



“The Business Case for Using  
Forensic DNA Technology  
to Solve and Prevent Crime”

Ray Wickenheiser

Ray Wickenheiser is the Laboratory Director of  
Acadiana Criminalistics Laboratory in New Iberia, Louisiana  
and produced this paper as a component of his MBA at  
University of Louisiana Lafayette

## **Executive Summary**

Use of forensic DNA technology to associate individuals with crimes has produced a revolution in the way crimes are solved. Forensic DNA now has the ability to conclusively eliminate or implicate an individual as the perpetrator of a crime even when the suspect is unknown to the victim. Previous to the advent of forensic DNA, crimes with unknown suspects, such as sexual assaults committed by a stranger to the victim, have been very difficult, if not impossible to solve. Crime laboratories historically see a small percentage of reported sexual assaults, particularly those committed by strangers. A two-pronged approach including the broad application of crime scene DNA to a large known offender DNA database has shown the potential to solve and prevent many crimes of sexual assault.

The estimated cost to analyze all of the 366,460 reported sexual assault occurring in the U.S. per year is \$366 Million. This represents an increase of \$310 Million over the estimated current spending level. The estimated savings resulting from apprehending serial offenders early in their “careers” and thereby preventing future crimes is \$12.9 Billion. This figure does not include investigative, legal, justice system, and preventative savings associated with the prevented sexual assaults. The savings is 35.2 times the investment.

An expanded U.S. DNA offender database is required to reach the same 3.5% of the total population needed to achieve the same 42% success rate now attained by the Forensic Science Service of Britain. The DNA database now has 1.3 Million offender samples.

The total expense of processing an additional 8.85 million known DNA samples for an expanded U.S. DNA database is estimated at \$265 Million.

A comparison with other forms of social spending, such as AIDS research, Cancer research, and Heart Disease and Stroke research demonstrates the high relative worth of an additional investment in forensic DNA. A straightforward forensic DNA case costs \$1000, compared with annual research spending of \$68,998 (AIDS), \$3524 (Cancer), and \$3792 (Heart and Stroke) per incidence of the respective condition. With these investments in crime scene DNA and an expanded U.S. DNA database, an estimated 40% of future sexual assaults by strangers could be prevented by earlier apprehension of serial offenders.

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## **Abstract**

Use of technology to associate individuals with crimes has produced a revolution in the way crimes are solved. Current forensic DNA technology now has the ability to conclusively eliminate or implicate an individual as the perpetrator of a crime even when the suspect is unknown to the victim. Previous to the advent of forensic DNA, crimes with unknown suspects, such as sexual assaults committed by a stranger to the victim, have been very difficult, if not impossible to solve. Crime laboratories historically see a small percentage of reported sexual assaults, including those committed by strangers. A two-pronged approach including the broad application of crime scene DNA to a large known offender DNA database has shown the potential to solve and prevent many crimes of sexual assault. This article provides the business case for the broad application of DNA to all cases of sexual assault demonstrating an extraordinary return on investment. It explores the costs and benefits of DNA, the necessary size of a known offender DNA database to achieve success, and discusses estimated expenditure levels required to maximize this return on investment. Spending comparisons with other major preventative social spending are provided, and an optimal cost benefit level for forensic DNA is proposed.

## **Introduction**

Recent years have seen dramatic improvements in forensic DNA technology. Simply touching an object transfers minute quantities of biological substances that can often be successfully analyzed.<sup>1</sup> Biological fluids, such as semen, blood, and saliva, left behind at crime scenes or on victims can identify an assailant in many cases. The speed of analysis

has increased, while the cost has decreased. Unsolved crimes can be linked together, and DNA from known offenders or arrestees can be placed in databases and compared to outstanding crimes.<sup>2</sup> Crimes which have been previously unsolved can now be solved, and perpetrators apprehended early in their criminal careers, before they graduate to more serious crime.

Is the forensic DNA analysis itself a scarce resource that should be rationed? Or, is the lack of forensic DNA simply the result of other scarce resources? As are most successful applications of existing technology, forensic DNA is the use of proven scientific principles, using modern equipment, trained staff, appropriate facilities, chemicals and utilities. While forensic scientists are highly trained, the biological science graduate trainees used are not in extremely short supply. The specialized equipment, lab space and chemicals are expensive, but likewise are available at a market price. Forensic DNA is simply the result of combining specialized skilled labor and capital (building, equipment, supplies, and utilities) to provide a service. Therefore, a cost benefit analysis will facilitate comparison between forensic DNA technology and other potential consumers of the same resources. In this manner, one can objectively determine which consumer is a more effective use of available resources.

The association of individuals to crime scenes is not a new concept. Identification of the perpetrators of crime is a concept as old as human justice itself. Using technology to assist in identifying a perpetrator has also been used for decades. Forensic serology used protein polymorphisms (variations between individuals) in the 1960s and 70s to

differentiate blood types between individuals to eliminate and include suspects. In 1985, the blueprint for these proteins, the DNA itself, was first used to identify suspects.<sup>3,4</sup> Since that time, the use of forensic DNA as a tool to conclusively eliminate and identify perpetrators of crime has become commonplace, well accepted in the scientific community, and well as in the court system. Many wrongfully convicted suspects have been exonerated through forensic DNA.<sup>5</sup> Likewise, previously unsolved crimes have been solved using this technology.<sup>6</sup> With newer Polymerase Chain Technology (PCR) DNA analysis techniques, the sensitivity of forensic DNA has increased over 1000 times greater compared to that of earlier methods, permitting the successful analysis of exhibit items never thought possible.<sup>1</sup> As now even minute quantities of skin cells can yield a DNA profile, simply contacting an item may help place a perpetrator at a crime scene, further expanding the application of forensic DNA technology.

DNA possesses a number of attributes that makes it an ideal means of helping solve crime. One of these attributes places it in the rare position of actually developing suspects in crimes where no suspect previously existed. In some cases the crime has no witness, or the perpetrator is unknown to the victim. In others the victim is deceased, leaving no living witness aside from the assailant. DNA has become the voice for those who have none. DNA offers objective identification where memory does not fade over time. DNA can eliminate an individual with 100% confidence with the notable exception of identical twins, and include a suspect with virtually the same certainty.

The focus of this paper is upon the ability of forensic DNA to solve “no suspect” crimes. Use of standardized forensic DNA testing has provided a uniform system, known as the CODIS (Combined DNA Index System - FBI), which allows results from one lab to be compared to another. DNA profiles can be “databased”, allowing crime scene DNA profiles to be compared to each other, and to databases of known individuals. This capability now provides for this new application of forensic DNA, which is the ability to develop suspects where there was none previously known. Before this potential, if a crime lab did not have a known person to compare a crime scene sample to, a case was unsolvable.

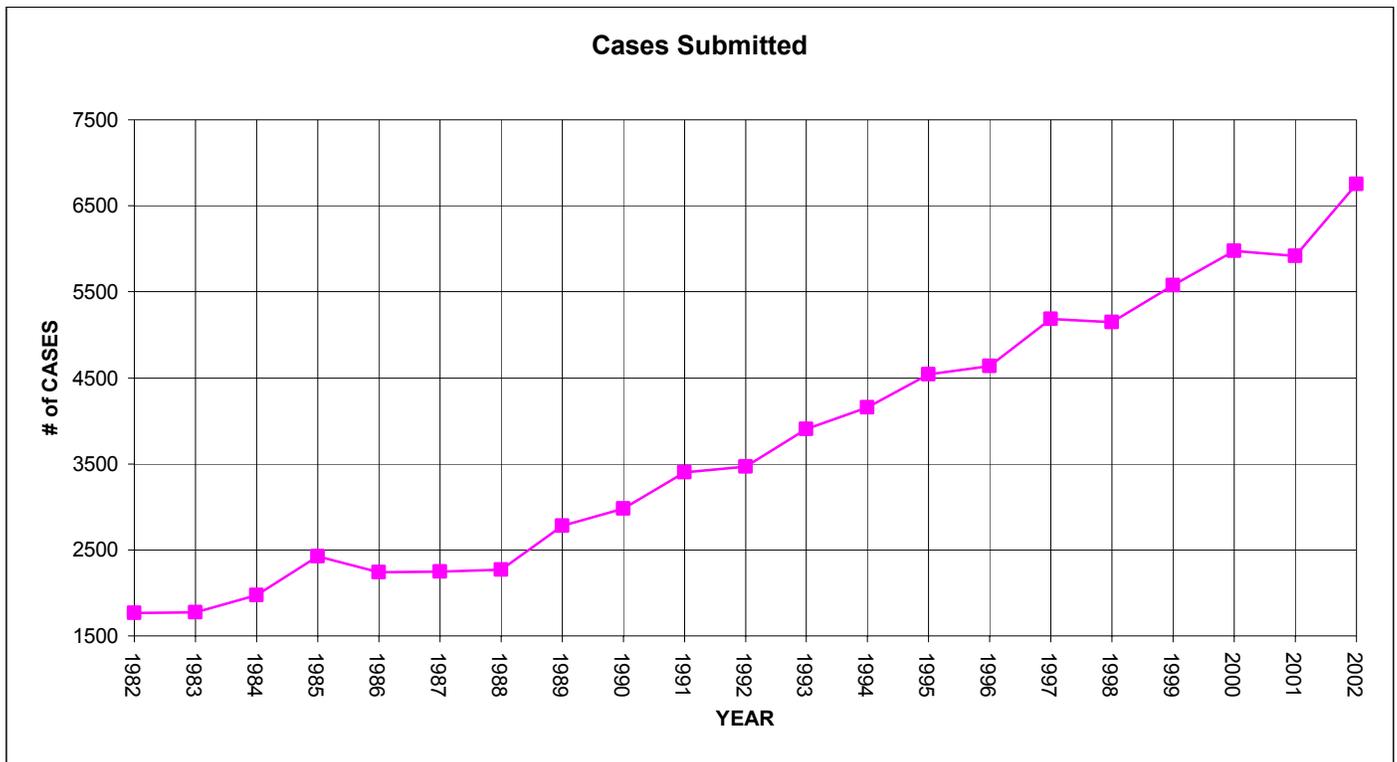
### **The State of Forensic DNA at Acadiana Crime Lab**

Located in New Iberia, Louisiana, the Acadiana Criminalistics Laboratory (ACL) is a local multi-parish (county) crime lab, which provides forensic service to the 602,000 residents of South Central Louisiana. The lab is a nonprofit institution, serving all levels of law enforcement for the parishes of Acadia, Evangeline, Iberia, Lafayette, St. Landry, St. Martin, St. Mary, and Vermillion. Overseeing the laboratory is a 21 member commission, which consists of the 4 District Attorneys for the area, the sheriff and a police jury member from each parish, and the police jury president from the lab’s home parish of Iberia.

Collection of court costs is the only stable source of funding for the Acadiana Crime Lab. \$10 is received for each guilty plea or verdict from each speeding ticket, and \$50 from each DWI (Driving While Impaired) and drug offense. This amount has not been

changed since 1992. Since that time, case receipts at the lab have increased over 80%, and additional services, most notably forensic DNA and CODIS (Combined, DNA Index System), have been added. The attached graph demonstrates the cases received annually at the Acadiana Crime lab since 1982 (Figure 1).

Figure 1: Graph of case submissions to the Acadiana Crime Lab



In the 2001 state legislative session, a bill was introduced providing for an increase in court costs from \$10 to \$15 for speeding offenses, and from \$50 to \$75 for DWI and drug offenses. Fearing court costs were getting too high, as the cost of speeding tickets average \$120 to \$135, state legislators denied the increase. A court cost review committee was struck to examine the court cost funding mechanism. Studying the subject for nearly 2 years, in 2003 the committee chose not to remove or add new funding

sources or recipients. They did recommend that a panel closely scrutinize all future additions to court costs, however.

