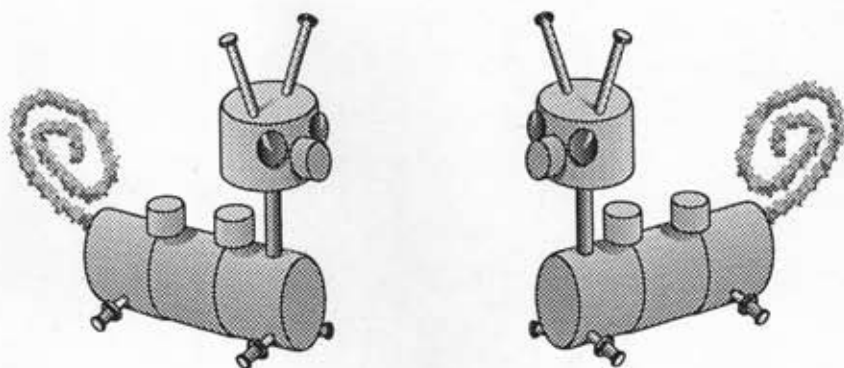# MARSHMALLOW
MEIOSIS

by Patti Soderberg

Are you in need of a simple activity that will help explain why meiosis is responsible for the tremendous variation that exists in every species? Try breeding reebops! Reebops are imaginary organisms that are prolific and require minimal care. These creatures are made out of marshmallows and other inexpensive materials that can be found around the home.

During the reebop activity, your students will have the opportunity to observe all of the offspring produced by one set of reebop parents. Your students will sort Mom and Dad reebop chromosomes, select the new baby reebop chromosomes, decode the secret code found on the baby reebop chromosomes, and construct the baby reebop according to the code. In other words, your students will be mod-

> *Explore genetics by raising reebops in the classroom*

eling the processes of meiosis, fertilization, development, and birth. After all of the babies are "born," the reebop family will be assembled so that all the offspring can be compared to one another.

GETTING STARTED

Prior to class, you will need to assemble the reebop parents (see Figure 1). Mom and Dad reebop each have a marshmallow head, two antennae (small nails), two eyes (thumb tacks), an orange nose (a colored miniature marshmallow), three body segments (large white marshmallows), two green humps (green miniature marshmallows), four blue legs (blue push pins), and a curly tail (a pipe cleaner). The creatures are easier to construct if you let the marshmallows sit out overnight to harden a bit. The reebops tend to be too floppy to stand properly if fresh marshmallows are used.

