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A Powerful New Crime-Solving Tool

WHEN A CRIME is committed, something is always left at the scene of the crime, and something else is always carried away by the criminal. Those things are evidence. Fifty years ago, two scientists made a discovery that would give forensic specialists a powerful new tool to analyze that evidence. James Watson and Francis Crick, who worked together at Cambridge University in London, discovered the structure of the deoxyribonucleic (DNA) molecule. They did not realize it at the time, but their discovery that DNA is a double helix curled up inside the cell's nucleus would change the course of criminal investigation. Evidence from crimes would no longer be limited to things that could be seen, touched, or heard. DNA evidence, invisible to the naked eye, had the power to identify who had or had not been present at the scene of a crime. Barry Scheck and Peter Neufeld, defense attorneys best known for their work on behalf of the wrongly convicted, explain in the book *Actual Innocence* why DNA fingerprinting is so important to the criminal justice system: "DNA testing is to justice what the telescope is for the stars: not a lesson in biochemistry, not a display of the wonders of magnifying optical glass, but a way to see things as they really are."[1] DNA evidence changed criminal science forever.

The first criminal case involving DNA evidence was solved in England only twenty years ago. The exciting

technology almost immediatedly leaped to the shores of the United States. But despite its promise and some early successes, the introduction of DNA testing to the United States was highly controversial. There were problems to overcome before this new technology could be fully embraced in this country.

DNA makes its grand entrance

The first criminal case involving DNA began with the murder of a young girl in the English countryside. Lynda

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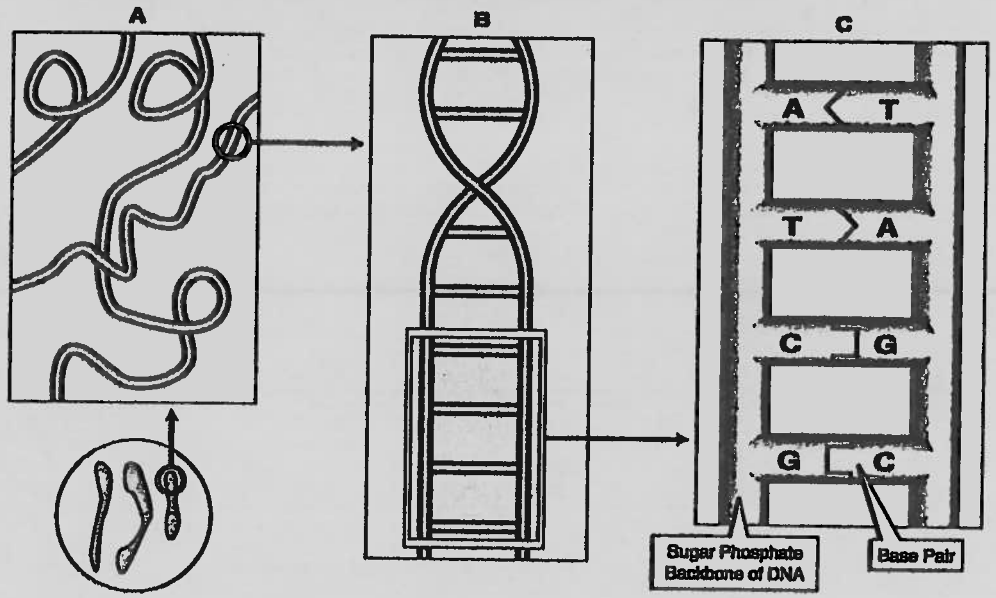
Rungs on a Ladder: The Structure of DNA



A. A chromosome is a chainlike strand of DNA, which contains many genes.

B. When the chromosome is greatly magnified under a microscope, it looks like a long ladder that is twisted into a double helix. The twisting allows these amazingly long strands to fit inside a single tiny cell.

