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# Structured Controversy: A Case Study Strategy

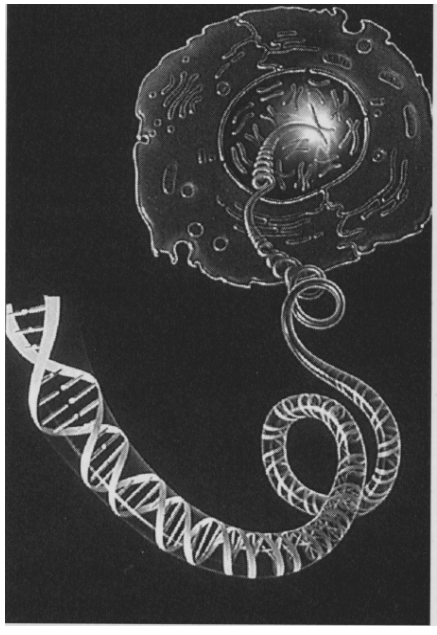
## *DNA Fingerprinting in the Courts*

*Clyde Freeman Herreid*

***Continuing JCST's series on case-study teaching, we introduce a dynamic form of the case-instruction method that involves debate and compromise. It is suitable wherever there is a controversial issue at hand.***

Science has always been filled with controversy whether the issue is the Big Bang hypothesis versus the steady state universe, the cold fusion debate, or the wave versus particle theories of the nature of light. It is the nature of the business to question, debate, and argue. Science is not special in that regard. Human society as a whole is besieged by debate and probably always has been. It is personified by Adam and Eve arguing with the serpent. It is Galileo Galilei at the Inquisition. It is Bob Dole versus Bill Clinton.

Formal debate technique is part of a lawyer's arsenal. The seeds of the adversarial approach to problems are sewn in law school classrooms, nurtured in moot courtrooms, and reach full bloom in the criminal and civil courthouses of America. Whatever else it does, the adversarial system hones the wits of the participants and brings the issues of any problem into sharp focus. However, it leaves little room for compromise. Indeed, it seems the debaters are often more interested in winning the argument than seeking justice or truth. Furthermore, much of life is not a zero-sum game where there is a winner and a loser. Many would argue that cooperation and negotiation towards a compromise is a better model for life. In fact, many of the great debates in science ended with a compromise solution, which brings us to the technique at hand.



*The now familiar image of the double helix.*

Structured controversy is a teaching technique that uses the strengths of conventional debate and ends with two sides seeking ways to resolve the conflict through compromise. Its virtues in the classroom have been championed and summarized by Johnson and Johnson (1989) and Johnson, Johnson and Holubee (1992). Compared to most other methods of instruction, structured controversy results in greater student mastery and retention of the material and a greater ability to generalize the principles learned (Johnson and Johnson, 1988).

There are at least four major critical thinking skills required by the controversy structure (Johnson and Johnson, 1989, 1992):

▲ Students must collect data and analyze the research in order to present evidence supporting a position.

▲ Students must evaluate and criticize the opposing position using rules of logic and evidence. At the same time, they must repel the attack of their opponents and shift and refine their own positions.

▲ Students must see the issue from both perspectives.

▲ Finally, students must synthesize and integrate the best evidence from both sides and reach a compromise consistent with both positions.

### TWO VERSIONS OF STRUCTURED CONTROVERSY

Johnson, Johnson, and Holubee (1992) summarize the major steps used in structured controversy in the classroom.

* * *

▲ *First*, a controversial topic is proposed by the instructor (*e.g.*, nuclear

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power plants should form the basis of our nation's energy policy; *e.g*, logging operations should cease in our national forest and parks).

▲ *Second*, students are coupled in pairs (teams) to research literature and prepare arguments for either the pro or con side of the issue.

▲ *Third*, opposing teams meet and give their "best case" arguments to one another, courteously debating the issue.

▲ *Fourth*, the opposing teams reverse their roles presenting the opposite view as convincingly as possible.

▲ *Fifth*, the opposing teams abandon their advocacy roles and write a compromise report.

▲ *Sixth*, all individuals in the class take a written test based on the material and receive bonus points if all members of their compromise team score over a set criterion.

▲ *Seventh*, the teams give a 10-minute oral report on their compromise to the class with all team members participating.