Chromosomal analysis has revealed that reebops have seven pairs, or 14 total chromosomes. Construct identical sets of Mom and Dad reebop chromosomes for the students to sort. Each pair of students will need a complete set of Mom chromosomes and a complete set of Dad chromosomes. Use the chromosome key
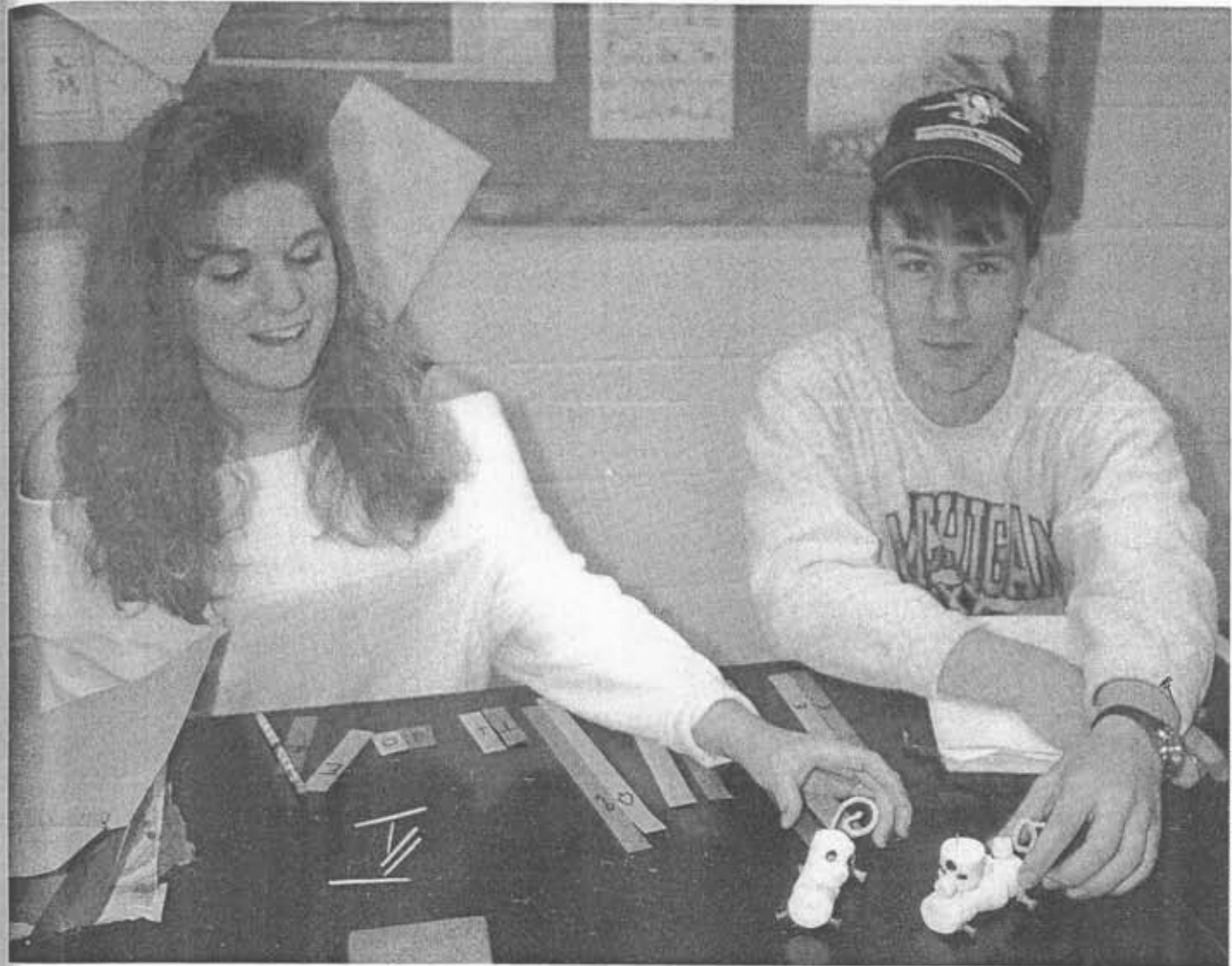
(Figure 2) as your guide. I use different colored sheets of paper for each parent. For this article, we have selected red for Mom and green for Dad (you may wish to use your school colors).

Cut the paper into strips to create the chromosomes, sort them into one set per student group and place them in a large envelope. Each envelope should contain one set of 14 red chromosomes and one set of 14 green chromosomes. Each parental set should consist of seven pairs of chromosomes of different lengths. In order to ensure the greatest possible combination of phenotypes, the parents should be heterozygous at all loci, with each gene locus appearing on a different chromosome; seven traits, seven pairs of chromosomes—all able to sort independently (see Figure 2).

More traits, such as sex, can be easily added if you wish. Seven pairs of chromosomes seems to be a large enough number to insure that no two offspring produced

by a class will appear identical. However, if you are working with a large group of students, you may want to increase the chromosome number to increase the certainty of variation among all offspring.

There are 128 chromosome combinations possible from an organism that has seven pairs of chromosomes (2 to the 7th power). Or, in other words, there are 128 possible genotype combinations from this arrangement. However, in this case the actual number of phenotypic combinations is less than 128 as some of the possible combinations of alleles code for the same phenotype (for example, both LL and Ll code for blue legs). If each gene locus were to exhibit codominance, then the number of genotype combinations would be the same as the number of phenotype combinations.