C. The sides of the DNA ladder are made of sugar and phosphate molecules. Between the two sides are rungs made up of the four base pairs—AT, TA, CG, and GC. The letters stand for the four bases that make up the pairs: adenine, guanine, cytosine, and thymine. A single strand of DNA may contain billions of rungs. The different arrangements of these four base pairs are codes that call for different combinations of amino acids. Amino acids combine to make up proteins, which, in turn, direct the endless variety of features that make up every living thing. Each sequence of base pairs that contains the instructions for making a single protein is called a gene.

Mann, a fifteen-year-old babysitter from Narborough, a small village in England, never made it home one cold night in late November 1983. Her mother was frantic. In the dawn light of the following morning, her lifeless body was discovered by a hospital worker on the Black Pad, the name given to a footpath that divides the local psychiatric hospital from a cemetery. She had been raped and strangled. Although semen stains were recovered from her body, her murder remained unsolved.

Then, three years later on a Saturday in August 1986, another young girl was murdered in the same small English village. Dawn Ashworth, also fifteen, was out visiting friends one evening and never returned home. The afternoon headline in the local newspaper reported that Narborough police with tracking dogs were searching for the missing girl in the same area in which Lynda Mann had been found murdered three years earlier.

Two days later, Dawn's body was discovered in a field near Ten Pound Lane, another footpath. Again, the cause of death was strangulation, and once again, the young girl had been raped. It was not long before a seventeen-year-old hospital worker named Richard Buckland was under suspicion. Buckland even mentioned to one officer that he had walked with Dawn on the night she was murdered. That was enough information for the police to arrive at Buckland's home at five o'clock in the morning on August 8, 1986, and arrest him for murder. But, though Buckland admitted having spent time with Dawn, he denied at first that he had murdered her.

The police questioned Buckland for hours, and finally, he confessed. But, though authorities were convinced that the two murders had been committed by the same man, Buckland refused to confess to the first murder.

A new type of fingerprint

The police needed more information to prove that Buckland was guilty of the murders of both young girls. They were hoping that Buckland's guilt in both cases would be confirmed by a new process that was being developed in a laboratory not far from the scene of the grisly crimes. Dr. Alec Jeffreys, a geneticist, was working in his laboratory at Leicester University on a technique he called "genetic fingerprinting." Jeffreys was using the recent discovery that cells found in blood, skin, saliva, and semen—cells often left at crime scenes—contain DNA. Since no two individuals except identical twins have the same DNA, Jeffreys believed that it

The Blooding, an account of the Narborough murders, author Joseph Wambaugh recounts Jeffreys's certainty about the accuracy of DNA fingerprints. According to Wambaugh Jeffreys claimed:

> You would have to look for one part in a million million million million million before you would find one pair with the same genetic fingerprint, and with a world population of only five billion it can be categorically said that a genetic fingerprint is individually specific and that any pattern, excepting identical twins, does not belong to anyone on the face of this planet who ever has been or ever will be.[2]

Jeffreys chose the term *genetic fingerprinting* deliberately because he was certain that DNA fingerprinting would have important applications in police science, just as traditional fingerprinting had changed forensics in the nineteenth century.

The structure of DNA

Jeffreys's work was an outgrowth of one of the most important discoveries ever made in molecular biology. Thirty years earlier, in 1953, James Watson, a twenty-three-year-old American, and Francis Crick, a thirty-five-year-old Englishman, who worked together at Cambridge University in England, had announced to the world that they had unraveled the structure of the DNA molecule.

Crick, Watson, and other biologists had known for a long time that the nucleus of a cell contains its chromosomes, which act like a package of instructions that tell each cell what its role is and how to organize itself into a living creature. Every living plant or animal has chromosomes. Humans have forty-six, arranged in twenty-three pairs. The chromosomes contain the hereditary information that is passed from the mother and father to the child. Chromosomes consist of proteins and DNA. Watson and Crick discovered that DNA is formed by two winding strands that wrap around each other like a spiral ladder with 3 billion rungs. These rungs are composed of four chemicals called bases: adenine (A), thymine (T), guanine (G), and cytosine (C). The bases are always paired: each A is linked to a T, and each C is connected to a G. Watson and Crick immediately recognized the importance of understanding this structure. Watson, in his book *DNA: The Secret of Life*, wrote:

> DNA, as Crick and I appreciated, holds the very key to the nature of living things. It stores the hereditary information that is passed on from one generation to the next, and it orchestrates the incredibly complex world of the cell. Figuring out its 3-D structure—the molecule's architecture—would, we hoped, provide a glimpse of what Crick referred to only half-jokingly as "the secret of life."[3]

Watson and Crick knew that their discovery would have far-reaching effects in biology, chemistry, and medicine. But not even they predicted how this discovery would eventually wind its way into the field of criminal science.

Why is the structure of this molecule so important? The individual strands of DNA are so tiny that 5 million would fit through the eye of a needle. The twisting turns of this double-helix molecule cause it to coil up tightly inside the nucleus of each cell. The length of DNA in a single human cell is about one foot. Since each human being is composed of about 100 trillion specialized cells, the DNA strands in one human body would stretch to the sun and back one hundred times. The structure of DNA allows it to hold the vast amounts of information needed to program each of these cells to perform its unique and necessary function.

Since all human beings share most of the same features such as hands, feet, liver, heart, and lungs, huge chunks of DNA are the same in every human. In fact, human beings have 99.9 percent of their DNA in common. Small lengths of that molecule called polymorphisms, however, vary from person to person. For example, where one person might have an A, another person might have a G. These polymorphisms were considered unimportant at first, since they did not appear to be involved in any of the crucial directions to the cells. But it turned out that polymorphisms were the key to what made each person unique. Jeffreys noticed that in these polymorphic segments, the pattern of

A:T and C:G base pairs repeated over and over again. He found that he could analyze the polymorphisms using a process called RFLP analysis. It was given that name because a special chemical called a restriction enzyme is used to cut the DNA into small fragment lengths to analyze the polymorphisms. By then attaching a radioactive molecule to the segment being analyzed, Jeffreys found that he could x-ray the segment of DNA. The A:T and C:G pattern in each person's DNA then showed up on the X-ray like a code, almost like a bar code on packages in the grocery store. And most important for solving crimes, no two individuals except identical twins have the exact same code.

