Letters

For Want of a Word

Dear Editor:

An article in the March 24, 1995, edition of *Science* reports on the discovery of a master gene that governs eye development. The gene or variations of this gene are found in such diverse organisms as insects, mollusks (squid) and mammals (humans). The implications of this discovery are that this master gene must have been established very early in evolution, perhaps as early as 500 million years ago, and was passed to these various groups as they evolved.

It should not be too difficult to accept the analogous idea that genes related to behavior (that increase survival rates) such as aggression, kinship bonding, self preservation, threat displays, etc. also evolved early and are common in many animal groups.

A few weeks ago I let my three-year-old granddaughter out of the car and turned to close the door. She took off across the parking lot into oncoming traffic. Without thinking, I yelled and ran after her, completely oblivious of traffic. It was an interesting reaction, strictly instinctive; an inherited response geared to survival of the species. She was not hurt (and, by chance, neither was I).

In writing a friend, I wanted an adjective to describe how I shared this reaction of protecting close kin with many other species. I wrote, "My reaction was ?; I reacted as many other animals would." I could have used the word *altruistic,* relating my response to the altruistic gene, first proposed by William Hamilton in 1968, but I wanted to encompass a broader idea. My primitive response was linked to behavior commonly shared by many species of many diverse groups. The genes for such basic responses, just like the gene for eye development, must have evolved early in the history of evolution.

Random House Unabridged Dictionary, 2nd ed., offered two words, *atavistic* (atavism) and *zoomorphic* (zoomorphism). *Atavistic* came close, but was off the mark. *Atavism*: 1a) The reappearance in an individual of characteristics of some remote ancestor that have been absent in intervening generations. 1b) An individual embodying such an earlier type; a throwback. *Atavism* emphasizes the unusual or surprising reappearance of ancestral traits, like a human born with a tail or hairiness that completely covers the body.

My reaction was no throwback, no surprise. It was as common as salt.

Neither of the two definitions of zoomorphism were applicable since they refer not to behavioral traits but to resemblances of gods or humans to animal forms.

May I offer a new word, *anthropozooic;* a term relating human to animal. *Anthropozooism*: An inherited human trait or traits thought to be, or accepted as, shared with other animal species (e.g. pair bonding, aggression, territorial defense, etc.). *Anthropozooic* is the best I can come up with. If you can think of a better word, that's great—but we need a new word. So now I can complete my sentence: "My reaction was anthropozooic; I reacted as many other animals would."

Think what this will mean to countless students who get the dreaded comment "anthropomorphic" for daring to attribute human traits to animals in a sentence such as, "The chimpanzee died of grief." Is grief recognized by science as a solely human response? I don't think so. (Neither is depression. Prosac was first tried on monkeys in various stages of depression before it was given to humans.) The student could counter, "Grief is anthropozooic. It is a trait we share with many other animals." Surely it's time that we recognize the work of scientists such as Lorenz, Goodall, Fosse, Wilson and dozens of others who have studied the behavior and social organization of species as diverse as geese, chimpanzees and ants, and found an astonishing number of common traits. Although *anthropomorphic* is a useful word, perhaps it is overused.

We should perhaps spend less time suggesting, rightly or wrongly, that some animal traits approach human characteristics and more time emphasizing the fact that many of our human traits are anthropozooic, having arisen early in evolution and therefore shared with many other animal species.

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Double Helix Clarified

Dear Editor:

My article "The Double Helix Revisited" was just published in *ABT*, March, 1995. I have just discovered an error and hope that you can print a correction.

On page 146, I state that the Noble Prize winning work won the prize in 1954. This is clearly a mistake. The correct year was **1962.**

I apologize for the error. It must have been my oversight.

Thank you.

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More on Meiosis

Dear Editor:

I was delighted to see John Stencel's article, "A String & Paper Game of Meiosis That Promotes Thinking" in *The American Biology Teacher* (January 1995). For the past five years I have been using almost the same technique as Stencel with my students, except that recently I have discovered an even easier method that demonstrates meiosis and its consequences more clearly. Most students are easily confused when they cannot physically demonstrate the exchange of a single gene (a segment of a DNA molecule) during the process of crossing-over, by simply using strips of paper, as shown in Stencel's article (and as I did in the past). Crossing-over is the process through which the reciprocal exchange of corresponding segments of genetic material between two homologous non-sister chromatids takes place. The result is rearrangement of genes. My solution was to use various lengths of different-colored, thin clothesline, and insert them into different lengths of colorless straw. This method of demonstrating meiosis (including crossing-over, independent assortment and their consequences) is vividly observable and easy for students to understand, and it also makes the process of teaching this complex topic much easier. (The following is a brief summary of my method, which will be published in its entirety in a forthcoming paper called, "Instructional Strategies for Teaching Genetics Effectively.")

Preparation for the Clotheslines/ Colorless Straws Technique

As in Stencel's article, the preparation for this technique is minimal. I usually go to the local dollar store and buy hula hoops, colorless straws, different-colored clotheslines, a plain rope and paper lunch bags. Before class I prepare a set of four paper lunch bags (numbers 1, 2, 3 or 4) with specific materials and one hula hoop (to represent the cell membrane)—each for a group of four students.

Paper bag #1 has one piece of rope tied in a circle to represent the nuclear membrane, and three pairs of colored clothesline (e.g. green, red and yellow), each pair cut in different lengths (4", 8" and 12") to represent three pairs of homologous chromosomes.

Paper bag #2's content is identical to paper bag #1 except there is no rope tied in a circle.

Paper bag #3 has six colorless straws (two at 4", two at 8" and two at 12"). Each pair of same-size straws has one green piece of clothesline in one straw, and one red piece of clothesline in the other.