BREEDING REEBOPS

Introduce your students to Mom and Dad reebop and distribute the chromo-

some sets, one to each pair of students. Ask one member of each pair to take the red chromosomes, and the other the green. Have them turn the chromosomes face down on the table so that no letters are visible and ask each student to sort their set by length. At this point you may want to ask the students to hypothesize as to why the chromosomes can be sorted into pairs of similar length and why each pair differs in length from the other pairs.

Next, ask each pair of students to arbitrarily take one chromosome of each length from their set and place them together in a separate baby pile. This new set will be their reebop baby's chromosomes. The remaining chromosomes can be returned to the envelope. Each reebop baby should have 14 chromosomes, half red and half green.

The students can discover what their baby will look like by turning over their baby's chromosomes and decoding the secret code by referring to the key in

FIGURE 1. An adult reebop.

small nails

thumb tacks

green miniature marshmallows

orange miniature marshmallows

pipe cleaner

stick

large marshmallows

push pins

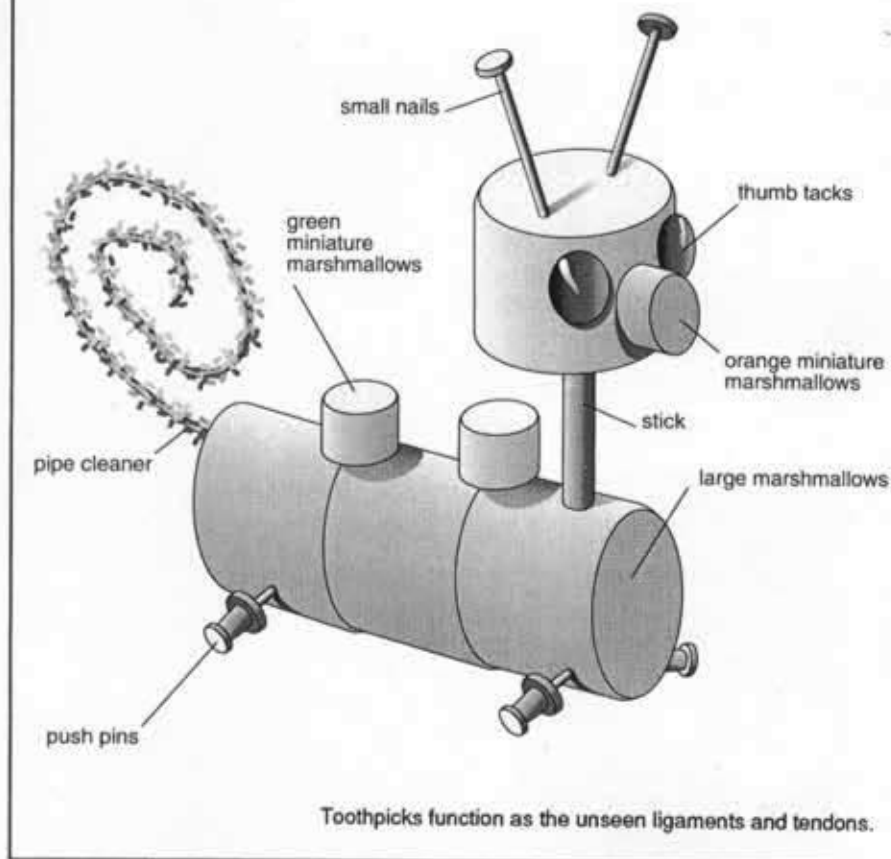Toothpicks function as the unseen ligaments and tendons.

Figure 3. Each pair of students should construct a baby according to their secret code. Have the proud parents place the completed reebop babies in a designated nursery. Ask the students to observe the siblings. Are any two alike? Why are they all different? What makes identical twins identical? Are identical twins *exactly* identical? If not, why?