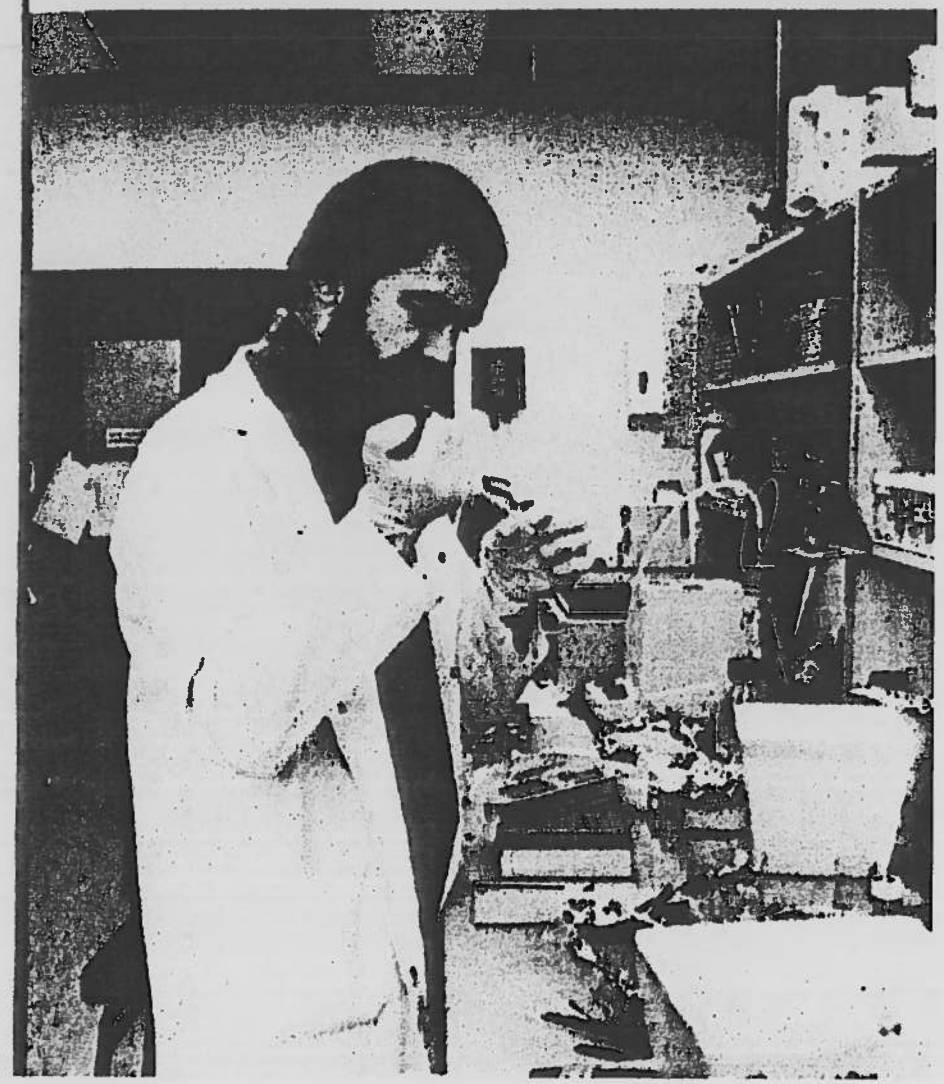
Two years after the first Narborough murder and a year before the second, Jeffreys was interviewed by the *Leicester Mercury* and concluded, "This new technique could mean a breakthrough in many areas, including the identification of a criminal from a small sample of blood at the scene of a crime."[4] Jeffreys was convinced that if skin cells, blood cells, or semen cells could be found at the scene of a crime, the unique DNA in those cells would lead to the culprit, and that crime could be solved.

