Meiosis and Punnett Squares

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Cell division is one of the most difficult topics to teach in biology and life science. Almost 42% of all science teachers surveyed recognize it as a hard subject to teach. These same teachers claim meiosis to be the most difficult part of cell division to teach to their students (Oztap, et al 2003; Smith, 1991). It has also been reported that misconceptions pupils hold in meiosis make it more difficult to solve genetics problems, particularly monohybrid and dihybrid crosses (Brown, 1990). It is very important that the study of genetics be closely tied to an understanding of cell division (Smith, 1991). Yet the very topic many teachers find most difficult to teach is also a component of Content Standard C for Middle school students from the National Science Education Standards. These standards state that as a result of their activities in grades 5-8, all students should develop an understanding of the following:

- reproduction and heredity
- know that hereditary information is contained within genes on chromosomes
- half of the new genetic information of an offspring comes from the mother and half from the father.

Recognizing the difficulties students have with meiosis and the importance the understanding of meiosis plays in the ability to solve genetic problems, our group is collaborating on several lessons dealing with meiosis, Punnett squares and probability. A math component is also added to the lessons showing the relationship between Punnett squares and the squaring of a binomial. Using the steps recommended from "The Teaching Gap", we have chosen the problems with understanding meiosis and Punnett squares as our "defined problem".

Certain specific student misconceptions need to be considered and corrected when teaching meiosis and genetic problems. Replication of DNA, the separation of homologous chromosomes during meiosis I and the separation of sister chromatids in meiosis II have all been cited as the most common areas of student misconceptions (Brown 1990; Smith 1991; Oztap, et al. 2003). These areas of difficulty translate into students incorrectly determining gamete formation for Punnett squares. Classroom experiences of our teaching group have seen students form gametes for a dihybrid cross problem as follows: Crossing 2 plants heterozygous for tallness and purple flowers, gametes listed have been Tt x Pp, TtPp x TtPp, or TP x tp. All of these student answers fail to show an understanding of the separation of homologous chromosomes and/or sister chromatids during meiosis. (The correct possible gametes are TP, Tp, tP and tp crossing with 4 identical gametes from the other parent). The primary misconception seen by the math teacher in our group is that when students square a binomial $(a + b)^2$, they often forget the middle term in the correct answer where $(a + b)^2 = a^2 + 2ab + b^2$. This is because they think they can distribute the power to each term in the binomial. This misconception stems from the unit on squaring a monomial, where the power *is* distributed. When using a Punnett square analogy to teach this math concept, students can correctly see the derivation of the middle term. The aforementioned specific misconceptions may lead to anticipated student questions such as "How do we know

which genes to put in which gametes?" "How do the gametes form?" "Why don't we look exactly like our mother or father?" "What happens when the gametes come together?" The lessons chosen by our teaching group will address these anticipated questions as recommended in "The Teaching Gap".

According to recent research, several specific teaching methodologies should be used to address students' misconceptions. Model building has been shown to elicit student misconceptions (Brown 1990; Oztap 2003). Therefore, to teach the meiosis lesson we will use a hands-on model students manipulate as they learn. Definitions have been shown to cause significant student difficulties. Correct terms and definitions will be introduced throughout the activities. As students practice the activities, they will be required to use correct terminology as a way to check for understanding. Using the model of meiosis in our lesson allows students to practice the process of meiosis and focus on original and final chromosome number, two practices recommended by Smith. By including the meiosis flip book as a homework assignment, it serves as an assessment tool and allows for the recommended student drawing of meiosis (Smith, 1991). The specific lessons used by our teaching group are attached, fulfilling step 3 suggested in "The Teaching Gap". Hopefully we will have the opportunity to evaluate these lessons and reflect on their effects. (Steps 4-8)

To aide students with learning differences, the following tools are, or could be, implemented throughout the lessons. The use of manipulatives during the meiosis portion of the unit allows visual learners to better understand the process of meiosis. Working in groups encourages peer feedback and learning. Vocabulary cards could be made by those with language difficulties. Single traits rather than multiple alleles could be used throughout all activities for those students who need modifications.

To summarize the flow of our lessons, students would have previously completed lessons on mitosis. A class discussion on inherited traits would initiate the unit. Comparisons of "Dad's eyes, Mom's hair" would ensue. The attached meiosis modeling activity would then occur, and the flip book assigned for homework to check for understanding. Once the students demonstrate their ability to show how meiosis creates gametes using their flip book and the model, the lessons on forming Punnett squares and interpreting the results would follow. Cross-curricular connections to math would be made, using the Punnett square to demonstrate how to square a binomial.

Unit Objectives/Goals:

-Students will understand the process and steps of meiosis

-Students will be able to describe the correct formation of gametes for a given parental genotype

-Students will understand the possible genotypes and phenotypes of resultant offspring

-Students will understand the pattern of a squared binomial using geometric representations and Punnett squares

Resources:

Brown, C.R. (1990) Some misconceptions in meiosis shown by students responding to an advanced level practical examination question in biology. Journal of Biological Education, 24(3), 182-186.

Oztap, Ozay and Oztap (2003) Teaching cell division to secondary school students: an investigation of difficulties experienced by Turkish teachers. Journal of Biological Education, 38(1), 13-15.

Smith, Mike (1991) Teaching cell division:Student difficulties and teaching recommendations. Journal of College Science Teaching, 21(1), 28-33.

Stigler, Hiebert (1999) Excerpts from The Teaching Gap

www.nap.edu National Science Education Standards