If, during the activity, you happen to have a pair of students who sort their chromosomes improperly and end up with either the wrong number of chromosomes, or end up with 14 chromosomes that do not include pairs of each of the seven lengths, resist correcting them at this point. If they are encouraged to build their baby according to their secret code, their reebop baby will most likely be missing some traits and have duplicates of others. That baby will be a wonderful example of the need for both the correct number and kind of chromosomes given to the baby by Mom or Dad.

If none of the groups of students mis-sorts their chromosomes, you may wish to have a pre-constructed baby that has extra parts and is missing others. This

baby will be a perfect lead-in to a discussion of non-disjunction and the importance of complete sets of chromosomes in offspring.

RECOMMENDATIONS

I suggest that you and your students breed reebops to introduce the concept of

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Multiple generations

of reebops might

be used to

introduce a

genetics unit.

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meiosis *before* genetics is taught. You can refer back to the reebops when introducing a unit on Mendelian genetics. Also, try to minimize new vocabulary when directing the reebop activity. For example, you can begin by referring to the letters

on the chromosome as "the secret code."

At the end of the exercise, you can introduce the concept of a gene and stress that a gene actually consists of two forms, a paternal form and a maternal form. The reebops exercise should help your students understand the meaning of allele, independent assortment, meiosis, gamete, zygote, genotype, and phenotype before you introduce these terms at a later date. By using reebops, students should be able to comprehend the concept, then learn the scientific label.
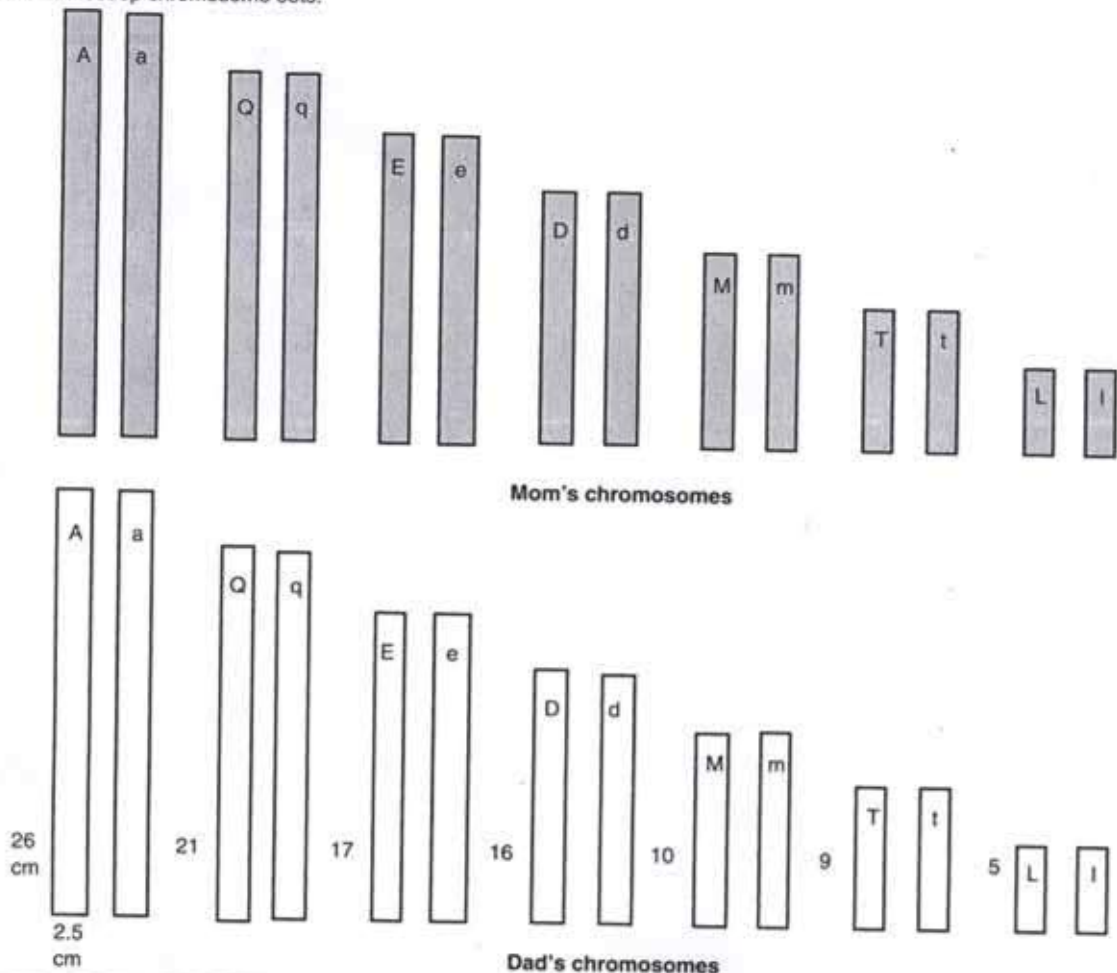
THE REEBOP ADVANTAGE