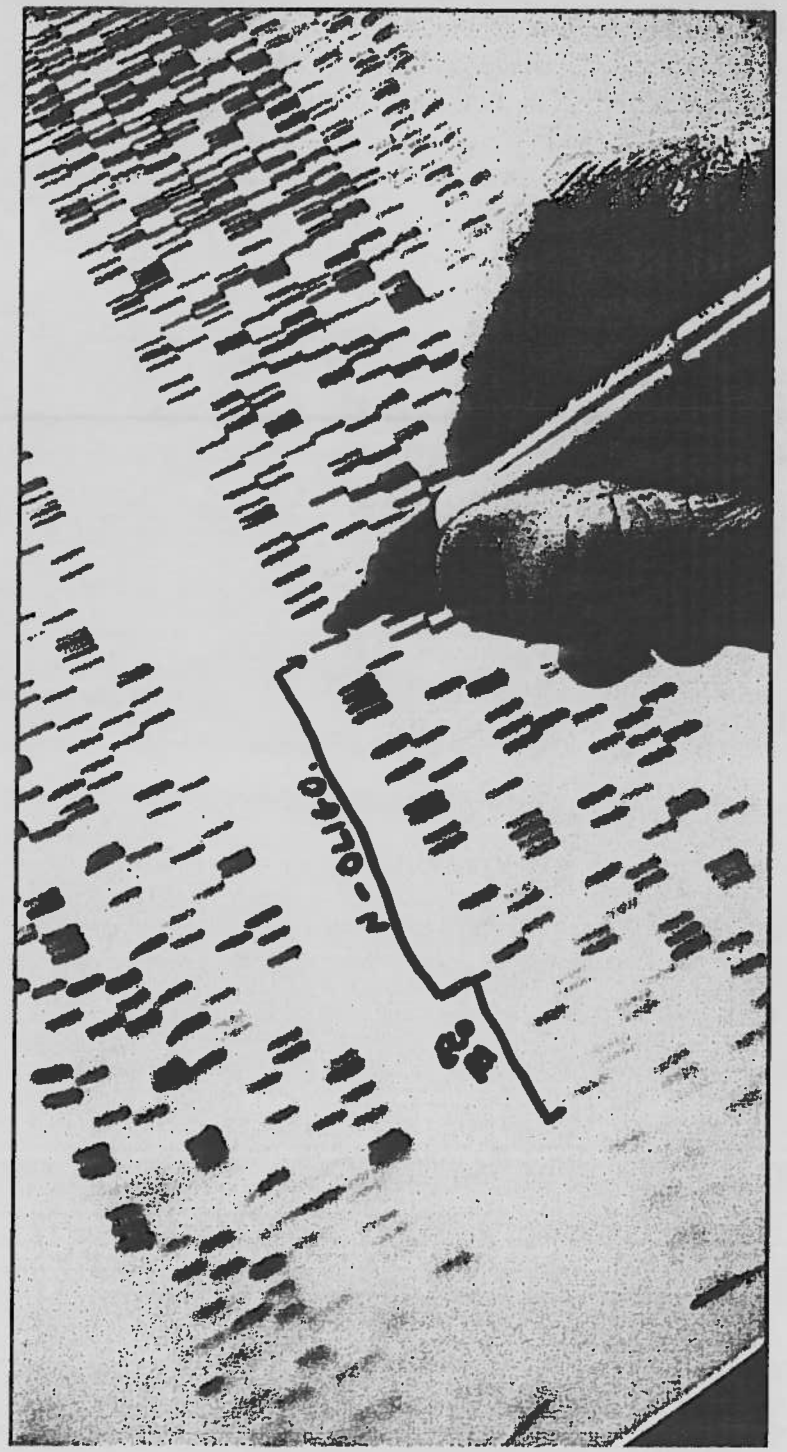
A new mystery

Though Jeffreys used his technique for the first time to determine paternity in an immigration case in England, he was waiting for the opportunity to use DNA fingerprinting to solve a crime. He soon had the chance. When the police sent him semen and blood samples to analyze from the two rapes and murders in nearby Narborough, he had some shocking news for the Narborough police. Just as they suspected, the two girls had indeed been raped and murdered by the same man. But that man was not Richard Buckland, their primary suspect and the man who had confessed to the murder of Dawn Ashworth.

To find the real killer, the police asked all the men who lived or worked in the vicinity of the three neighboring villages to voluntarily submit blood or saliva samples for testing. They used traditional blood typing to eliminate anyone who had a different blood type than the murderer. The re-

maining 10 percent of the samples were subjected to Jeffreys's new DNA fingerprinting process. As each male villager was ruled out as a suspect, the community became more anxious and the authorities more desperate to nab the killer. Then, one day, a young baker named Ian Kelly was overheard in the local pub telling friends that he had been persuaded by his buddy Colin Pitchfork to take the test in his name. Pitchfork had claimed that he was too afraid of needles to take the test himself. Once they knew that, the





A researcher labels genetic code on a DNA X-ray. Forensic investigators use such code in order to link suspects with criminal acts

police arrested Pitchfork and tested his DNA. Pitchfork's DNA matched the DNA evidence found on both Lynda Mann and Dawn Ashworth. Faced with the scientific truth, he confessed to the murders and was sentenced to life in prison in 1988. DNA had lived up to its promise. It had proved its power to law enforcement agencies around the world. It had both exonerated an innocent man and led to the conviction of a guilty one. Forensic science would never be the same.

Problems with the new DNA test

The initial success of DNA fingerprinting was hailed by many. It promised to be a flawless system of identification, and one that guaranteed objectivity. Now, many thought, if biological evidence could be collected, innocent suspects would not spend time in prison for crimes they had not committed. And those who were actually guilty of crimes where biological evidence could be found would not escape the punishments they deserved. But, despite its promise, early DNA testing had limitations to overcome and skeptics who needed to be convinced.