* * *

Johnson and Johnson's *Structured Controversy* method is a powerful technique that can be applied to case study teaching. It clearly achieves the learning goals I summarized earlier.

Nevertheless, the technique requires a large investment of classroom time; six class periods are recommended. Barbara Watters of the State University of New York at Oswego (personal communication) has recently developed an alternative approach that meets many of the above goals, yet it can be accomplished in one or two classroom periods. It requires a minimum of 75 minutes to complete.

Watters' model works this way:

▲ *First,* a controversial topic is assigned.

▲ *Second,* each student working on his own searches the literature and writes two position papers, one for the pro and another for the con side of the controversy.

▲ *Third,* during class, small groups of students are formed. Half of the groups are asked to role-play the pro side and half are asked to role-play the con side. Each group chooses its three best arguments.

▲ *Fourth,* the instructor then calls on a pro side group to present its top argument, identifying its assertion and evidence to support it. Con-group members are asked to comment on the pro argument. Rebuttal is permitted. Then, a con-group presents its best argument. Pro commentary follows with debate. This process is repeated with pro and con teams alternating their arguments.

*The structured controversy method is excellent for dealing with cases that are highly charged and should be added to the list of techniques for teaching case studies. It forces all parties to analyze the best evidence on both sides of the question and then to search actively for a compromise solution.*

▲ *Fifth,* the instructor asks the groups to abandon their advocacy roles and to try to come up with a compromise statement that might be found reasonably acceptable by the opposing groups. These solutions are listed on the board with commentary by each group.

▲ *Sixth,* the instructor or a student closes with a summary analysis.

The structured controversy method is excellent for dealing with cases that are highly charged and should be added to the list of techniques for teaching case studies (Herreid, 1994). It forces all parties to analyze the best evidence on both sides of the question and then to search actively for a compromise solution. The method is best understood by showing an example of a recent case using the DNA fingerprinting which received notoriety in the O.J. Simpson murder trial.

When using this technique, the instructor must be sure to give clear instructions in order to get good written and oral responses. Students must understand how to write individual position papers on the pro and con sides of arguments and the proper rules of debate conduct.

To start the students out with the right strategy, I give them handouts on the *Elements of Argumentation*, which is drawn from Govier (1992), Hinderer (1992), and Zeidler, Lederman, and Taylor (1992). Then, I assign a topic with instructions on how to proceed. I also include an abbreviated example of a student paper on a different topic.

For the readers of the *Journal for College Science Teaching*, I am including an example of the use of DNA fingerprinting in forensic medicine, which follows this article. ❑

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# Structured Controversy: A Case Study Strategy: Part II

## *Student Assignment: An Example of the Use of DNA Fingerprinting in Forensic Medicine*

*Clyde Freeman Herreid*

Write an analysis paper of the arguments surrounding the use of DNA evidence in courts of law. In order that you gain an understanding of both sides of the issue, and acquire experience in identifying assertions and evidence, please structure the paper in the following manner.

**TITLE**: *e.g.*, DNA Evidence Should be Used in Forensic Medicine

**AUTHOR** · Your name

**INTRODUCTION**: Several sentences briefly introducing the controversy.

**PRO-SIDE OF THE ARGUMENT**: Here you should lay out four of the major assertions and evidence that would be used in arguing in favor of the proposition stated in the title.

A note on assertions: Those that are short are often more easily defended than longer, more complex assertions. Good assertions are falsifiable in principle; *i.e.*, they can be tested and we will know if they are wrong.

A note on evidence: Be sure that the evidence that you use speaks directly to the assertion you make and meets the conditions of a good argument: the evidence must be adequate, relevant, and succinct. Finally, when you refer to data in the literature, proper citations should be appended to the paper.

**CON-SIDE OF THE ARGUMENT**: Here, you should write four major assertions and offer supporting evidence against the proposition in the title, using references where appropriate.

**POSSIBLE COMPROMISES**: Here, try to find any compromise statements or positions that both sides of the argument might agree to include.

**PERSONAL OPINION**: Write your personal views on the proposition.

**REFERENCES CITED**: Write out complete references to papers that you have cited.

A short version of a student paper follows.