Reebops are suitable for a wide range of ages. We have found that elementary teachers as well as college instructors are enthusiastic about the lessons they have taught with reebops. Of course, the goals of the reebop activity will vary depending on the grade level of the students. For example, with young children, the goal of the activity may be simply to understand the concept of generations.

With older students, the goals may be for students to discover why each parent contributes the same amount of genetic information to a child, why siblings in a given family look similar yet are all different, and why identical twins are identical. The reebops can be used with advanced students to teach concepts such as linkage and multiple alleles. They can even be used to teach population genetics, as reebop offspring can interbreed to produce numerous generations.

In addition, multiple generations of reebops might be used to introduce a genetics unit. The students could construct reebop pedigrees and look for patterns of inheritance (prior to learning about simple dominance), and subsequently infer models that account for these patterns. This would enable them to look at the world through Gregor Mendel's eyes (he also looked at seven independently sorting traits—in pea plants). They could engage in the type of

FIGURE 2. Reebop chromosome sets.

Mom's chromosomes

Chromosomes labeled: A a, Q q, E e, D d, M m, T t, L l

Dad's chromosomes

Chromosomes labeled: A a, Q q, E e, D d, M m, T t, L l

Scale: 26 cm, 2.5 cm, 21, 17, 16, 10, 9, 5

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thinking similar to what Mendel did, by creatively building models.

I have found that the reebop activity generates numerous questions from students, especially when related to the effect of non-disjunctional events in humans. There are very few viable forms of aneuploidy (extra or missing chromosomes) in humans. One example is, of course, Down Syndrome. Most adolescents are familiar with Down Syndrome, particularly if they have seen the weekly television show "Life Goes On." Fetuses with either trisomy 13 or 18 who survive to birth will usually die shortly after.

There are living individuals who may exhibit a variety of sex chromosome aneuploidies. However in most cases, aneuploidy in humans will not result in viable offspring and a miscarriage will occur. A conservative estimate calculates that at least sixty percent of all miscarriages that occur before the twelfth week of gestation are due to an incorrect number of chromosomes in the developing fetus.

REEBOP WRAP-UP

The strength of the reebop breeding activity is that it helps students to understand that the function of meiosis is not only to reduce the chromosome number prior to sexual reproduction, but that it is a mechanism to ensure variation within a species.

As variation is the "raw material" for the process of natural selection, the driving force of evolution, it is important for our students to appreciate both the amount of variation and the causes of it.

After breeding reebops, students are more apt to recognize and understand both of these different functions of meiosis, because they are not getting bogged down in the jargon of phase names or genetics phenomena.

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FIGURE 3. Reebop decoder key.

1 antenna = AA
2 antenna = Aa
No antenna = aa

1 green hump = MM
2 green humps = Mm
3 green humps = mm

Red nose = QQ
Orange nose = Qq
Yellow nose = qq

Curly tail = TT or Tt
Straight tail = tt

2 eyes = EE or Ee
3 eyes = ee

Blue legs = LL or Ll
Red legs = ll

2 body segments = dd
3 body segments = DD or Dd