RFLP testing, though highly accurate, had some practical problems that made it difficult to use in some criminal cases. It took a lot of time—often months—and required a large sample of fluid or tissue. Sometimes, all that was available at a crime scene was a tiny speck of evidence. Barry Scheck explains in the book *Actual Innocence* how it was not always realistic to expect there to be enough DNA to test at every crime scene. As he says, "The problem with the DNA fingerprint test known as RFLP was that it could work only when there was a lot of DNA available. That was fine in the laboratory. But in the messy reality of crime scenes, DNA can be a scarce commodity."[5] Sometimes there might be enough DNA to complete one series of RFLP tests, but not enough left over to repeat the tests if necessary. Also, since RFLP involved attaching a radioactive molecule to the DNA, some scientists were reluctant to use it. Too much exposure to radioactive substances can be dangerous to humans.

Another early problem that surfaced with RFLP was that of its supposed objectivity. DNA matches are always expressed in probabilities rather than ~~absolute~~ certainties. In the early days of genetic fingerprinting, there were no standards for calculating those probablities. Defense attorneys argued with prosecutors who claimed that DNA matches between crime scene evidence and suspects were unquestionable. Watson explains in his book *DNA: The Secret of Life* how challenging it could be to determine DNA matches when the technology depended on RFLPs: "In this method, the DNA fingerprint appears as a series of bands on an X-ray film. If bands produced by the crime scene DNA were not identical to those produced by the suspects, just how much difference could be legitimately tolerated before one had to exclude the possibility of a match? Or how same does 'the same' have to be?"[6] These questions would have to be addressed before the U.S. criminal justice system would wholeheartedly embrace the new technology.

However, in spite of these early questions, law enforcement agencies in the United States were eager to try DNA fingerprinting to help solve crimes. The opportunity presented itself almost immediately in Florida the year after Colin Pitchfork murdered Dawn Ashworth in England. A series of break-ins, rapes, and robberies had been plaguing the city of Orlando. When the police arrested Tommy Lee Andrews for a different crime, they discovered that his DNA matched the DNA collected from one of the rape victims. At his trial, two geneticists testified for the prosecution. One was from Lifecodes, the first lab in the United States to do DNA analysis for criminal investigations, and the other came from the prestigious Massachusetts Institute of Technology (MIT). They agreed that the DNA belonged to Andrews and that his DNA profile could be found in only one in 10 billion individuals. On November 6, 1987, the circuit court in Orange County, Florida, convicted Andrews of rape, and he was sentenced to twenty-two years in prison. This was the first case in the United States in which DNA evidence was used to convict a criminal.

Shortly after the conviction of Tommy Lee Andrews, DNA was put to the test again. This time, it almost did not pass. David Rivera returned home from work in the Bronx in New York one evening to find that his pregnant common-law wife, Vilma Ponce, and their two-year-old daughter, Natasha, had been violently murdered. Though police suspected Rivera at first, after a monthlong investigation, they arrested the building handyman, Joseph Castro. While interviewing him, a police detective noticed a bloodstain on Castro's watch. Detectives sent the watch to the Lifecodes laboratory in Westchester, New York. The lab reported that the DNA on Castro's watch belonged to the victim, Vilma Ponce. Castro's fate seemed sealed. But then, Eric Lander, a scientist from MIT, challenged the scientist from Lifecodes.

Lander argued that Lifecodes had used sloppy technique in the lab. He also claimed that misleading statistics overstated the likelihood of a DNA match between the blood on the watch and that of the victim. The judge, convinced that the DNA results could not be trusted, excluded them as evidence. The case against Castro, though, was compelling enough without the DNA that he eventually pleaded guilty to the two murders anyway in exchange for a lighter sentence. After he was sentenced, more tests were conducted that verified that the DNA on Castro's watchband did belong to the victim.

The Castro case represented a turning point for DNA evidence. It was now clear that legal standards for both laboratory procedures and statistics needed to be established before DNA evidence would have universal credibility. Everyone agreed that this fledgling technology could not afford another close call without risking a giant setback in its acceptance as a crime-fighting tool.