***DNA EVIDENCE SHOULD BE USED IN FORENSIC MEDICINE*** *(shortened version of a student paper)*

*INTRODUCTION*: Technology concerning DNA fingerprinting has been developed for use in forensics. However, some believe this technology is unreliable and may in fact cause a false positive reaction, thus causing the imprisonment of an innocent person. The admission of DNA evidence into court has been extremely controversial, as was seen in the O.J. Simpson case.

**PRO**: Yes, DNA fingerprinting should be used in forensic medicine.

**ASSERTION 1**: DNA-based identification is more reliable than other forms of identification, such as blood groups and enzymes.

**EVIDENCE 1**: "If enough tissue or semen is available, forensics laboratories can perform tests to determine the blood or tissue type. However, such tests have limitations...there are many people in the population with the same blood type or tissue type...this approach can only exclude a suspect...DNA testing, on the other hand, can theoretically identify the guilty individual with certainty because the DNA base sequence of every individual is unique" (Campbell et al., 1994).

"DNA-based identification has been so widely embraced by the judicial system because...a suspect can for

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all practical purposes be positively identified" (McElfresh et al., 1993).

"Another problem with traditional forensic methods is that, during the weeks or months [of the investigation], evidence may have to wait before being examined by a forensic scientist and proteins can become degraded or denatured so their antigenic properties are lost. For examination in forensic samples, DNA is more suitable than protein because DNA remains intact in the environments where such evidence generally is found. Indeed, small fragments of human DNA have been isolated and cloned from the tissue of a 2,400-year-old Egyptian mummy. Although the length of these DNA fragments was too small for RFLP analysis, this work does illustrate the impressive stability of the DNA molecule" (Moody, 1989).

**ASSERTION 2**: Statistical analysis has shown that it is almost impossible for two people to share the same DNA unless they are identical twins.

**EVIDENCE 2**: No two people have the same DNA (nucleotide sequence) unless they have an identical twin (Campbell *et al.,* 1994). Even family members do not carry an identical genetic make-up. They share some of the markers, but there are genetic differences that are specific to each person (McElfresh et al., 1983). The main purpose of DNA based-identity is to take evidence and compare the similarities or differences to that of the suspect.

DNA tests are so variable that "an almost infinite number of genotypes across several loci can be identified" (McElfresh et al., 1993).

Inheritance of DNA patterns is independent among loci, thus the probability of each is multiplied to find the total probability. "It is not unusual for a four-locus DNA pattern to have individual loci with average probabilities of a 1 in 100 and therefore a combined probability of .1 in 100 million" (McElfresh et al., 1993).

**ASSERTION 3**: DNA fingerprinting is generally accepted by the scientific community.

**EVIDENCE 3**: "In most states, scientific evidence is admissible only when it has 'gained general acceptance' in the scientific community" (Witkin, 1994). "Forensic DNA testing has been adopted not only throughout the United States, but in Canada, Europe, and elsewhere. Similarly, paternity testing, which uses identical methodology, has been accepted for years" (Devlin et al., 1993). DNA fingerprinting has met with the requirements of scientific evidence allowable in court.

DNA fingerprinting, as the process is called, is a complex, high-tech forensic test that can link a suspect to the commission of a crime - or establish his innocence. While still controversial, use of the test is gaining acceptance in American courtrooms" (Cray, 1994).

* * *

**CON**: No, DNA fingerprinting should not be used in forensic medicine.

**ASSERTION 1**: There are inherent errors in the techniques used to determine a DNA fingerprint.

**EVIDENCE 1**: Possible sources of error include band shift, DNA degradation, partial restriction digesting, and inconsistencies in the electrophetic gel. "Forensic samples are different in origin, storage, and collection from the standards. Such differences between the samples may be reflected in mobility differences between the DNA bands. It is just as probable that band shift could move away from a match as into one, and there is no way to predict which will happen" (McElfresh et al. 1993).

In the RFLP method, restriction enzymes break the DNA strands at specific sites, resulting in variable fragment lengths between individuals. However, "heat, humidity, bacterial contamination, and UV light damage DNA by causing random breakage of the helix" (McElfresh et al., 1993). This will result in random fragment lengths that may cause errors in the DNA fingerprint produced. Slight inconsistencies in the electrophoretic gel can skew the positions of the DNA fragments. "Occasionally, restriction bands do not separate completely, or they end up at slightly different positions in different gels" (Campbell et al., 1994).