The Acadiana Crime Lab 2003 annual budget is approximately \$1.328 Million. Court costs are projected to bring in \$720,000. In the later part of 2002, a grant from the state of Louisiana provided \$1 Million to the 7 regional non-state crime labs. Due to the severe funding situation at the Acadiana Crime Lab, the ACL share of the \$1 Million state grant was \$340,000. The local parish governments were forced to make up the remaining \$268,000 shortfall in order to meet the budget requirements of the lab for 2003.

With the court cost committee still sitting prior to their decision not to change the court cost formulas, the regional crime labs appealed to the Louisiana state government for continued temporary assistance for 2004. A second grant of \$500,000 was allotted during the 2003 summer legislative session. A formula for division of the \$500,000 between the 8 crime labs of Louisiana has not been struck, however crime lab directors will meet in late summer to decide the allocation.

The Acadiana Crime Lab budget is early in the preparation phase for 2004. With 85% of the annual budget accounted for by salaries and direct staff compensation costs, and 10% going to chemicals and direct costs of forensic analysis, very little room is left for cost cutting measures. The 5 - 10% of the budget that can be considered discretionary includes training and equipment purchases, which cannot be deferred for longer than a

short term. The projected share of the \$500,000 state grant is approximately \$70,000 if a decision is taken to divide the money on a per capita basis. With the severe funding constraints, the mercy of the other 6 lab directors may be appealed upon. Even with this, an amount above \$150,000 is very unlikely, as 3 of the regional crime labs are in very similar funding shortfall situations to the Acadiana Crime Lab. Compounding the budget woes, the Acadiana Crime Lab's involvement in the Derrick Todd Lee South Louisiana Serial Killer Case consumed the year's DNA supplies and many hours of lab labor.<sup>7,8</sup> Lab staff salaries are linked to the American Chemical Society annual wage survey. Aware of budget restrictions in 2002, staff accepted a deferred wage increase spread over 2003 and 2004. With a limited increase in the lab budget to cover last year's salary commitments and the cost of the serial killer investigation, the lab will require and estimated additional \$600,000 annually to maintain the status quo.

While Acadiana Crime Lab's budget difficulties appear acute, they are by no means unusual. In early 2003, facing major state deficits, the state of Oregon laid off approximately 65% of its 125 forensic staff.<sup>9</sup> This included the DNA technical leader, effectively shutting down the entire state's forensic DNA program. Since that time, emergency funding has kept the program operating on a temporary basis. In Mississippi, the last DNA analyst has left the state.<sup>10</sup> No qualified personnel has been found to restart their program at this time.

A study of the state of U.S. crime labs conducting forensic DNA analysis was conducted in 2000 by the U.S. Department of Justice Bureau of Justice Statistics.<sup>11</sup> At that time,

there were large backlogs of both forensic (crime scene) and database (known individuals) samples across the country. Smith Alling Lane, a consulting service, has been commissioned by the National Institute of Justice to conduct a comprehensive study of the forensic DNA backlog, and is in the process of collecting data.<sup>12</sup>

### **The Impact of the South Louisiana Serial Killer Case**

With Louisiana in the midst of the massive South Louisiana serial killer case, in May of 2003 the state legislature allotted \$650,000 for the outsourcing of no suspect sexual assault cases in Baton Rouge and Acadiana to private labs. The estimate per case, which includes one questioned sample with sperm identified and one known sample from the complainant, was \$595.<sup>13</sup> This permitted 1083 cases of this type to be sent to private labs for analysis. 401 cases in the Acadiana Crime Lab and 548 in the Louisiana State Police Crime Lab in Baton Rouge were in backlog. Those cases, along with 134 in Jefferson Parish (near New Orleans) are in processing at private labs.

The 401 “no suspect” sexual assault cases in Acadiana date back to 1985. Staff reviewed all old samples retained in storage by the Acadiana Crime lab, located the corresponding archived case files, and reviewed each individual case. The total number of no suspect sexual assault cases found was 605. Of these cases, sperm was located in 401, or 66% of the cases. 5 test cases have been sent to each of 3 private forensic DNA labs. Acadiana Crime Lab staff will review results, and the balance of the cases will be assigned pending satisfactory procedures and findings. Results from all cases will be compared to each other, compared to all other outstanding cases, and then compared to all known persons

in CODIS. The number of samples generating a profile will be recorded, as well as the number of “hits” to other cases and to known persons.

In years 2001-2002 and 2002-2003, the Louisiana State Police Crime Lab applied for a federal backlog grant on behalf of the crime labs serving the state. In May of 2003, \$2.48 million was awarded to work backlogged cases. The grant cannot be applied to current budgets or salaries, only towards outsourcing or paying overtime to complete the backlogged cases. All of the known “no suspect” backlogged cases in the state will be completed with this grant. Acadiana Crime Lab staff has committed to complete 68 non-sexual assaults backlogged cases by working evenings and weekends in order to justify the purchase of new DNA equipment with grant funds. The no suspect sexual assault cases will be completed with State grant money as described previously. Acadiana Crime Lab has applied for all other available federal grants, but to date no federal funding has been received.

Of the 16 member staff at the Acadiana Crime Lab, 3 forensic DNA analysts and one technician is employed full time in the Biology Section responsible for performing forensic DNA analysis. In order to determine information regarding forensic DNA coverage, and the use of forensic DNA, a survey was undertaken to provide a view of the national situation. Through informal contacts, responses were obtained from U.S. forensic laboratories conducting forensic DNA casework. The output and case receipts of the Biology Section of Acadiana Crime Lab is found in Table 1, along with that of 12

other forensic labs. A copy of the 4 questions asked is provided in Appendix I. Key statistics calculated through the survey include the following:

a. The estimated number of DNA analysts per 100,000 U.S. population, which is 0.41 (see Table 1). This number varies from lab to lab as each has a different system of classifying staff and duties, and many are in training.

b. The number of sexual assault cases currently being submitted per 100,000 U.S. population, which is 20.29 ((3956 sexual assaults/19,495,000 population) X 100,000).

c. The average success rate of labs in developing interpretable male DNA profiles in sexual assault cases, which is 47.58% (see Table 1).

Table 1: A Survey of Forensic DNA Laboratories

	DNA Analysts	Population Served	Analyst per 100,000	Sexual Assault Cases	Sexual Assault Cases/Analyst	% Profiles Obtained
Broward County Ft. Lauderdale, FL	8	1400000	0.57	316	39.50	50
Acadiana Crime Lab, New Iberia, LA	3	602000	0.50	212	70.67	66
Prince George County Police Dept, MD	4	800000	0.50	175	43.75	50
Albuquerque, NM	3	500000	0.60	528	176.00	25
Lake County, OH	1	230000	0.43	40	40.00	20
Utah Dept of Public Safety	6.5	2200000	0.30	250	38.46	50
Palm Beach SO, FL	7	1200000	0.58	300	42.86	50
Las Vegas, NV	4	1600000	0.25	150	37.50	85
DuPage County, IL	1.65	950000	0.17	200	121.21	70
Los Angeles Police Dept, CA	24	4000000	0.60	500	20.83*	42
Michigan State Police	5	2000000	0.25	750	150.00	33
Vermont State Crime Lab	2.5	613000	0.41	145	58.00	40
San Bernardino County Sheriff's Office, CA	6	3400000	0.18	390	65.00	30
Total	75.65	19495000	5.34	3956	903.78	611
Average	5.81	1499615.4	0.41	304.31	69.52	47.58

\* A number of forensic labs have a disproportionately large number of vacancies and staff in training. As a result, the output per analyst statistic appears artificially low.

## **The Crime of Sexual Assault**

According to the U.S. Department of Justice Bureau of Justice Statistics, 366,460 reported sexual assaults per year is the U.S. annual average 1992-2000.<sup>14</sup> This represents over 1,000 sexual assaults occurring each day, 42 per hour, or one every 86 seconds. Sexual assault has been described as one of the most terrible of crimes, in that the victim is often traumatized for life. The physical scars of the assault may be visible, but emotional and invisible damage can last a lifetime.

This 366,460 reported sexual assaults occurring annually<sup>14</sup> equates to approximately 131 sexual assaults per 100,000 persons per year. Contrast this number versus the estimated 20.29 sexual assault cases per 100,000 persons per year submitted to forensic labs for DNA analysis. This represents a 15.5% U.S. estimated national forensic DNA usage as opposed to if all reported cases of sexual assault were submitted. As indicated in table 2, Acadiana Crime Lab is receiving about 26% of the estimated number of reported sexual assault cases.

The Louisiana 1990-2000 average number of forcible rapes per year is 40.11 per 100,000 population.<sup>15</sup> The annual 1992-2000 U.S. annual estimate for sexual assaults<sup>14</sup> taken by population amounts to 130 assaults per 100,000 population. Using this factor, the estimated number of reported sexual assaults occurring in the Acadiana Crime Lab area is 788 (Table 2).

Table 2: Annual Estimate of Reported Sexual Assaults in Acadiana

US Sexual Assaults	366460
US Population	280000000.00
US Reported Sexual Assaults per 100,000	130.88
Estimated Number of Cases per 100,000 Submitted to Forensic Labs	20.29
Estimated Percentage of Reported Sexual Assaults Submitted to Forensic Labs	15.5
LA Average Reported Forcible Rapes 1990-2000 per 100,000 (14)	40.11
Ratio of Reported U.S. Sexual Assaults to Louisiana Forcible Rapes	3.26
Acadiana Population	602000.00
Annual Estimated Reported Sexual Assaults in Acadiana	787.89
Number of Sexual Assaults Received at Acadiana Crime Lab 2002	212
% of Sexual Assaults Submitted to Crime Lab Compared to Number Occurring	26.91

### **Level of Reporting**

There is cause for concern regarding the true number of sexual assaults, as opposed to the reported number of 366,460 sexual assaults per year U.S. annual average 1992-2000.<sup>14</sup>

Less than 5% of completed or attempted rapes against college women were reported to law enforcement<sup>16</sup>; therefore the true number may be much higher. In any given year, 4.9% of all college women are a victimized.<sup>16</sup> As most students are on campus for several years attaining their degree, the percentage of victimization may be between 20 and 25%.<sup>16</sup> The National Institute of Justice (NIJ) and Bureau of Justice Statistics sampled 4,446 college women, and had an 85.6% response rate, adding credibility to this data.<sup>16</sup>

The total number of female college students in the U.S in 2000 was 8,631,000, which is made up of 5,554,000 full time, and 3,077,000 part time students.<sup>17</sup> With only 5% of sexual assaults reported, and 4.9% of all students assaulted, this provides for as many as 8.4 million sexual assaults annually. Women in college appear to be at greater risk of sexual assault than the general population.

This is borne out by the actions of the South Louisiana Serial Killer, who stalked the area near the Louisiana State University campus for victims, while his residence in St. Francisville, LA, was 23 miles away. Had the arrestee and convicted offender DNA database legislation been in force when the suspect was arrested earlier, 5 of 6 known victims could have been spared.<sup>18</sup>

Table 3: Reporting of Sexual Assault Cases

Year	% of Cases Reported
1993	29.8
1994	30.6
1995	30.9
1996	30.7
1997	30.5
1998	31.6
1999	28.3
2000	48.1
Average	32.5625

Source: Rennison, C.A., “Criminal Victimization 2000 – Changes 1999-2000 with Trends 1993-2000, U.S. Dept. of Justice, Office of Justice Programs, Bureau of Justice Statistics, Survey, June 2001.

Another study indicates that less than one third (32.56%) of sexual assaults are actually reported (Table 3).<sup>19</sup> Therefore, estimates of numbers of sexual assaults used in the calculations in this study are very conservative relative to the actual number of sexual assaults actually occurring annually.