Paper bag #4 is set up identically to paper bag #3, except each pair of clothesline is cut into two or more pieces before the pieces are inserted into their straw. It is important that the matching pairs (two at 4" of red and green each and so on), are cut into identical proportions.

Explaining Meiosis Using Colorless Straws & Colored Clotheslines

I explain meiosis two times with a different emphasis each time. In both cases, students are not allowed to take notes, but only to follow my explanations by physically demonstrating what is happening in each phase of the meiotic divisions using the simple materials provided.

First Explanation

In the first explanation of meiosis, students are asked to use only paper bags #1 and #2. In addition to understanding meiosis as a continuous process, the main objectives of the first explanation of meiosis are for students to understand:

a. The concept of sister and non-sister chromatids, synapsis, tetrad, and bivalent
b. Which chromatids have a tendency to cross over each other and which don't
c. The difference in chromosome number and type between the mother cell, the daughter cells in the first meiotic division, and the daughter cells in the second meiotic division
d. The reduction of chromosome number by half in gametes (haploid cells have unpaired chromosomes). At this point, I explain meiosis almost in the same way as Stencel's technique, but without integrating questions. Thus, I will bypass the first explanation and concentrate only on the second.

In the second explanation of meiosis, students are asked to use only paper bag #3 and later, #4. This time, meiosis is explained with both crossing-over and the possibility of the reciprocal exchange of corresponding segments of genetic material between two homologous non-sister chromatids that result in gene recombination. The main objectives for explaining meiosis the second time are for students to understand:

a. Segregation and the independent assortment of homologous pairs of chromosomes in meiosis I, and the separation of the sister chromatids in meiosis II. The random alignment of chromosomes in several possible ways during metaphase of the first meiotic division is one of the keys to understanding the different genetic makeup (gene combination) of the four haploid nuclei produced by two separate meiotic divisions.
b. The difference in genetic makeup of the mother cell, the daughter cells in the first meiotic division, and the daughter cells in the second meiotic division.
c. Nondisjunction phenomenon, or the failure of either chromosomes or sister chromatids to separate normally during cell division, thus producing various types of aneuploid daughter cells.

Second Explanation

In the second explanation each group is using only paper bags #3 and #4, each of which contains six colorless straws. Each pair of same-sized straws has one green piece of clothesline in one straw, and one red piece of clothesline in the other. They represent three pairs of homologous chromosomes. Remember, each pair of clothesline in paper bag #4 is cut into two or more pieces before they are inserted into their straw.

1. Each group of four students is using the hula hoop as the cell membrane, and the piece of rope to represent the nuclear membrane inside the hula hoop.
2. Each group is asked to empty paper bag #3 inside the nucleus, and make sure that the members of the three pairs of various lengths of colorless straws are scattered within the nucleus. This represents the interphase stage. Even though the chromosomes are already replicated in the interphase stage, students can only see them as replicated chromosomes in early prophase (because they become thicker and shorter in that phase).
3. Moving toward the stage of prophase I, each group is asked to empty paper bag #4 beside the hula hoop. Remember, bag #4 is set up identically to paper bag #3 *except* each pair of clothesline is cut into two or more pieces before they are inserted into their straw. The matching pairs in paper bag #4 (two at 4" of red and green each and so on), are cut in identical proportions, so each piece can be removed and exchanged during the process of crossing-over.
4. Use the three new pairs of straws of various lengths from bag #4 to show that the chromosomes have become shorter and thicker and thus can be seen now as duplicated chromosomes (but the sister chromatids of each chromosome are still attached to each other through the centromere).
5. Homologous chromosomes have a tendency to pair side-by-side. Hence, the students are asked to show that the homologous chromosomes are aligned side-by-side, a process called synapsis.
6. During synapsis, two homologous non-sister chromatids may cross over each other and exchange corresponding segments. Students are asked to exchange corresponding segments between non-sister chromatids of pairs of homologous chromosomes, by removing and exchanging one or two pieces of green clothesline inserted in a

given length of straw, with one or two pieces of red clothesline inserted in the similar corresponding lengths of straw. The exchange of corresponding segments and the rearrangement of genes become visually clear to the students. They can actually see and understand the process.

7. I continue explaining and the students continue demonstrating the rest of meiotic divisions one and two, concentrating this time on:

   a. The random alignment of chromosomes in several possible ways during metaphase of the first meiotic division. The students can see and understand the potential of how each lineup gives a different gene combination in the final gametes.
   b. The source of genetic variety in resulting gametes.
   c. The difference in genetic makeup between the original nucleus (of the mother cell), the nuclei at the end of meiosis one, and the nuclei at the end of meiosis two.

8. At the end of the demonstration, we take about 20 minutes to go over any questions the students may have.
9. After students understand the nature, mechanism and process of meiosis, I shift the emphasis to the changes in chromosome structure and chromosome number that may occur during meiosis. We use *paper bags #1 and #2* to demonstrate the changes in chromosome number (nondisjunction), and paper bags #3 and #4 to demonstrate the changes in chromosome structure (e.g. deletion, duplication, inversion, shift and translocation).
10. At the end of the session, the groups of students are asked 22 questions [mostly "how" and "why" questions which are selected (a few with modifications) from various biology and genetics textbooks] which examine their understanding of the process of meiosis and its consequences and applications to human life. The groups answer these questions in writing.

I have found this method of teaching students about meiosis to be very effective and practical. Oftentimes my students take their new understanding of meiosis and practice it on their own, eventually adding more and more chromosome pairs. Indeed, with the *clotheslines/colorless straws technique*, students never fail to understand the complex topic of meiosis, and they are able to answer various questions that relate to meiosis and to its implications.

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