inheritance. However, for students who are already familiar with the basic principles, this game has potential for helping to consolidate those basic principles as well as providing a more complex example using an organism that most students find appealing according to the in-class testing conducted by the author. The fact that the cards depict real rabbits helps to add a level of realism and to remind students that the principles being learned are not merely theoretical.

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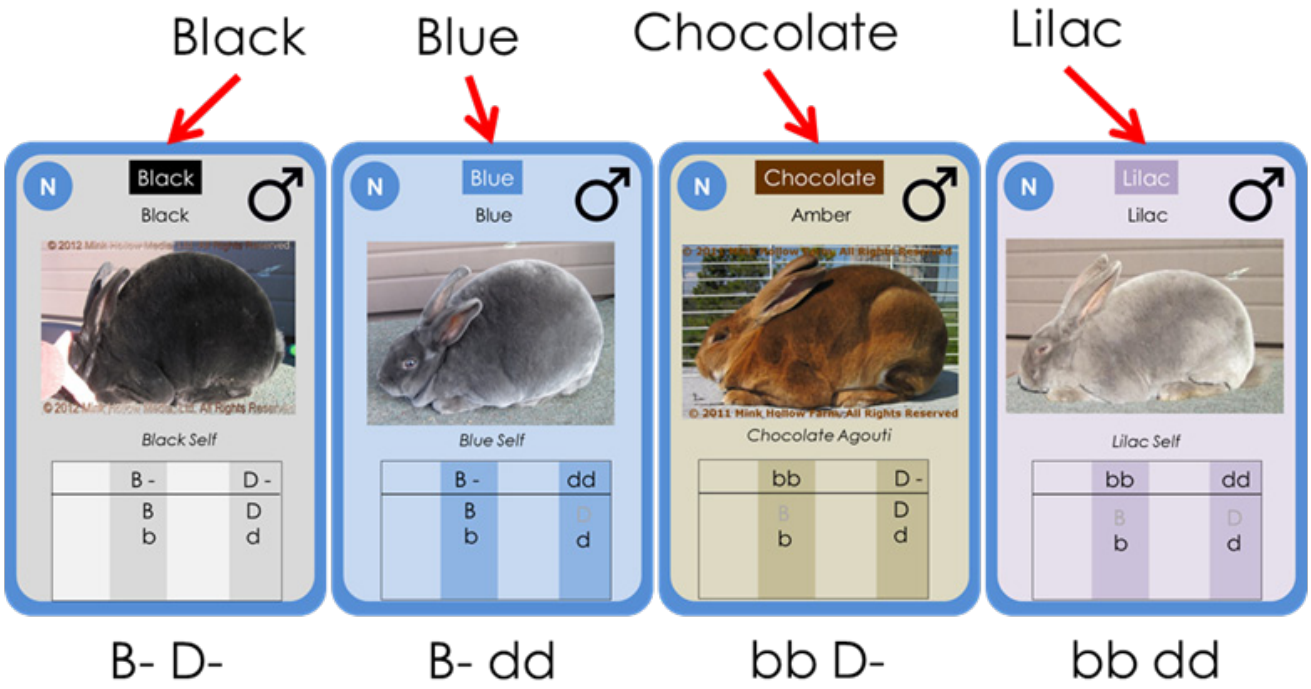

Figure 2. This figure shows the four *shades* used in the **Novice** set. It also includes a corresponding set of female cards (not shown).

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About the Author

Katrin Becker is an award winning, internationally known expert in the design and analysis of Serious Games. With over 30 years of teaching experience in Science, Engineering, Education, and Art, she has taught computer science, video game design, digital game-based learning, and technical writing. Her teaching innovations have been internationally recognized and she is widely published in the areas of computer science education, educational technology, and digital game based learning, including a book on simulations and games for non-technical people. She designs and develops eLearning in all sectors, and has consulted for various organizations on the use of digital games for instructional purposes. She has designed and developed numerous educational and advertising games.

Finally, she runs a small farm where she has been raising waterfowl and other animals for over twenty years. This farm forms the basis for her Ducks in the Classroom program, which provided eggs for hatching in classrooms locally from 1988-2011, and still provides information on school hatching projects globally. It is what keeps her grounded, and what accounts for the occasional bit of dreck on her shoe.

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