**Recidivism**

Perpetrators of sexual assault are commonly repeat offenders. This means they commit the same or a similar crime, affecting multiple victims. The nature, severity, and frequency of their offenses often escalate as the offender progresses. For example, the average number of sexual assaults per sexual offender is 8 (Table 4)<sup>20</sup>.

Table 4: Recidivism Rates in Sexual Offenders

Mean age at first offense	18.8
Detected Sexual Assaults	2.8
Undetected Sexual Assaults	5.2
Average number of sexual assaults per offender	8
More Than 1 Offense (recidivism)	67.1%

Source: Groth, Longo, McFadin, “Undetected Recidivism Among Rapists and Child Molesters, 1982.

Practical experience from the DNA database of the state of Florida Department of Law Enforcement supports these statistics.<sup>21</sup> The number of repeat offenders seen through Florida DNA database matches and case data also reflects the recidivism rate of 8 sexual

assaults per sexual offender. Similarly, their data also backs up a high level of repetition in the offenders with multiple offenses, supporting the level of 67% cited in the earlier study (Table 4).<sup>19</sup>

### **The Cost of Crime**

Many countries and jurisdictions have attempted to put a price on the cost of crime.<sup>22-27</sup>

Sexual assault is the costliest of all crimes, when the damage to the individual is accounted for.<sup>28</sup> An extensive study conducted by the U.S. Department of Justice Bureau of Justice Statistics estimated the cost of a single instance of sexual assault at over \$87,000 in 1995 dollars.<sup>28</sup> This study focused only on the victims' costs without also estimating the cost to society. Therefore costs to the criminal justice system and other social costs associated with the fear of crime, and private security expenditures are not included in this figure. Therefore, this is a conservative estimate of the cost of crime. With adjustment for the increase in the consumer price index<sup>29</sup>, the cost for each sexual assault is \$111,238 (Table 5).

Table 5 shows the cost of crime according to 1993 estimates. Also included is the CPI (Consumer Price Index) adjusted dollars to May 2003. While the total of the tangible costs of crime total \$5600, adjusted to \$7161 (May 2003), the vast majority of the estimated cost of crime is intangible, at \$104,078 in terms of quality of life. In this study,<sup>28</sup> the cost was estimated by considering similar injuries in 606 burn case settlements, as well as 1106 assault jury awards and 361 rape jury awards. Only the portion of the award

designated to compensate for pain, suffering, and lost quality of life was considered. Similar cases were considered and matched in order to provide accurate estimates of intangible losses.

Table 5: Cost of Crime Adjusted to CPI 2003 May

Area of Cost	CPI Adjusted to 2003 May	Proportion of Total Cost	1993 Base Year Estimate
Productivity	2812.92	2.53	2200
Medical Care/Ambulance	639.3	0.57	500
Mental Health Care	2812.92	2.53	2200
Police/Fire Services	47.31	0.043	37
Social/Victim Services	34.52	0.031	27
Property Loss/Damage	127.86	0.11	100
Quality of Life	104078	93.56	81400
Total	111238.2	100	87000

Sources: Miller, T.R., Cohen, M.A., and Weirsema, B., “Victim Costs and Consequences: A New Look”, U.S. Dept. of Justice, Office of Justice Programs, National Institute of Justice, <http://www.ncjrs.org/textfiles/victcost.txt>, January 1996 and “Consumer Price Index – Urban Wage Earners and Clerical Workers, US City Average, Not Seasonally Adjusted, All Items”, U.S. Dept. of Labor, Bureau of Labor Statistics, Bureau of Labor Statistics Data, [www.bls.gov](http://www.bls.gov)

### **Solving No Suspect Sexual Assault Cases with Forensic DNA**

There are two pieces to solving any crime with forensics in general, and forensic DNA in particular. The first piece is the crime scene. Questioned biological material of some kind must be found at the crime scene. The second piece is the known sample, or a reference sample of known origin. A comparison of the two is conducted scientifically, and scientists can determine with some magnitude of confidence that the two items shared a common origin.

In the days before forensic DNA, comparisons were done with proteins, such as the ABO blood typing system. Just as individuals may differ with the proteins in their blood and body fluids, so too do they vary within their DNA. As DNA is responsible for all human variation, in fact all of the biological variation seen, it makes sense that when seeking to differentiate between individuals, one goes to the source of the variation. Just as someone with type B blood was eliminated from being the donor of suspect type A blood at a crime scene, so too is DNA used to eliminate suspects. If any point on the DNA profile from the suspect is different from that of the crime scene sample, that suspect is eliminated as a potential source. If that suspect cannot be eliminated in that all points of comparison in their DNA profile “matches” that of the crime scene profile, then they are included. Other individuals in the population may have the same “type” at a single location examined. However, if a number of independent locations are also compared, which is the chance of having one feature does not affect the chance of having the other feature, then the individual probabilities can be multiplied together. This is a commonly

accepted mathematical process, known as the product rule of probability. The CODIS 13 DNA loci (locations) have been selected to differentiate between persons. Each loci usually produces a probability of including someone around 1 in 10. That is, for any given DNA type at a particular DNA location, only 1 person in 10 will have that type. As there are 13 loci tested with each independently inherited at a different chromosome, the probability of 2 persons having the same DNA type under this model is 10 raised to the power of 13, or 1 in 10 trillion. In reality, the number varies depending on the actual type of the person, but this is a reasonable approximation.

Once a full 13 CODIS profile is generated through forensic DNA, it is by nature exceedingly rare. The “typical” crime worked on by forensics labs involves finding some biological material, developing a DNA profile, and then comparing it to the DNA profile developed by suspects. For a detailed description of this process, consult Appendix II for the investigation, and Appendix III for the forensic lab process. The suspects are then eliminated or included. The forensic context must be considered. The forensic context refers to “what does that exclusion or inclusion mean to the crime?” If the DNA is found in a very incriminating location, as on a vaginal swab in the instance of a sexual assault, the results are very meaningful. If the DNA is found on a bed sheet of a married complainant, and matches that of the husband, the DNA result may be of limited value. Therefore the context of the evidence within the crime is of pivotal importance.

In solving no suspect cases, few forensic tools have value if there is only one side of the crime scene/known sample equation available. Fibers can give some indication of what

the suspect may have been wearing, but clothes can be changed. Paint analysis may give an indication of the make and model of a vehicle in a hit and run, but vehicles are mass-produced. Hair can give an indication of the appearance and race of the individual, but can be cut off or altered by bleach and dye. Having a great set of known reference samples; in fact having everyone on earth in a DNA database, does not solve a single crime without DNA from each and every crime scene to be compared to. This 2-piece crime scene/known sample has been responsible for much confusion in the public in terms of how crimes are solved. Prior to the advent of DNA databases, finding DNA at a crime scene was useless if a known suspect was not available. With a nationwide database, now every crime has the potential of being solved if a DNA profile can be generated from the crime scene. As these no suspect crimes have been unsolvable until the DNA databases of today, most law enforcement agencies and crime labs have not processed the no suspect crime scene samples. Nor have they forecasted the capacity required to take advantage of the new crime solving capabilities and crime preventing potential represented by “no suspect DNA”.

Taking full advantage of forensic DNA requires full use of both sides of the two-part crime scene and database equation. Crime scene DNA has taken huge strides forward, to the point that a good percentage of crime scenes have DNA inadvertently left behind by perpetrators of crime. A very small number of DNA molecules can be found at the crime scene, also be severely degraded, and yet still produce a DNA profile. However, without a known suspect profile to compare against, the crime remains unsolved, as a person cannot be associated with the “human serial number” represented by that DNA profile.

With known profiles available for comparison in DNA databases, these unsolvable crimes can now be solved. Likewise, the largest DNA database in the world does not solve a single case without DNA profiles from crime scenes to be compared against. The two puzzle pieces must both be used to optimize crime solving potential. When they are used in concert, the tool of forensic DNA has the ability to change the way crimes are investigated and solved, in addition to solving previously unsolvable crimes.

Fingerprints represent many of the attributes of the ideal crime-solving tool. Every person has fingerprints, and each person is unique. Fingerprints are found at many crime scenes, and they are often left behind without the knowledge of the perpetrator of the crime. Through the AFIS (Automated Fingerprint Identification System) system, fingerprints are now databased, such that crime scene fingerprints can now be compared to known reference samples. Unfortunately, everyone knows about fingerprints, and therefore many criminals wear gloves to crime scenes. Much of the crime-solving value of fingerprints remains intact; however many crimes with unknown suspects are not solved if fingerprints are not found.

DNA shares many of the same ideal attributes as fingerprints as a crime-solving tool. Each person is different, except identical twins. Minute quantities of DNA are often shed without a suspect's knowledge. Full DNA profiles can be generated with as few as 20 cells, so the mere contact with items is often sufficient for identification.<sup>1</sup>

Now, with the CODIS system, DNA has a similar advantage. Generating a crime scene DNA profile gives the potential of solving the crime through comparison to the database. It stands to reason that the larger the size of the database, the greater the chance of solving the crime. Lawmakers have realized that many criminals repeat offenses. Recidivism is the progression of the criminal career, starting with minor offenses, and gradually increasing in the frequency and severity of the crimes committed. This feature of criminals, particularly those who commit crimes against the person, creates the opportunity to prevent crime through earlier apprehension in the criminal's career. While we cannot say exactly what crimes would have been committed when a repeat offender is stopped early, experience with notorious cases and statistical summaries may give a prediction of the value of this early apprehension and prevention of future crime. The case of the South Louisiana Serial Killer is but one example, taking the lives of 6 known victims in 21 months from September 2001 until his apprehension in May 2003. As the suspect had committed numerous previous offenses that warranted a DNA database sample, lives could have been spared.<sup>18</sup> His progression included petty crimes, public indecency, and felonies for which his sample would have been included in the Louisiana State DNA database.

Without DNA, the span of killing committed by serial killers can continue for decades. In King County, Washington, similar murders occurred from as early as July 1982 until early 1984, which were attributed to the Green River Killer. His victims in that short time period are estimated at 49 victims. Officials are at a loss to explain the break in the murderer's trend after that time. Gary Ridgway was finally apprehended and arrested in

November 2001. He was a suspect in the Green River Murder cases in the mid 1980's, but insufficient evidence prevented his positive association to the murders. He was a family man who held stable employment over a 30-year period. DNA played the major role in Ridgway's apprehension and he now has been charged with 7 of the homicides. The cases are still before the courts.<sup>30</sup>

Canadian pig farmer Robert (Willie) Pickton may be Canada's most prolific serial killer. He has been arrested in the murders of 15 of 61 women who are missing from the Downtown Eastside of Vancouver, British Columbia. Tens of thousands of pieces of DNA evidence are being processed in the case, which is not expected to begin trial until the fall of 2004.<sup>31</sup> The women missing in the Vancouver cases were all from the margins of society, perhaps part of the reason the serial killings escaped notice for so long. Without friends and family knowing the immediate whereabouts of these women, an assailant was able to abduct and murder them without arousing suspicion. Attitudes regarding the disappearance of women, particular those living on society's fringes, compound the problem in solving cases of their murders. Drug culture, prostitution, and a transient lifestyle often preclude a stable home address, and gathering of basic investigative information. Where was she last seen, with whom, and which associations are of investigative interest? DNA is an invaluable tool in solving cases of serial killing, as no witnesses remain aside from the killer himself.

A strength of forensic DNA examination is that it is not subjective. Eyewitness testimony is very dependant on the individual and the conditions of the situation, and has been show to vary. A conclusive identification based on DNA evidence is objective and

can be studied and repeated. Eliminations of individuals being the donor of crime scene DNA is done with 100% confidence. Wrongfully accused suspects of crime have no greater ally in proclaiming their innocence than forensic DNA. Depending on whether a suspect is guilty of a crime, forensic DNA will be their best friend, or their worst enemy.

The 13 CODIS loci have been chosen from non-coding genetic regions. This means that none of the DNA is made into any component of our bodies; hence no information about our physical make-up can be determined from this profile. This prevents misuse for non-forensic purposes or discrimination.