A major stumbling block in the ability to test DNA evidence was overcome in the late 1980s when scientists realized that they could take a technique that was being used in medical science and apply it to criminal investigations. A few years earlier, Kary Mullis, a chemist, figured out how to take a small piece of DNA, copy it millions of times, and then run the tests on the copies. Mullis called his process polymerase chain reaction (PCR) because an enzyme called a polymerase is used to cause a chain reaction that produces millions of identical copies of a piece of DNA. PCR was an improvement over RFLP because it became possible to take the tiniest bit of evidence—even a single cell—and copy the genetic information from the nucleus over and over until there was enough to test. The PCR process does not rely on X-rays, so it has the extra benefit of not requiring the use of radioactive materials. Even Mullis did not realize at first that his idea would have important applications in fighting crime. But in 1988, PCR provided the critical evidence in the first DNA exoneration of an innocent man in the United States.

Gary Dotson had served eight years of a twenty-five-to-fifty-year sentence for rape in Chicago, but he had never stopped proclaiming his innocence. When he heard about the DNA work of Dr. Jeffreys in England, his lawyers arranged to send the semen evidence from his trial to England for an RFLP test. But by then, there was insufficient evidence for the RFLP. The sample was then sent to San Francisco to be subjected to the newer PCR test, which confirmed Dotson's innocence. He was freed from prison.

PCR changed the scope of physical evidence. Prosecutors build their cases with many kinds of evidence, but it is the physical evidence that is often crucial to solving a crime. Paul L. Kirk explains the importance of physical evidence in his book *The Art and Science of Criminal Investigation:* "[Physical evidence] is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It cannot perjure itself; it cannot be wholly absent. Only its interpretation can err. Only human failure to find it, study and understand it, can diminish its value."[7]

DNA evidence is physical evidence on the molecular level. When PCR arrived on the scene as a new weapon in the arsenal of criminal investigation, it meant that the physical evidence left at or taken from a crime scene could now be as small as a single cell. A skin cell found beneath a victim's fingernail, semen stains or bloodstains, saliva residue, even a hair could now be used to identify a specific individual. Microscopic evidence now had enough power to determine with near absolute certainty whether or not an individual had been at the scene of certain crimes. Its power in the criminal justice system was steadily growing. But there was still another major obstacle to overcome.

Convincing the courts

As convincing as DNA fingerprinting could be, it was useless as evidence unless it was accepted by the courts as testimony. New breakthroughs in science are often

Chemist Kary Mullis perfected a testing process in which even a single cell of DNA could be accurately analyzed.

can change people's lives forever, so new kinds of evidence must be proven trustworthy before juries can be asked to use them to make life-changing judgments. Since scientists are the only witnesses permitted to express opinions as well as facts in their testimony, those opinions can sway a jury. In 1993, the U.S. Supreme Court decided how to approach new scientific information. In a case known as *Daubert v. Merrell Dow Pharmaceuticals*, the Supreme Court adopted the Federal Rules of Evidence. This ensured that scientific information used as evidence in a case had first been published in respected scientific journals. The new Federal Rules of Evidence also required that the rates of error be acknowledged so that juries could judge whether the science being used as testimony was open at all to interpretation. This decision helped clear the way for DNA evidence in the courts. The [illegible] of this new DNA technology began to be felt more intensely as prosecutors and defense attorneys honed their skills at using it to further their causes.

There is no escape from DNA evidence. Believed to be individually specific, it has the power to point its genetic finger at the culprit—overriding confessions, accusations, suspicions, and even eyewitness accounts. In the space of less than twenty years, DNA technology has revolutionized crime fighting. DNA has given crime fighters the power to overcome human tendencies to deny responsibility, hide from the law, run from captivity, and claim innocence despite guilt. DNA has the power to unpeel the truth from layers of deceit. As the methods of DNA testing become increasingly accurate, it can truly be said that there is no hiding from genetics.