In addition to the inherent errors in the techniques, there is always the possibility of human error. "The largest source of error lies in poor laboratory practices" (Roberts, 1992). "The lab error is the most likely place to get a false incrimination of an innocent person or a guilty person going free" (Nowak, 1994).

**ASSERTION 2:** A lack of consensus is often evident when interpreting DNA typing results.

**EVIDENCE 2:** Each forensic lab has defined its own "match criteria." LIFECODES Corp. of Stanford, Connecticut has established that two bands would be declared a match if they fall within 2.8% of each other in size. This is based on their calculated standard deviation which derives from empirical data. The FBI has determined that, based on their empirical data, matching bands exist if two bands are within 2.5% of each other

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in size (McElfresh et al., 1993).

Lack of defined protocol or criteria leads to a lack of consensus in interpretation. In a 1989 court case, a LIFECODES Corp. forensic scientist calculated the odds of a random match between the evidence and the suspect to be one in a million. Other forensic scientists who examined the same data calculated the odds to be one in 24 (Neufield and Colman, 1990). "Most scientists with training in molecular biology and population genetics would accept DNA typing as probative, but most also view it with some caution since it involves the confluence of many theories and techniques" (Ayala and Black, 1993).

**ASSERTION 3**: DNA evidence is at best circumstantial.

**EVIDENCE 3**: All DNA evidence admitted to court consists of a "visual/measured interpretation of the pattern of DNA bands on the autoradiography and if the patterns have been declared to be the same, a mathematical declaration of the probability of finding that DNA pattern in a given population" (McElfresh et al., 1993). These probability estimates are a function of the number of VNTR loci examined but "the variation in the frequencies ranges from one in 400,000 to one in 4,000,000" (McElfresh et al., 1993).

It is interesting to note that, while these probability estimates for a perfect match may be compelling, up to 400,000 people can expect to pass within 10 blocks of a rape incident in New York City's Central Park on a typical business day, and 4,000,000 people within three miles of the crime. Viewed in this light, when the suspect falls within the "high probability" range of being the perpetrator, it becomes problematic to correlate "high probability" with "highly likely" without taking into account such things as population density within the area of the crime scene.

Circumstantial evidence "consists in reasoning from facts which are known or proved to establish such as are conjectured to exist" (Black's Law Dictionary, 1990). Now, it is a relatively simple matter for scientists to establish the "fact" that the probability of a given suspect committing a crime is one in 1,000 or one in 2,000,000, but given this fact, it is still necessary for a jury to infer, given other evidence, that this probability is compelling enough to establish guilt. By definition, then, since estimates of genotype probabilities are, as yet, never equal to one, the legal community must (through conjecture) establish guilt or innocence via other evidence. DNA evidence is thus circumstantial at best.

**POSSIBLE COMPROMISE**: Statistical analysis shows that the probability of a false positive match varies from one in 400,000 to one in 4,000,000 people. Although at first this number seems sufficient enough to convict the suspect, when considering that 4,000,000 people can be found within a small geographical region in densely populated areas, this ratio becomes unconvincing. Therefore, DNA evidence can never prove with certainty the guilt of a suspect.

In light of this, DNA evidence should be used only to corroborate other evidence to implicate a suspect or, conversely, to exonerate that person. Further, regulations should be passed and enforced establishing universal techniques and standards in processing DNA. This would include private and FBI labs.

**PERSONAL OPINION**: We believe that DNA fingerprinting is a very useful tool in the field of criminal justice. It has been shown to be very powerful and exact in determining the identification and guilt or innocence of a suspect. Like any method, however, DNA fingerprinting is subject to error, and these possible fallacies must be regulated and insured against to warrant the validity of DNA testing.

We feel that research should be conducted to define the frequency of a particular DNA fingerprint occurring in the population in order to reach consensus in the scientific community, that DNA tests should be standardized to avoid the scrutiny that follows due to variations in methods and results, and DNA labs should be regulated, either by the federal government or some other body, to insure the exactness and validity of results.

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*(Continued from page 96)*

## *TEACHING NOTE*

### IS THIS REALLY A CASE?

I have called this a case-study method and in spite of the facts, the approach does not appear to tell a story. Yet, because the assignment is in the context of the O.J. Simpson civil trial, there is an underlying story line. Nothing more is needed for the student. In the student paper and in the classroom debate which follows, the trial pervades.