As DNA evidence is converted to a numeric code, like a human serial number it can be databased. As DNA is unique to each individual, with the notable exception of identical twins, and does not vary for the life of the person, it is a great tool for identifying people. One sample of DNA can be taken in one's lifetime, compared to any incident of crime after that time, and then eliminated or included from suspicion. Forensic DNA is very rarely stands alone in a case against a defendant. Other types of evidence are also involved, such as motive and opportunity. Checks and balances in the process of forensic DNA have also been included, to ensure the correct person has been implicated.

One such check is the repeating of samples. Once a match using a DNA database has been made, a second sample is drawn from the suspect individual. The entire test is done again on the suspect's sample, complete with full comparison to the crime scene profile.

To date, all database matches have been independently confirmed by second testing, indicating no errors in the system.

Another check is lab accreditation. Only fully accredited labs may participate in the CODIS (Combined DNA Index System), which is administered by the FBI. All accredited labs are subject to specific personnel and training requirements, and ongoing biannual proficiency testing, yearly audits, and annual training.

It is a felony offense for misuse of any DNA information and samples in the DNA database. Information is carefully guarded against any misuse. No misuse of DNA information has occurred to date.

Wherever possible, forensic samples are preserved for retesting by independent labs. Some cases require consumption of all DNA in order to obtain a profile. In all cases, however, all lab notes, procedures, and documentations are open to scrutiny by defense experts. Persons are eliminated from suspicion on a daily basis using DNA technology. Many investigators are using DNA results to direct investigations by saving time and effort in conclusively eliminating and/or including suspects.

### **Success of Crime Scene DNA**

As stated previously, crime scene DNA has outpaced criminologists' wildest expectations in the ability to generate DNA profiles. With as few as 20 cells capable of generating a full DNA profile, and individuals shedding 400,000 skin cells daily, simple contact with

items at crime scenes are often enough to associate a suspect with a crime.<sup>1</sup> Body fluids commonly are found at crime scenes, such as blood, semen, and saliva, contain ample DNA for generation of DNA profiles. Not only can a suspect deposit bodily fluids on a victim, but also a victim can transfer fluids onto the suspect. In the case of sexual assault, the perpetrator often leaves behind sperm. In some cases of sexual assault, especially those involving younger children, sperm is not present. In these cases, the forensic DNA technique is now sensitive enough to detect the victim's profile in the suspect's undershorts, or on penile swabs.<sup>1</sup> Cases of oral sexual assault involve saliva, which can also be profiled.<sup>1</sup> Even in the case of a suspect who has had a vasectomy, sufficient male cells are present for DNA profiling. In summary, all manner of sexual assault can generate a DNA profile. From the national survey, that success rate is 47.58% of sexual assaults (Table 1).

### **Success of DNA Databases**

Early versions of DNA databases commonly include convicted offenders of sexual assault and murder. While these databases are useful in solving old crimes, they have limited preventative capacity, as the offenders are no longer active, but in jail. Once they are released, they must then re-offend, and that case must be worked with forensic DNA, in order that the database be of assistance.

The size and nature of the DNA database is also very important. The more suspect samples populating a database, the greater the chances of obtaining a match when comparing a crime scene DNA profile. In October, 2002, Iberia Parish, Louisiana

became the first jurisdiction in United States obtaining known DNA samples from suspects of a variety of offences in the booking process. These arrestees represent the portion of the active criminal population committing current crimes. As such, these DNA samples are those most likely to match current crime scene DNA profiles. Thus, the crime preventing potential of using larger databases of active participants in crime is much greater than that of convicted offender databases. Ultimately, if every individual on earth were typed, every crime with a DNA profile would be solved. A balance between the extreme of full DNA sampling and public safety will be an interesting topic for public debate as awareness of the trade-off becomes apparent.

It is intuitive that the larger the size of the database, the greater the chances of making a match between a crime scene DNA profile and a DNA profile from a known source. Rather than theorize on potential case solving ability, other counties success can provide real examples. The Forensic Science Service of Great Britain is a world leader in implementation of crime scene DNA, and the use of DNA databases. Their DNA program produces hits at a rate of over 1000 per day, with a crime scene to suspect hit % rate of over 42%.<sup>32</sup> 69% of samples loaded onto the database resulted in a scene to scene or a scene to suspect DNA match.<sup>33</sup> This kind of success readily demonstrates the realization of some of the crime solving potential harbored by DNA databases.

### **Cost of Forensic DNA**

In order to conduct a cost benefit analysis for forensic DNA, costs of processing sexual assault cases and generating a forensic DNA profiles is required. A detailed analysis was

conducted to determine the cost of processing one DNA sample at the Acadiana Crime Lab. With accurate costs, a comparison to benefits will determine the value of an investment in forensic DNA.

Table 6: DNA Cost per Sample Consumables

<b>Item</b>	<b>Bulk Units</b>	<b>Number</b>	<b>Cost per Item</b>	<b>Items per Sample</b>	<b>Total Cost</b>
<b>Identification</b>					
Hematrace Cards (blood)	98.00	25.00	3.92	1.00	3.92
P30 (semen)	107.00	25.00	4.28	1.00	4.28
Average					4.10
<b>Extraction - Column Kit</b>					
Qiagen	417.00	250.00	1.67	1.00	1.67
Pipette Tips	0.10	1.00	0.10	7.00	0.70
Transfer Pipettes	0.10	1.00	0.10	2.00	0.20
Test Tubes (1.5 ml)	10.00	500.00	0.02	2.00	0.04
Ethanol	30.00	500.00	0.06	1.00	0.06
Subtotal					2.67
<b>Extraction - Differential</b>					
PCIA	80.00	100.00	0.80	2.00	1.60
Pro K	77.00	1000.00	0.08	2.00	0.15
DTT	63.00	1625.00	0.04	1.00	0.04
Microspin (spineze)	65.00	250.00	0.26	1.00	0.26
Microcon	2.00	1.00	2.00	2.00	4.00
Pipette Tips	0.10	1.00	0.10	40.00	4.00
Transfer Pipettes	0.10	1.00	0.10	14.00	1.40
Test Tubes (1.5 ml)	10.00	500.00	0.02	26.00	0.52
Subtotal					11.97
Subtotal per sample					5.99
<b>Extraction - Organic</b>					
PCIA	80.00	100.00	0.80	1.00	0.80
Pro K	77.00	1000.00	0.08	1.00	0.08
Microspin (spineze)	65.00	250.00	0.26	1.00	0.26
Microcon	2.00	1.00	2.00	1.00	2.00
Pipette Tips	0.10	1.00	0.10	20.00	2.00
Transfer Pipettes	0.10	1.00	0.10	5.00	0.50
Test Tubes (1.5 ml)	10.00	500.00	0.02	12.00	0.24
Subtotal					5.88

<b>Quantification</b>					
Quant Kit	180.00	380.00	0.47	1.00	0.47
Chromagen Developer	49.50	760.00	0.07	1.00	0.07
Subtotal					0.54
<b>Amplification/Profile Dev.</b>					
PCR Tubes	30.00	1000.00	0.03	1.00	0.03
Test Tubes (0.5 ml)	50.00	1000.00	0.05	2.00	0.10
Identifiler/Powerplex					15.25
PCR Tube Strips	95.00	125.00	0.76	0.12	0.09
Septa	95.00	485.00	0.20	1.00	0.20
Pop4/formamide/GAB/GS500	513.00	800.00	0.64	1.00	0.64
Capillaries	45.00	600.00	0.08	1.00	0.08
Subtotal					16.38
<b>General</b>					
Versa-Dry Bench Coat	0.12	1.00	0.12	1.00	0.12
Gloves	85.00	50.00	1.70	3.00	5.10
Labels	30.00	1500.00	0.02	3.00	0.06
Buffers					1.00
Subtotal					6.28
<b>Known</b>					
Extraction - Column Kit	2.67				
Quantification	0.54				
Amplification/Profile Dev.	16.38				
General	6.28				
Total	25.87				
<b>Differential</b>	5.99				
Identification P30 (1/2)	2.14				
Extraction - Differential	5.88				
Quantification	0.54				
Amplification/Profile Dev.	16.38				
General	6.28				
Total	37.21				
<b>Other (blood)</b>					
Identification - Hematrace	3.92				
Extraction - Organic	5.88				
Quantification	0.54				
Amplification/Profile Dev.	16.38				
General	6.28				
Total	33.00				

Table 7: Cost of Materials for Forensic DNA Analysis at Acadiana Crime Lab - June 2002 to November 2002

	Profiler	Cofiler	Total	Full Profiles	Annualized	Materials	Annual Cost
Positive Control	\$45.00	\$45.00	\$90.00	\$45.00	\$90.00	\$33.00	\$2,969.92
Negative Control	\$45.00	\$45.00	\$90.00	\$45.00	\$90.00	\$33.00	\$2,969.92
Ladder	\$45.00	\$45.00	\$90.00	\$45.00	\$90.00	\$33.00	\$2,969.92
Extraction Blank	\$187.00	\$186.00	\$373.00	\$186.50	\$373.00	\$33.00	\$12,308.68
Differential (Female and Male Fraction)	\$66.00	\$66.00	\$132.00	\$66.00	\$132.00	\$37.21	\$4,911.13
Other Biological/Trace DNA	\$231.00	\$233.00	\$464.00	\$232.00	\$464.00	\$33.00	\$15,311.60
References (Blood/Oral)	\$142.00	\$147.00	\$289.00	\$144.50	\$289.00	\$25.87	\$7,476.47
Totals	\$761.00	\$767.00	\$1,528.00	\$764.00	\$1,528.00	\$228.07	\$48,917.65
Control Overhead Cost per Sample	23.98						

Table 8: Annual Cost per Forensic DNA Sample at Acadiana Crime Lab - Summary

Table

	Control Overhead Cost per Case Sample	Reagent Cost Per Sample	Labor Cost per Sample	Capital Cost per Sample	Equipment Cost per Sample	Total Cost per Sample
Differential (Female and Male Fraction)	\$23.98	\$37.21	\$288.88	\$12.43	\$38.34	\$400.83
Other Biological/Trace DNA	\$23.98	\$33.00	\$288.88	\$12.43	\$38.34	\$396.62
References (Blood/Oral)	\$23.98	\$25.87	\$288.88	\$12.43	\$38.34	\$389.50

The labor and benefit total cost per sample has been calculated to be \$288.88, which includes a yearly estimate of 885 DNA samples, and a salary and benefit cost for 3 lab scientists and one lab technician of \$255,656.40. The equipment cost is \$38.34, and the other capital cost is \$12.43 per sample. This brings the total cost per forensic DNA sample to between \$389.50 and \$400.83, depending on the sample type (Table 8).

The small size of the work unit of Acadiana Crime Lab prevents the establishment of an economy of scale. Three DNA analysts and one lab technician work forensic cases in a very labor intensive, non-automated fashion. Therefore, cost per sample estimates will be very conservative if greater volume was sought. Capital cost of expansion must also be incorporated, as building space and existing equipment are both at maximum capacity.

### **Outcomes**

Thirty-four percent of sexual assaults nationwide were committed by a stranger to the victim.<sup>19</sup> With about one of three sexual assaults committed by an unknown individual, use of forensic DNA now offers hope to solve almost half of these cases (Table 1), as the average forensic DNA lab success rate with these samples is 47.58%. That is, on average 47.58% of the sexual assault cases processed result in a full DNA profile. Given the first sexual assault may not be preventable, but with reporting and successful DNA analysis, subsequent assaults may be stopped. Therefore, there are currently a number of unnecessary sexual assaults occurring, which could be prevented with proper application of forensic DNA. The recidivism rate is approximately two thirds, which means that the

majority of criminals will repeat offend. As the average serial perpetrator of sexual assault commits 8 assaults, if a DNA profile was generated early in this “career”, a number of later offenses could be prevented. Using these estimates, the number of unnecessary sexual assaults can be estimated.

As the cost of each sexual assault is \$111, 238 (Table 5), a calculation can be made as to the cost of a no suspect sexual assault. In this manner, the potential impact of using the technology of forensic DNA to help solve these cases earlier, thus preventing crimes, can be calculated. Subtracting the cost of forensic DNA, the benefit can be measured, and the attractiveness of the investment in prevention measured.

Contrast the estimated 20.29 cases per 100,000 submitted to crime labs for DNA analysis compared to the 131 per 100,000, which are reported. If only the sexual assaults by strangers were processed, this would equate to  $(366,460 \times 34\% = 124,596)$  over 124,000 no suspect sexual assaults, or 41.82 no suspect sexual assaults per 100,000 population. As nationally 20.29 cases are submitted to crime labs versus 41.82 reported, the usage is only  $(20.29 / 41.82 \times 100) 48.58\%$ , assuming that crime labs are only conducting no suspect sexual assaults presently. Currently most cases submitted to forensic labs have suspects. Making the very conservative assumption that the crime labs are only analyzing stranger sexual assaults presently, if the remaining stranger sexual assaults were to come into labs, an increase in case demand over 2 times current demand would be seen. If a number of cases currently performed are cases with suspects, which is indeed the case, then the increase would be even greater. Therefore, a minimum of 100%

increase in sexual assault DNA capacity is required to conduct testing on the reported no suspect sexual assault cases not currently submitted to crime labs.

366,460 reported sexual assaults per year in the U.S. (1992-2000 average)<sup>14</sup>

X

34% committed by a stranger (termed a “no suspect” sexual assault)<sup>19</sup> (therefore these cases are not normally solved without DNA (both crime scene and database DNA working together))

= 124,596 reported “no suspect” sexual assaults

X

2/3 of the offenders are repeat offenders<sup>20,21</sup> (Table 4)

= 83,056 of no suspect sexual assaults are committed by repeat offenders

X

7 offenses per serial sexual offender are now preventable with crime scene DNA done on every case and a current DNA database (8 offenses per serial sexual offender, minus the first offense to risk getting caught)<sup>20</sup> (Table 4)

= 581,392 future sexual assaults that are preventable

X

47.58 % crime scene lab success rate (% of cases where sperm is found and a DNA profile is generated) (Survey of U.S. Crime Labs) (Table 1)

= 276,626 unnecessary victims of preventable sexual assaults

X

42% DNA database success rate (% of cases where a hit is made to a known offender)<sup>32</sup>

= 116,183 estimated sexual assaults solved

X

\$111,238 cost of crime per offense committed, adjusted from 1995 study to 2003 dollars (Table 5)

= \$12,924,000,000.00 or over \$12.9 Billion saved cost

Table 9: The Potential Cost Savings of Preventing Serial Sexual Assaults

Annual Sexual Assaults <sup>14</sup>	366,460
Offenses Committed by a Stranger (%) <sup>18</sup>	34
Recidivism <sup>20,21</sup> (Table 4)	0.6666
Preventable Offenses per Serial Offender <sup>20</sup> (Table 4)	7
Crime Scene DNA Success Rate (%) (Table 1)	47.58
DNA Database Success Rate (%) <sup>32</sup>	42
Cost per Sexual Assault (Table 5)	\$111,238.00
Total Potential Savings	\$12,924,000,000.00

Note that these costs do not include the cost of investigation, apprehension, legal costs, trial and the justice system, and crime prevention costs. These savings represent the potential savings to victims, including their medical, tangible and intangible costs. To realize these savings one must look at the cost of providing the forensic DNA service to apprehend the perpetrator as early as possible in his criminal career. This means the

earlier the offender is placed in a DNA database; the more likely it is to catch him after only the first offense. If all males were in a DNA database, early apprehension would be guaranteed. Obviously, there would be a corresponding sacrifice of individual rights for the prevention of future sexual assault victims. Victims of crime must also be encouraged to report all offenses, to ensure that another victim is spared from enduring the same ordeal needlessly. Both crime scene and database DNA samples must also be processed quickly; to prevent multiple sexual assaults occurring while the sample is in the analytical process, lest the offender strike again quickly.

Is sexual assault by an unknown suspect a preventable crime? Even with the demonstrated recidivism, perhaps the first sexual assault is not preventable. It has been demonstrated that DNA is recoverable in 47.58 % of cases (Table 1), and a hit is obtained from a successful database 42 % of the time. Therefore the serial offender is potentially stoppable on the second and subsequent offenses, assuming reporting by victims and a quick and successful forensic DNA response.

Is sexual assault a crime against one segment of society? All segments of society experience and commit sexual assault. However, 99% of forcible rapes and 94% of all sexual assaults were against females.<sup>19</sup> Besides victimizing those less able to physically protect themselves, young persons are also targeted. Two-thirds (67%) of all victims of sexual assault reported to law enforcement agencies were juveniles (under the age of 18 at the time of the crime).<sup>34</sup> Furthermore, over half the juvenile victims were under 12, and 1 out of 7 (14%) of victims were under the age of 6.<sup>34</sup> The detailed age profile of

perpetrators shows that the single age with the greatest number of offenders is 14.<sup>34</sup> This increased number of juvenile offenders versus adult offenders is borne out by the survey of 40 countries, which shows the ratio of sexual offenders to total offenses is 2 and one half times higher in juveniles as it is in adults.<sup>35</sup> While both victimization and offenders start at an early age, the offenders are nearly all male, and the victims are female, with many harmed at a very young age.

### **Expenditure Comparison**

While there is no direct link between forensic DNA to Federal Health Expenditures, it is an interesting exercise to contrast the amount of resources expended on major issues affecting society. Such major issues as research into AIDS, cancer, and heart disease and stroke are of great importance to every member of society, as the impact of these diseases touches every one of us. The potential impact of forensic DNA on society also touches every member of society, as demonstrated by the large number of annual sexual assaults; therefore it is appropriate to examine the emphasis placed on each of these areas.

Table 10: U.S. Federal Expenditures on Research for AIDS, Cancer, and Heart Disease/Stroke, in Contrast to DNA on a Sexual Assault Case with No Suspect, Where Semen is Identified.

Expenditure Category	Number of New Infections/Incidences per Year	Number of Incidences per 100,000 Persons	Total Annual Funding	Funding per Incidence
AIDS <sup>36-38</sup>	40000	14.29	\$2,759,940,000	\$68998.50
Cancer <sup>39,40</sup>	1334100	476.46	\$4,702,394,000	\$3524.77
Heart Disease and Stroke <sup>41,42</sup>	751000	268.21	\$2,848,000,000	\$3792.28
Sexual Assault	366460(a)	130.88	\$56,812,000(b)	\$595(c)

Sources: <sup>36-42</sup>

- (a) 366,460 sexual assaults per year is the U.S. annual average 1992-2000.<sup>14</sup>
- (b) 20.29 sexual assaults worked at crime labs per 100,000 U.S. population, times 2800 (thousand U.S. population), times an estimate of \$1000 per case for DNA analysis (see c).
- (c) \$595 is the cost of outsourcing a positive sexual assault swab to a private DNA lab.<sup>13</sup> Note this swab has been pre-screened, as in male biological material (seminal fluid) has been found. An additional cost factor of about \$400 has been added to the \$595 for this handling, as well as interpretation, peer reviewing, reporting, and uploading to the national DNA database. Therefore a cost of \$1000 has been used for the calculation in (b).

The above estimates in no way criticize the spending on very serious issues affecting the U.S. Rather, the intent is to highlight the relative importance, spending level, and likelihood of a particular event has in affecting the average citizen. Also noteworthy, the NIH (National Institutes for Health) Annual Budget for Bioterrorism is \$3.7 Billion for 2003. The projection for 2004 is \$4.3 Billion. The NIH Bioterrorism budget does not include forensic (crime) laboratories.

### **Optimization of Cost/Benefit**

Note also the current estimated level of total U.S. nationwide expenditure on solving sexual assault with forensic DNA of \$56,812,000. This amount is derived from the factor of 20.29 sexual assaults per 100,000 U.S. population submitted to forensic labs, as calculated from Table 1, estimated for the U.S. population of 280 Million, times a cost of \$1000 per case. With the estimated saving by solving and preventing reported sexual assaults at over \$12.9 Billion, and the current forensic DNA expenditure at \$56.8 Million, or less than 1/227<sup>th</sup> of the cost, there is clearly a case be made for a greater investment in solving and preventing crime through the application of forensic DNA. Again, these estimated savings do not include the cost of investigation, legal, court, justice system and prevention.

Finding the appropriate level of investment given the very large estimated impact is difficult. On one hand, the reporting of sexual assault is clearly far less than the actual number occurring. As stated previously, the estimates of unreported cases of sexual

assault ranges from 67%<sup>19</sup> to 95%.<sup>16</sup> Based on these estimates, in contrast to the 366,460 reported sexual assaults, the true number of sexual assaults occurring could be 3 to 20 times higher. The true number of sexual assaults could range from as low as 1,099,380 to as high as 7,329,200 annually.

On the other hand, the goal of the investment is to save individuals and society the ordeal and cost of preventable sexual assaults. By preventing sexual assaults, the number of incidents should decrease. The estimate of preventable sexual assault cases is 7 (8 sexual assaults per offender, minus the first assault to now potentially get caught) times 47.58% (Table 1, lab success rate in recovering a DNA profile) times the 42 % database success rate estimate. This prevention of future sexual assaults equates to preventing a factor of 1.4 future assaults, or 40% of future assaults can be prevented by early apprehension through applied forensic DNA.

In the wake of the solving of the South Louisiana serial killer case, local public awareness of DNA forensics has never been higher. One of the communities involved in the serial killer task force was Lafayette, Louisiana, following the nearby recovery of the body of one of the victims of the serial killer. The Lafayette Police crime statistics reported rapes and attempted rapes increased a stunning 251% in the first 6 months of 2003.<sup>42</sup> From January to June 144 rapes and attempted rapes were reported to police compared with 41 in the first six months of 2002 and 37 in 2001.<sup>43</sup> Public awareness of crime and use of forensic DNA to fight it may be responsible for increase reporting, rather than an actual increase in the number of incidents. A byproduct of an aggressive

campaign toward increased and successful use of forensic DNA will be increased reporting of sexual assault. With victims becoming aware of the high chance of solution to their assault, reporting will increase. In fact, assuring the maximum benefit to society will include actively encouraging victims to come forward to prevent future assaults.

Could the decrease in incidents resulting from the early apprehension of serial offenders offset the increase in case numbers due to increased reporting? Estimates of approximately 67% of sexual assaults not reported and 40% of sexual assaults being preventable are substantial, however they may offset each other to some extent. Too many factors are present to accurately project whether additional capacity is required, aside from that additional capacity required to conduct the DNA analyses to save the 40% in the first place. Therefore, to optimize the benefit to society in preventing the maximum number of sexual assaults, all cases of sexual assault should be both reported and processed for forensic DNA in a very timely manner.

The initial optimum level of expenditure lies at the current level of reported sexual assaults. Some future contingency should be allowed for a miscalculation in the estimate of prevention versus reporting, and accommodation for adjustments as case submissions at forensic labs are realized. Even if this 40% saving is compared to the more conservative estimate of 67 % of sexual assaults that are not reported, there is still a large projected increase in the requirement for forensic DNA capacity. Given that the crime of no suspect sexual assault is only a portion of the cases conducted by forensic biology

sections, other capacity can easily be applied to improving response times on murder cases, suspect sexual assaults that require corroboration, and other crimes.