In addition, I set up a story context in two other ways. First, I gave the students handouts or literative references to the O.J. Simpson trial where expert witnesses debate the problems of DNA fingerprinting. Students are told they must include additional references if they are to receive an "A." Second, I do a "lab exercise" marketed by Ward's Scientific which is a "DNA Whodunit kit" designed for 30 students. It consists of a hypothetical murder mystery involving the "blood" from a victim, a murderer, and five suspects. Students, using popbeads, first build DNA models which vary among the suspects. Then they proceed to go through simulated steps of the DNA fingerprinting process with "restriction enzymes," "electrophoresis," and "radioactive probes," finally identifying the murder. College students in my Evolutionary Biology course found this exercise exciting and it can be done in any classroom in a period of 75 minutes. Together with the structured controversy assignment, there is no doubt as to the story line.

### BLOCKS OF ANALYSIS

In a traditional case study where the instructors include an extensive description of a particular murder or dilemma, traditional blocks of analysis would be found here. But this is not about the O.J. Simpson trial or any other trial. The student has been asked to write a series of assertions and evidence statements using the literature, some of which the instructor may not have seen. Consequently, there is the possibility of more surprises with the structured controversy approach than with most other case study teaching methods. Yet, there are still clear blocks of analysis which we can predict given that the case is to be used in a science class.

### DNA STRUCTURE

This case, especially if the instructor uses the "Whodunit Kit," provides clear opportunities to get the DNA structure indelibly printed in the mind of the student. This will not likely come up directly in the debate unless the instructor asks the students to clarify or amplify some points of evidence. But if the instructor spends too much time asking questions on this or any other point, the spontaneity and drama of the debate itself is easily lost and the instructor reverts to the role of Socratic discussion leader.

### DNA FINGERPRINTING

There exist excellent drawings, descriptions and models of the various steps of the DNA fingerprinting process. If these are made available to students in the handouts, there should be little difficulty understanding the process. Questions about the method, however, frequently appear in the debate, as do questions about the use of Polymerase Chain Reaction (PCR) in amplifying nucleotide chains and the use of electrophoresis and probes.

### GENETICS

The structural discussion of DNA is a natural platform to discuss variability in the genome and the uniqueness of the individual. Topics of mutation, junk DNA, and hypervariability lurk not far behind, along with the use of DNA fingerprinting to detect genetic disorders and gene replacement.

### ETHICAL CONSIDERATIONS OF GENETIC ENGINEERING

Screening methods for genetic disease and the potential for gene therapy naturally evolve into questions of "What do we do with this information?" Are abortions an option if we detect an abnormality? Do we inform patients? Employers? Insurance agents? Will we permit individuals to manipulate their childrens' genetic makeup at will? These questions, although off the mainline of DNA fingerprinting, are close at hand and it will take an alert instructor to avoid some of these issues if they are not on the agenda for discussion.

### THE USES OF DNA FINGERPRINTING

By now the public knows that murders and rape and paternity cases can be solved with a small amount of DNA. Less well known is the role of DNA in detecting evolutionary relationships, determining family connections in animals, and identifying animal carcasses in cases of poaching of endangered species. These topics are interesting sidelights to the case.

A part of these discussions will focus on the issue of misidentification, which is an especially grievous error in criminal cases. Lab procedures, security measures, and cross-checking between labs are all discussion points, as are questions about how the age and condition of a sample can affect analysis, how band shifting might occur on electrophoresis gels, and how clearly DNA fragment lengths can be identified ("The bin size problem").

### PROBABILITY THEORY

Much of the discussion involving DNA fingerprinting centers on the probability of making a correct match of suspect to murder. This issue is touched upon in the accompanying student paper. An extensive analysis of the probability of finding matches in certain ethnic groups is central to the discussion. It will be important for the instructor to ask how we can decrease the chances of making such an error. Part of the answer should be to increase the number of identifying probes. Certain to be part of the discussion will be how one calculates the probability of a match and the use of the "product rule." The conflict involving the use or non-use of the "ceiling principle" advocated by the National Research Council is appropriate here.

In a normal discussion case found