The optimal cost benefit level of applying forensic DNA to solve and prevent crime is therefore:

366,460 sexual assaults

- (Minus)

56,801 sexual assault cases now received (15.5% of all reported cases which are currently sent to crime labs) (Table 1 and 2)

= 309,659 reported sexual assault case not received by crime labs

X

\$1000 cost per sexual assault case

= \$309,659,000 or an additional \$310 Million annually to process all sexual assault cases in the U.S. each year

Given the \$12.9 Billion dollar cost of preventable sexual assault, the investment or expense of spending \$366 Million to prevent those sexual assaults amounts to a 3520% return on investment. This spending level represents a \$310 Million increase over the estimated current level of expenditure of \$56 Million. For every \$1 spent on conducting forensic DNA on all sexual assault cases, there is a \$35 saving. Each \$1 invested prevents \$35 of cost. This demonstrates that forensic DNA is clearly an outstanding investment, which must be made in order to realize these savings to society.

From Table 2, forensic labs are receiving 15.5% (Table 2) of the reported sexual assaults that are occurring. The \$310 Million increase in annual forensic DNA operating expenses amounts to 1/35<sup>th</sup> of the \$12.9 Billion cost of sexual assault, with an additional one time larger capital expenditure requirement to furnish the building space and equipment. With the crime labs now receiving less than 1/6<sup>th</sup> (15.5%) of the 366,460<sup>14</sup> reported sexual assaults occurring annually, and all the sexual assaults be processed for forensic DNA as proposed, this would amount to a six-fold increase in DNA capacity requirement. That is 6 times the current capacity of DNA analysis is required to reap these benefits. Coincidentally, this number roughly coincides with the five-fold increase in case submissions realized in the first 3 years of operation by the Forensic Science Service in Great Britain when their national DNA database was introduced. In 2001 to 2002 alone, they experienced a nearly four-fold increase in DNA submissions.<sup>33</sup> The Forensic Science Service has hits on their database at a rate of over 1000 per day, with a crime scene to suspect hit % rate of over 42%.<sup>32</sup> 69% of samples loaded onto the database resulted in a scene to scene or a scene to suspect DNA match.<sup>33</sup> At that hit rate, over 123,000 DNA cases must be processed yearly to solve that number of crimes. In fact, over 150,000 forensic cases were processed by the FSS in 2002-2003.<sup>43</sup> With implementation of this plan, every law enforcement officer will know that with no suspect, by simply finding a biological substance at the crime scene, nearly half the time the crimes will be solved by forensic science.<sup>32</sup> The nature of how crime is solved in the U.S. will dramatically change with this monumental increase in the effectiveness with which crime is solved.

### **Estimate for Optimal DNA Database Size Requirement**

If every person on earth were in a DNA database, every crime scene with a DNA profile from the perpetrator could be solved. Aside from the size and cost of this undertaking, civil liberties must be considered. A realistic approach for estimating possible impact of DNA databases considers previous precedent set for other crime solving tools.

Fingerprints are routinely taken at arrest as part of the booking process. Similarly, they are retained on file, and are compared to unsolved cases via a national computerized system (AFIS – Automated Fingerprint Index System – FBI). While a balance must be maintained between individual rights, and individual and societal requirement for public safety, this level of DNA sampling affords practicality, precedence and some prior reasonable suspicion for the purposes of this discussion.

The Forensic Science Service (FSS) in Britain is a world leader in implementation of crime scene DNA, and the use of DNA databases. Their success in applying both crime scene DNA technology and DNA databases is recognized in solving unique and previously unsolvable crimes, as well as generating unprecedented statistics.<sup>45,46</sup> An estimate for the required size of an American DNA database to achieve similar crime-solving and prevention potential can be based on the achievements of the FSS of Great Britain.

As stated previously, the FSS has hits on their database at a rate of over 1000 per day, with a crime scene to suspect hit % rate of over 42%.<sup>32</sup> The population of Great Britain

served by the Forensic Science Service is estimated at 58 Million.<sup>44</sup> Notably, the DNA database used by the FSS includes samples from arrestees, which is now being implemented in Louisiana and Virginia.<sup>47</sup> In 2002 the DNA database for known individuals for the Forensic Science Service crossed the 2 Million sample mark.<sup>45,48</sup> This means that to achieve a 42% hit rate, approximately 3.5% of the population served by the FSS was in the DNA database.

Accordingly, the U.S. will require the same relative size of DNA database to achieve similar results. Criticism has been leveled at the crime solving capability of forensic DNA with respect to limited DNA database success.<sup>49</sup> Without arrestees in DNA databases, it can be argued that offenders currently committing crimes are not available in the DNA database, and hence DNA match potential is limited. Crime solving successes dramatically increase as databases grow in size, as experience by Florida, Virginia, and the FSS.<sup>22,45,47</sup> The latest population estimate for the United States is 292,274,597 as of October 07, 2003.<sup>50</sup> With the 3.5% ratio of DNA database samples to population served, this would estimate that the required size of the U.S. database be in the order of 10.2 Million. This estimate makes a number of assumptions including that crime rates and recidivism is similar in the U.S. compared to Britain. The current total number of convicted offender samples in the NDIS (National DNA Index System) U.S. DNA database is 1,353,948 as of July 2003.<sup>51</sup> A 7.5 fold increase in the U.S. database size is required to reach the same offender to population ratio as the FSS database. The estimate of 10.2 Million DNA database samples demonstrates the additional effort required to make major inroads in crime solving and preventing potential.

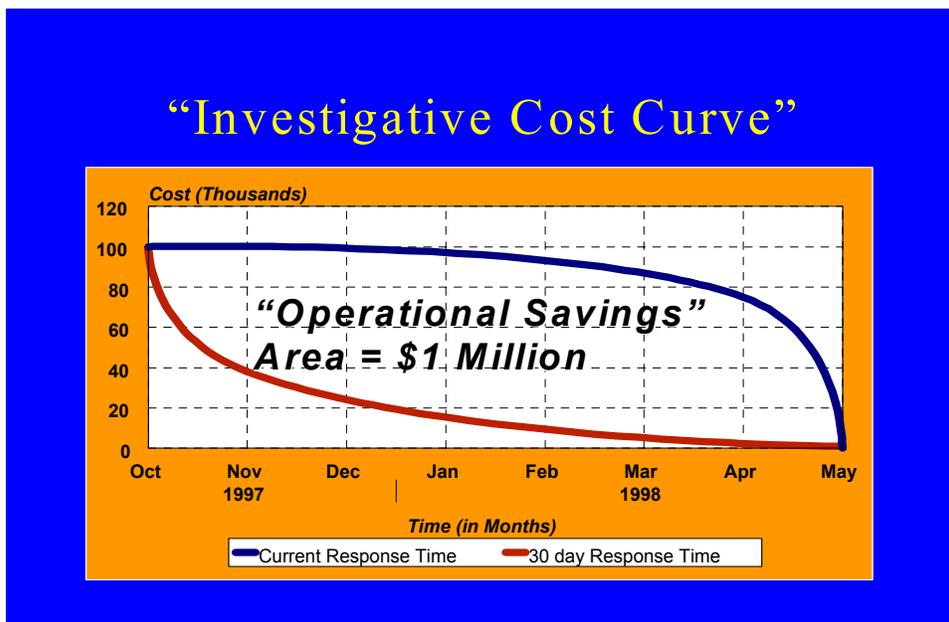
The cost of the additional DNA database size can also be estimated. When grouped en masse, large numbers of buccal (oral) swabs can be cost effectively batched, and profiles generated in an assembly line fashion. As these samples do not first have to be searched for and located, are not challenged in sample size and quality, and can be repeated if a sample fails, a far more cost effective analysis is possible compared to forensic samples. DNA database sample analysis can be contracted to private DNA laboratories for less than \$30 per sample.<sup>13</sup> With this cost, the additional samples (10.2 Million – 1,353,948 = 8,846,052 samples times \$30) required to bring the U.S. database into the same crime fighting realm as the FSS would be approximately \$265 Million. This estimate also assumes a one-time investment, when in reality a DNA database is built incrementally over time as arrests and convictions occur. Therefore, with an additional investment of \$265 Million to provide an appropriately sized database, a similar 42% DNA crime solving potential should be realized in the United States.

### **Speed of DNA Sample Processing**

Speed of processing of DNA samples is also a factor. If DNA analysis is slow, the maximum benefit is not realized, as serial rapists may strike again while a sample is in processing. The majority of investigative resources are spent early after the occurrence of the crime (Figure 2). Rapid elimination of suspects, or a match to a suspect, is a great investigative time saving aid, saving police resources to be used on other open cases.<sup>52</sup> Eliminating both DNA database and DNA “crime scene” casework backlogs is critical in realizing the massive savings potential. A DNA case does not cost any more if conducted

months after the crime is committed, rather than hours later. Arguably, additional overhead is incurred in juggling large numbers of backlogged cases, storage issues, organizing and performing analysis on priority bases, and responding to status queries. Crime labs currently recognize the value of and are working towards the goal of a 30-day turnaround target, but are swamped with demand; therefore most are still far from reaching that goal.<sup>53</sup>

Figure 2: The investigative cost curve



Source: G.H. MacLeod, Lab Manager (retired), Royal Canadian Mounted Police Forensic Laboratory, Regina, Saskatchewan, Canada.

Most of the time spent by cases backlogged in crime labs is not in analysis, but rather waiting their turn behind previously submitted cases. If DNA analysis was commenced the moment a case was received in the lab, many cases could be conducted in a week or

less. An analogy is a drive through at a fast food restaurant. While the target service delivery time may be 90 seconds, this may only apply if you are first or second in line. If you are number 100, your wait may be over an hour, constructed of multiples of 90 second units as each client ahead of you is served.

A crime lab only need be under-resourced by a small percentage in order to slowly fall further and further behind incoming cases, creating a backlog of cases, and an unacceptable waiting time for analysis results. Likewise, a small percentage of over-capacity would keep the backlog at a minimum and allow very quick response, as no time would be spent while a case “waits in line”.

Increased reporting and solution of crime will yield increased public security, and also increase perceptions of personal safety. The real threat of catching criminals quickly and effectively may also act as a strong deterrent, perhaps even preventing the initial assault from occurring in the first place. As members of society perceive something is being done, feel safer, and report crime as it occurs, the very act of law abiding citizens venturing out further pushes crime into the shadows.

### **Implementation**

Many states, such as Louisiana and Virginia, have undertaken sampling arrestees in order to increase the size of the known DNA databases.<sup>47</sup> The ACLU (American Civil Liberties Union) has opposed such expansion<sup>54</sup>, citing invasion of personal rights to privacy, and that individuals are presumed innocent until proven guilty. Law

enforcement and legislators have seen the value in apprehending serial sexual predators early, and seek to solve crimes, as well as prevent future crimes. While a federal program has been proposed to provide \$200 Million in each of the next 5 years<sup>55,56</sup>, no study exists to include the cost savings represented by an investment in forensic DNA. Scientifically sound, accepted forensic DNA technology exists to provide for greater public safety of the nation's female citizens. This does not come without a price to the males of society; some sacrifice of their own personal freedoms in donating a DNA sample. The debate is open. What path will society chose to take? The benefits are clear.

It is one thing to identify a problem, while it is entirely another to bring that problem to solution. Until a problem is realized, however, no solution will ever be sought. A report to the Attorney General by the National Institute of Justice (NIJ)<sup>57</sup> outlines a number of the reasons for delays in forensic analysis. Factors of production for forensic DNA are no different than any technological product. Specialized trained personnel, capital equipment, expendable chemicals and supplies, and specialized building space are required to produce a quality forensic DNA product. The technology is in place in accredited laboratories, accepted by the forensic community worldwide, the courts, and now widely accepted by society. Television shows such as *Forensic Files* and *CSI* (crime scene investigators), which is the number one rated television show currently in the U.S., have not only raised public awareness, but public expectations as well. By and large the shows are reasonably true to life, with the exception of the very brief time frames within which forensic results are produced, and the abundance of resources at the

disposal of the show's "scientist investigators". The NIJ report cites shortages in these factors of production: a lack of trained scientists, staff retention problems due to low salaries, lack of sufficient infrastructure, and insufficient lab space. NIJ estimates that there are approximately 350,000 rapes and homicide cases in backlog nationwide<sup>57</sup>, echoing an earlier report of a large national DNA backlog.<sup>58</sup>

The recommendations are included with the NIJ study are not surprising; increasing infrastructure to improve the forensic DNA capacity of labs, eliminating casework and database backlogs, increasing support and training to forensic scientists and the justice system at large, and supporting DNA research and development. Independently developed recommendations are attached herewith.

**Motivation: The Mr. Justice Archie G. Campbell Judicial Inquiry into the Paul Bernardo/Scarborough Rapist Investigation**<sup>59</sup>

The following are excerpts from this Canadian investigation:

*Between May of 1987 and December of 1992, Paul Bernardo raped or sexually assaulted at least eighteen women in Scarborough, Peel, and St. Catharines and killed three women in St. Catharines and Burlington.*

*The tragic converse of this fact is that Bernardo, during the 25 1/2 months his DNA was waiting to be tested, raped four young women and raped, tortured, and murdered two others. In hindsight, it is clear that these rapes and murders could have been prevented if*

*Bernardo's DNA sample had been tested by the CFS [Centre for Forensic Science, Toronto, Ontario] within 30 or even 90 days of the December 13, 1990 serology test.*

*The Bernardo case shows that motivation, investigative skill, and dedication are not enough. The work of the most dedicated, skilful, and highly motivated investigators and supervisors and forensic scientists can be defeated by the lack of effective case management systems and the lack of systems to ensure communication and co-operation among law enforcement agencies.*

*To meet the additional work-load created by the Criminal Code amendments and to reduce the DNA testing delay to a reasonable turnaround time in the range of 30 days, additional funds for the CFS are urgently required.*

*From a financial point of view, the Bernardo case demonstrates that delays in DNA testing can cost millions of dollars in the investigation of offences that could be prevented by timely DNA testing. Again from a financial point of view, there is a rapidly developing body of law around the potential legal liability of government for failing to provide a reasonable standard of public protection, an area of liability which could prove very expensive to the government if reasonable standards are not met.*

*Delays in DNA testing can imperil personal safety and cost lives.*

Recommendations made by the inquiry include the following:

- 1. A reasonable turnaround time for DNA testing is required, in the range of 30 days*

2. *A continuing commitment of resources is required to achieve and maintain this turnaround time in face of technological change and rising workload*
3. *A system is required to better co-ordinate the work of forensic scientists and police investigators*
4. *Funding is required for the training packages, the establishment and maintenance of a reasonable turnaround time for DNA testing, and the start-up and maintenance of the proposed system. The necessary funds are modest compared with the human and financial costs of failing to increase, to a more reasonable level, the systems of public protection against serial predators. It would be institutionally reckless to fail to do so.*

### **Conclusions:**

In conclusion, estimated cost to process all of the 366,460 reported sexual assaults per year is \$366 Million. This represents an increase of \$310 Million over the estimated current spending level. The estimated savings resulting from apprehending serial offenders early in their “careers” is \$12.9 Billion, not including investigative, legal, justice system, and preventative savings associated with the prevented sexual assaults. The savings is 35.2 times the investment. The total expense of processing an additional 8.85 million known DNA samples for an expanded DNA database is estimated at \$265 Million, which would establish a potential for a 42% success rate, similar to that of Britain. A comparison with other forms of social spending, such as AIDS research, Cancer research, and Heart Disease and Stroke research demonstrates the high relative worth of an additional investment in forensic DNA. With these investments in crime scene DNA and an expanded DNA database, an estimated 40% of future sexual assaults by strangers could be prevented by earlier apprehension of serial offenders.

### **Recommendations:**

1. Comprehensive national plan – equal justice for all, achieve savings with national scope, partnership with local, state, and federal governments in terms of direction, and local and state tailoring to meet needs.
2. Standardized national standards to ensure impartiality and lack of bias – the power of DNA is in its ability to exonerate suspects as well as implicate them
3. National standardized training

4. National standardized equipment purchase/scientific methodology
  - a. Robotics to reduce demand for scientists
    - i. Extraction
    - ii. Quantification
  - b. One tube profiling – introduce and validate system in all labs, for a savings of 50% over two reaction system now used in many labs
  - c. Standardized interpretation of mixtures
  - d. Use of trace DNA/latest low level DNA analysis nationally to yield profiles from toughest of cases
  - e. Y STR DNA (newest technologies becomes cost effective in Regional labs with economies of scale, now have economies of scope) – cases where male suspect's DNA is overwhelmed by female DNA can be successful
  - f. MtDNA – mitochondrial DNA produces profiles on severely degraded DNA sources where other techniques fail
  - g. Marry plans for homeland defense with forensics to ensure coordinated efforts/no duplication of services.
5. See Appendices IV, V, VI and VII – where do we want to go (goals and mission statement), how to get there (system design and implementation), and novel concepts.
6. SANE program (Sexual Assault Nurses Education)
7. Educate law enforcement and first responders on forensics/DNA/sexual assault
8. Partner with social services for rehabilitation of offenders (Social Scientist Rick Bereti claims a 70-80% success rate in rehabilitation if young offenders are

- identified at an early age (1)) to maximize benefit of early apprehension through rehabilitation.
9. Standardization of appropriate lab facilities. (people, building, equipment, procedures, chemicals). As labs do need to be built, many savings can be realized on architectural building plans, and contracting.
  10. Educate the public
    - a. Encourage and empower victims to come forward and “break the serial sexual offender’s chain”
    - b. Regarding the implications of expanding DNA databases; give up these rights, and this safety is returned
  11. Review checks and balances in place to ensure no misuse of DNA information and profiles in national databases. Include these in advertising to ensure no fear of “big brother”. Partner with civil rights groups to ensure checks and balances have been reviewed.
  12. Plan and enact an appropriate level of forensic coverage, with response time targets (days, weeks, or hours demanded for completion of testing from when assault takes place) – citizens’ bill of rights – what is demanded from a dynamic forensic service.
  13. Involve all stakeholder groups in planning, implementing, and overseeing the national forensic plan. Ensure a comprehensive well thought out plan taking full advantage of all good ideas and input, establishing buy-in and support from those who are required for involvement/support/implementation/ongoing success.

14. Keep statistics and measures on many aspects of implementation and service to ensure quality service in a timely manner for all, and to implement best practices in all labs nationally.
15. Create local and regional boards of oversight to ensure adherence to mission: “Unbiased timely forensic service to all citizens”.
16. Celebrate the successes of the service in reducing crime, etc (see stats # 14).  
Advertising will also act as a deterrent, and encourage victims to come forward, promote and instill a feeling of safety and empowerment.

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## **Appendix I - Survey of Forensic DNA Laboratories**

1. How many trained DNA analysts are in your lab?
2. What is the population you serve?
3. How many sexual assault cases are submitted to your section?
4. What proportion of these yields an interpretable male DNA profile (10 loci or more)?

Survey conducted by Ray Wickenheiser July 07, 2003

## **Appendix II - The Process of Investigating a Sexual Assault Case**

1. Sexual Assault: Incident occurs and is reported.
2. First Response: First responders arrive at scene; take report of incident, and complainant (this term is used rather than victim, as at this point it an alleged offense has occurred).
3. Hospital: If a sexual assault has occurred, the complainant is escorted to the hospital for medical treatment, and a sexual assault “kit” is completed with the assistance of a SANE (Sexual Assault Nurse Education) trained nurse. The nurse (female) is specially trained to advise and educate the complainant, and respond both medically, and in the gathering of personal evidence.
4. Sexual Assault Kit: The sexual assault kit is usually comprised of the following, which depend on the nature of the offense:
  - i. Vaginal swabs
  - ii. Swabs of any other body area contacted in the assault
  - iii. Known reference sample for DNA
  - iv. Clothing worn at the time
  - v. Combing of pubic region
  - vi. Samples of scalp and pubic hair
  - vii. Medical history form including previous sexual history
  - viii. Statement of the nature of the assault
  - ix. Pictures and documentation of injuries
  - x. Results of the medical examination

5. Transport Kit to Crime Lab: The sexual assault kit is transferred to an investigating police officer, who transports the kit to the forensic lab.
6. Investigative Interview: The investigating officer reviews the statements of the complainant, re-interviews with respect to points, which may identify the suspect, and commences the investigation. A sworn statement of fact is taken from the complainant.
7. Crime Scene: the investigator visits the crime scene, and evidence is gathered at the crime scene. This may include blankets, items left by the suspect, trace evidence (hairs, fibers, etc), or items left by the complainant. Evidence gathering is very specific to the nature of the crime, the location of the crime, and the previous relationship of both the suspect and complainant to each other, and to the crime scene.
8. Statements: Other witnesses are interviewed. Statements are taken.
9. Supporting Evidence: Other evidence is submitted to the forensic lab, along with information, which aids the forensic scientist in selecting probative (valuable/information in context with the case) examinations.
10. Forensic Examination: Forensic examinations are conducted in coordination with information given by the investigator. Often, forensic examinations are reserved for cases where eyewitness and other strong evidence are lacking, or the investigator feel the case requires forensic evidence. Cases where the suspect admits contact indicated by the complainant are not pursued forensically. The most probative examinations are done first, in a step-wise manner, down to those likely to yield the least information. Non-destructive tests are done first,

- such that the most information is gleaned from each item. Once a suspect has been identified, examination is stopped, to prevent redundant examinations, which waste valuable resources.
11. Initial Forensic Report: Forensic evidence is conveyed to the investigators, including whether DNA bearing material is present (semen, blood, etc). The investigator is advised to submit known reference samples from suspected individuals. These samples may have been submitted at an earlier time at the discretion of the investigator.
  12. Final Forensic Report: Forensic comparisons are done between crime scene and known samples, and suspects are eliminated or included. During the course of the investigation, typically there may be one, or several interchanges of information, exhibit items, additional examinations, and reports between the scientist and the investigator.
  13. Investigation Concluded: The investigator concludes his case once a suspect is included, a statement is taken, and attempts have been made to confirm or deny alibis. A report is sent to the District Attorney for evaluation for charge.
  14. Legal Review: The District Attorney's office, or other prosecuting law enforcement body reviews the case; additional work and consultation routinely occurs.
  15. Charges Laid: As warranted by the case facts, charges are laid. A warrant is issued. The suspect is arrested. Many of these steps may vary in order depending on case circumstances, availability and strength of evidence, threat to public safety, etc.

16. Court: Court is held if the suspect pleads not guilty. The complainant, investigator, and forensic lab scientist testify, and a verdict is reached.

### **Appendix III - The Process of Using Forensic DNA in the Lab**

Case Receipt: The case is received in the forensic lab. Information is gathered from the investigator to decide the order of examinations. Examinations are conducted starting with the least destructive, and those yielding the most probative value, in order to maximize the value of the evidence. Documentation is created to track the case and the exhibit items from receipt, through examination, until case completion, reporting, and exhibit item release back to the contributing agency.

1. Exhibit Screening: Exhibit items are examined for biological evidence. Visual techniques with a variety of light sources are used to locate possible stains. Exhibit items and stains are documented.
2. Presumptive Testing: Stains are tested with presumptive screening tests. These tests are fast and simple methods for screening out stains with are not biological in origin. There are possible false positives, but more specific tests will be used to confirm findings. These tests are a method to cull down the number of stains to those with the most potential of developing a DNA profile.
3. Confirmative Testing: Screened stains are examined with more specific confirmatory tests. These tests are more labor intensive, but confirm that human blood or semen is present. Not all stains may be tested if there are many.
4. DNA Analysis Selection: An experienced scientist decides which stains analyze, or to attempt to generate a DNA profile with.
5. Extraction: DNA is extracted and purified. The substrate (cloth, swab, etc), lipids (fats), proteins, and carbohydrates (sugars), are removed from the DNA.

6. Quantification: The amount of human DNA recovered is determined. If no human DNA is present, the process usually stops at this point. Unfortunately, the profile generation step is now more precise than the quantification step, and is now able to generate full DNA profiles with minute amounts of DNA not detected in the quantification step. A new quantification step is needed, or it should be dropped in cases with minute DNA quantities.
7. Amplification: The PCR (Polymerase Chain Reaction) process multiplies the amount of DNA in small target areas. These areas have been pre-selected as those where persons are different. Several areas of DNA are amplified or multiplied simultaneously. Most labs use 2 reactions to produce the 13 CODIS loci. New kits have been developed to do all 13 simultaneously.
8. Profile Generation: DNA fragments are separated according to length in a gene sequencer.
9. Interpretation: An experienced DNA expert scientist assesses the DNA profile generated, and selects the DNA fragments which are used to make up the 13 core loci CODIS profile (under ideal circumstances). Under less than ideal circumstances, there may be degraded DNA, which generates a partial profile. There may be mixtures of DNA from more than one source. This may include the complainant and a suspect. Alleles, or integer numbers, are assigned to DNA fragments, and profiles belonging to individuals are deduced.
10. Comparison: DNA profiles from questioned (crime scene) and known individuals are compared. Probative value of the match is determined.

11. Reporting: A lab report is written, which includes the exhibit items reviewed, examinations conducted, and the results and conclusions.
12. Exhibit Release: Exhibit items are returned to the investigative agency.
13. Court Testimony: Where required, scientists attend court to testify on scientific findings.

## **Appendix IV – Mission Statement**

### **Goal**

If your or my child was abducted or sexually assaulted, what kind of response from forensics would we expect and be willing to pay (with our tax dollars) a reasonable amount for? Each case should be treated this way.

### **Mission Statement: Citizen’s Bill of Forensic Rights**

I have a right to:

- a. Quick crime scene response (within hours of notification), which is thorough, and multidiscipline (don’t miss anything, or have to go back, or lose/don’t preserve evidence).
  - a. Emphasis on investigative information.
  - b. Education of first responders to recognize and preserve forensic potential, and call in lab as needed.
  - c. Part of required training for all police officers.
  - d. Admin policies for crime scenes for each agency
- b. Updates of status on lab findings.
- c. Response time in days.
- d. Efficient system – local, regional, some centralized to create full blanket of service as required.
- e. Equal service for all.

## **Appendix V – System Design**

Define the problem:

How do we maximize the use of forensic technology in crime solving for the most benefit to society at the lowest cost?

### 1. Principles/Goals:

Standardization

Reduce overlap

Reduce duplication

Service

No backlog(s)

Add services

State of the art technology (ex. Toxicology)

Response time

Immediate/ASAP

Coverage

Full and equal coverage for all citizens

Access

Ready access for all law enforcement through local points of delivery

Accredited

Demonstrated quality

### 2. How to accomplish this:

Federalize the entire system/partnerships at multiple government levels

Expand local lab(s)

Expand regionally

Private labs

Start a new lab/take an existing lab and upgrade

More resources required, match resources to level of service needed

People

Laboratory space

Equipment

Infrastructure

Long term financial commitment – steady reliable flow of resources

Pay structure

Standardize levels, structure, and pay for scientists and support staff.

Standardize service

Coordinate service to ensure continuous blanket of timely, effective and efficient service, using the latest technology to solve all crime.

Problems/concerns:

1. Lack of transportability of lab skills.

The field of forensics is so diverse, and overhead in training so large, that bringing in new human resources is a major hurdle. A minimum of 6 months to 1 year of training is dictated in all disciplines, and training times of 2 years are not unheard of. As major cases occur, it is very difficult to shift resources from one area to another to meet sporadic demands. It can be argued that all cases dealt

with by certain sections of the lab are crimes against the person, and therefore shifting resources by prioritizing cases is a major issue. Whose case should be set aside?

## 2. Personnel requirements.

All personnel must have a B.S. degree as a minimum, and no criminal record. Security clearances and administrative overhead slow the hiring process.

The overhead of accreditation, proficiency testing and high standards, requires very careful, meticulous work, which can be very stressful in a “hurry-up” situation. Scientist burnout is a concern.

Given the long training time to bring a scientist into production, hiring and training must be proactive as opposed to reactionary. Needs must be projected, and some surplus capacity must be kept in the overall system to ensure backlogs do not reoccur. Backlogs defeat the benefits of forensic DNA.

## 3. Keeping up with current technology.

Ongoing training and research takes a back seat when cases are in constant backlog. Time and resources are required to stay current with increasing use of high technology. Any solution must provide not only sufficient resources to stay abreast of the steady flow of cases coming in, but provide additional resources to stay on top of current technology, and provide the ability to react to emergency demands without jeopardizing the “regular” case flow. Contrary to one’s immediate intuition, the amount of personnel resources need only be 10 or 20%

over the incoming case flow to eliminate backlogs, and allow for reactionary capability. This capability is available on standby for large and important cases, immediate assistance to law enforcement agencies, and other emergencies. Ongoing research and other professional development ensure optimal use of any minor planned capacity contingency.

## **Appendix VI - Implementation Plan**

1. Study the current national system, and create a map of existing resources, and forensic coverage.
2. Identify holes in coverage, overlap, and immediate areas of required improvement. Fill immediate holes on a priority basis.
3. Identify novel concepts (see Appendix VII) that can be put into place rapidly for quick benefit to all labs/services.
4. Identify/develop long-term plan involving capital construction and more major infrastructure improvements.
5. Work in concert with all levels of stakeholders to develop a comprehensive national plan. Present a framework through facilitated meetings with identified principles, needs, benefits, etc., within which to work. Generate ideas, ensure input and cooperation.

Stakeholders: Existing labs, federal, state, and local law enforcement and politicians, citizens, universities, attorneys, judges, etc.

6. Implement
7. Coordinate
8. Ongoing/constant feedback and adjustment
9. Retain some oversight to ensure new system continues to meet needs/goals.

## **Appendix VII - Novel Concepts / Recommendations**

### **1. National Scientist Candidate Pool**

Recruiting, evaluating, security screening, and selecting the best candidates for new scientists can impose a burden on local labs. Developing the best young scientists comes from selecting the best candidates nationwide. More and better candidates will likely join the list by having far better career opportunities through having single point access to all of the nation's crime labs. By releasing the local lab from advertising, recruiting, and screening candidates, large amounts of time and local resources are saved, and duplication of effort eliminated. Candidates can then be selected from the list based on qualifications and background, dependant upon local requirements. Considerable time saving will result, while the best candidates will be assured to make up the next generation of top-flight scientists.

### **2. Centralized training**

Training new scientists in the latest techniques is a tremendous burden on operational labs straining to keep up with case flows. The usual reason a new scientist is hired is because the load is too great, and now additional experienced scientist time must be taken from casework to train the new hire. Centralized training will reduce this local burden, as well as becoming a means to introduce standardization and new updated techniques and technology to existing labs. Hires from local labs would be sent to a central training facility for an extended period of time, and then upon passing that course, be polished at their local facility. The best and brightest scientists in the field could be pulled in to

assist with training modules, thereby exposing the next generation of scientists to the best technology and role models/mentors, while keeping their local flavor.

### **3. Modularized Training**

“Snap-on” training can be employed to bring new scientists into quick productivity by using short training modules. Once trained and doing limited casework, training components can be snapped-on one module at a time, as the need and time to train arises. These modules can be centrally developed, updated and delivered, increasing the standardization and maintenance of cutting edge technology. An example of this would be the searching of exhibit item materials for biological and trace evidence, or the identification of marijuana.

Standardized training for each discipline will ensure uniformity and use of up to date techniques and technology. Core training can be modified locally to include specialized techniques.

### **4. Coordinated Ongoing Training**

Personnel files on every forensic scientist would be kept centrally, including proficiency testing, and ongoing improvements in qualification. Centrally coordinated and provided training will ensure that latest techniques are implemented and maintained, and that personnel have the required skills and support to accomplish this. In concert with local training managers, the burden of keeping labs up to speed through training will be

assumed with central resources. This effort can be coordinated with the practical research initiatives, and centralized new scientist training initiatives.

### **5. Secondable employees**

Use of technicians that are funded by federal programs can boost the productivity of local labs, while maintaining staff for emergency call back. A model for this concept is National Guardsman Sergeant First Class (SFC) James Garner, who acts as a drug technician in Acadiana Crime Lab in New Iberia, Louisiana. With a 3-4 month training period, SFC Garner has been in the lab 7 years, and works over 4000 drug identification cases annually. He keeps abreast with his guardsman duties and training through annual courses and conferences held by the Louisiana National Guard. His service is invaluable to the Lab Drug Chemists, whom he assists directly in increasing productivity by acting as a drug identification technician.

### **6. Coordinated Practical Research Initiatives**

Local case-working forensic scientists are often the individuals to first recognize areas of required development, bottlenecks, or potential improvement. It is often difficult for these scientists to find time between cases to conduct research, or develop or refine methods. Likewise, small laboratories do not have the resources to take these scientists out of casework production to conduct research for the betterment of the greater whole. Giving away research ideas often does not occur, as publications are a means of recognition and status, and is fairly competitive. If those scientists with ideas were guaranteed a role and stake in research to be conducted jointly with a more flexible lab

group with adequate resources, considerably more ideas would come to the fore.

Problems identified from the case-working scientists could be worked on jointly, with credit shared jointly, but supported by central resources.

The central research laboratory would house multi-disciplined experts with exceptional backgrounds, who could bring tremendous talents to practical problems. A central lab such as this, perhaps affiliated with an institution of higher learning, could attract the brightest in their respective fields. Coordination between this group, and the centralized training group, would ensure continued state of the art forensic practice. Several such groups could work in concert nationwide as regional centers of research facilitation. This effort can be coordinated with the centralized scientist training initiatives.

## **7. Two Tiered or Multi-tiered Production Approach to Service (Selective use of Automation)**

Not all cases are created equal. As much as we treat each case on its own merits, and each case is individual with different circumstances, cases can be “binned” into cases of similar types. Division of DNA cases into types, corresponding to several selection criteria, will allow streamlining of production lines to match productivity to need. For example, consider two DNA cases. The first is a sexual assault with a known suspect who is in custody for a case in which screening has indicated a large amount of DNA bearing material is present. This case would be handled differently than a potential serial murder case of children, with the killer on the loose, and likely to re-offend, where very minimal quantities of DNA bearing material was left at the crime scene. One case type

may be much more amenable to automation, and have ample DNA for more sensitive retesting should the more general, less sensitive automated approach fail in some regards. A second case type may require a more labor-intensive approach in order to glean the maximum forensic value from challenging samples.

Criteria for selection of different streams (or assembly lines) could be based on the following:

- Urgency
- Danger to society
- Investigative assistance level
- Nature/severity of offense
- Likelihood for re-offence
- Amount of DNA present
  - Blood, large amount
  - Seminal fluid, large amount
  - Trace DNA, small amounts of DNA, novel exhibit type or DNA source
- Nature, amount, and significance of other forensic evidence

Experienced forensic personnel could consult with investigators to obtain all pertinent case information, and evaluate the case based on the criteria. A diary date could be “negotiated” with the investigators based on fulfilling their needs. Cases would be prioritized, and searched based on priority. Dependant on the amount and type of DNA bearing material found, the more cost effective automated assembly line could be tried.

Should the assembly line fail, or the nature of the case or DNA bearing material dictate, a more hands on approach with dedicated DNA analysts could be utilized.