The use of PCR change agent model to help reduce the backlog of forensic DNA specimens

Khalid M. Lodhi,[1,]***D.Sc.; Robert L. Grier IV,**[2]**Ph.D.; Muhammad A. Lodhi,**[2]**Ph.D.; Yung-fou Chen,**[3]**Ph.D.**

[1,2] *Forensic Science and Biotechnology Programs, Department of Biological Sciences, Fayetteville State University, 1200 Murchison Road, Fayetteville, North Carolina 28301 USA.*

[3] *Department of Forensic Science, Central Police University, 56 Shu-Jen Road, Kwei-San,Taoyuan 33304, Taiwan, R.O.C.*

Abstract

Forensic DNA laboratories are often overwhelmed with high-volume backlog of biological specimens. Such backlogs are partially responsible for overcrowding of the jails. The backlog is a worldwide phenomenon. The reduction of the backlog will require new DNA forensic technologies and new approaches to forensic DNA laboratory management. Standard operating procedures, equipment and lengthy training of the forensic DNA scientists using those procedures and equipment are blamed for the backlog. The DNA section of crime laboratory uses a number of procedures and equipment that must be validated through standard validation process. In addition, each forensic DNA scientist is responsible for validating the procedures and equipment independently for admissibility in court. The companies that develop new equipment and DNA kits offer workshops in the use and validation of these equipment and DNA procedures. Forensic DNA workshops aimed at training forensic DNA scientists, though quite helpful, take days to weeks thus taking them out of the laboratory which exacerbates the backlog situations. In addition, the workshops are not designed to educate forensic DNA scientists who can train other forensic DNA scientists, therefore, a number of forensic DNA scientists from the same laboratory have to attend similar workshops to learn new technologies before those can be validated and adopted. The authors propose a PCR change agent model to train forensic DNA scientists. The PCR change agent model addresses the shortcomings of the current DNA validation procedures and reduces the DNA backlog. A survey of forensic DNA scientists revealed a general consensus for the use of PCR change agents in reducing the DNA backlog.

Keywords: forensic DNA science, polymerase chain reaction (PCR), backlog, DNA validation training

Introduction

Overcrowding in jails is one of the most substantial issues facing the criminal justice and forensic community. It can be traced back to the backlog of unanalyzed DNA samples and biological evidence from crime scenes. National Institute of Justice defines a backlogged case as one that has not been tested in 30 days after it was submitted to the laboratory [1]. Forensic DNA laboratories are overwhelmed due to a number of reasons that include, the lack of adequate training opportunities of DNA forensic scientists on new technologies, lengthy validation and adoption procedures and a growing need

of DNA testing in crime investigations. A 2002-03 survey reported crime scene evidence from law enforcement agencies throughout the United States revealing 542,723 unsolved homicide, rape, and property offenses that need forensic DNA analysis [2]. The demand for DNA analysis is growing with approximately 400 public and private crime laboratories in the United States. There are 17,876 state and local law enforcement agencies (excluding federal law enforcement agencies and the military) in the United States that may require forensic DNA testing [3].

Even though the successful DNA typing methodology was developed over 25 years ago [4-6]

---

*Corresponding author: klodhi@uncfsu.edu

public crime laboratories have insufficient time to validate the new technologies and bring them online. Validation is a very vital issue of any forensic laboratory. Defense attorneys today rarely challenge the science behind DNA typing rather they challenge the process by which the laboratory performs the forensic DNA analysis. Thus, the forensic DNA community must carefully document the validity of new techniques and technologies to ensure that procedures performed in the laboratory accurately reflect the examined samples. In addition, a laboratory must carefully document their technical procedures and policies for interpretation of data and follow them to guarantee that each sample is handled and processed appropriately [7]. If the forensic DNA scientists start validating new procedures and/or equipment then he/she will not be available for DNA casework and consequently the DNA backlog increases.

There is a shortage of skilled manpower and resources. simply hiring more forensic DNA scientists to work in a crime laboratory will not necessarily result in more DNA samples analyzed per month. The newly hired forensic DNA scientist is required to demonstrate his/her mastery of the procedures in the crime laboratory and this training period ranges from six months to two years. The forensic DNA, technical leader/manager must supervise the new hire during this training period and thus has limited time for forensic DNA casework.

Furthermore, if the forensic DNA scientists start validating new procedures and/or equipment then he/she will not be available for DNA casework and consequently the DNA backlog increases. It is generally realized among the forensic DNA scientists in the crime laboratories that incorporation of DNA amplification based procedures, such as polymerase chain reaction (PCR) will enhance productivity.

A common practice is to send forensic DNA scientists to forensic DNA workshops to learn new procedures and/or equipment and their validation. On return to his/her respective crime laboratory the forensic DNA scientist must validate the new procedure(s) and equipment for adoption to DNA analysis. There are two problems with this approach. First, this practice requires that a member of a forensic DNA laboratory be

absent from the crime laboratory for 1-2 week(s), which adversely affects the backlog of forensic DNA cases. Second, the workshop participants are not prepared to train other members of his/her crime laboratory about the new procedures and/or equipment. It is neither cost effective nor practical to send all the forensic DNA scientists to a forensic DNA workshop. The authors of this paper propose, that a more cost-effective and efficient approach would be to train participants at a forensic DNA workshop as PCR change agents. The approach will hereafter be referred to as the PCR change agent model. With such an approach new technologies can be brought online without the disruption of the laboratory DNA testing turnaround time and build up the capacity to analyze more samples over a short period of time.

The theoretical basis of the PCR change agent model is based on the molecular biology technique of PCR [8]. In PCR, a DNA molecule is used as a template for the synthesis of a new DNA molecule that is a copy of the original DNA template. The DNA copy can serve as a template for subsequent rounds of DNA amplification. To train a forensic DNA scientist as a PCR change agent in his/her laboratory, one member of each participating crime laboratory will be selected in consultation with director of the participating crime laboratory. The PCR change agent will learn the new procedures or the use of new equipment, validation process and how to train other forensic DNA scientists in his/her DNA section of the crime laboratory. Thus the PCR change agent will become a trainer in the DNA section of the crime laboratory as well as a link between the forensic DNA scientists in his/her laboratory and the workshop mentors (see Figure 1). It is important that the PCR change agent be a member of the participating DNA section of the crime laboratory since he/she understands the culture of the laboratory including its strengths and weaknesses.

The PCR change agent model eliminates the need for all forensic DNA scientists of the DNA section of the crime laboratory to attend the forensic DNA workshop because the PCR change agent will become the instructor for his/her laboratory. In a busy DNA section of the crime laboratory it is not possible for all of the laboratory forensic DNA scientists to attend even a short duration workshop
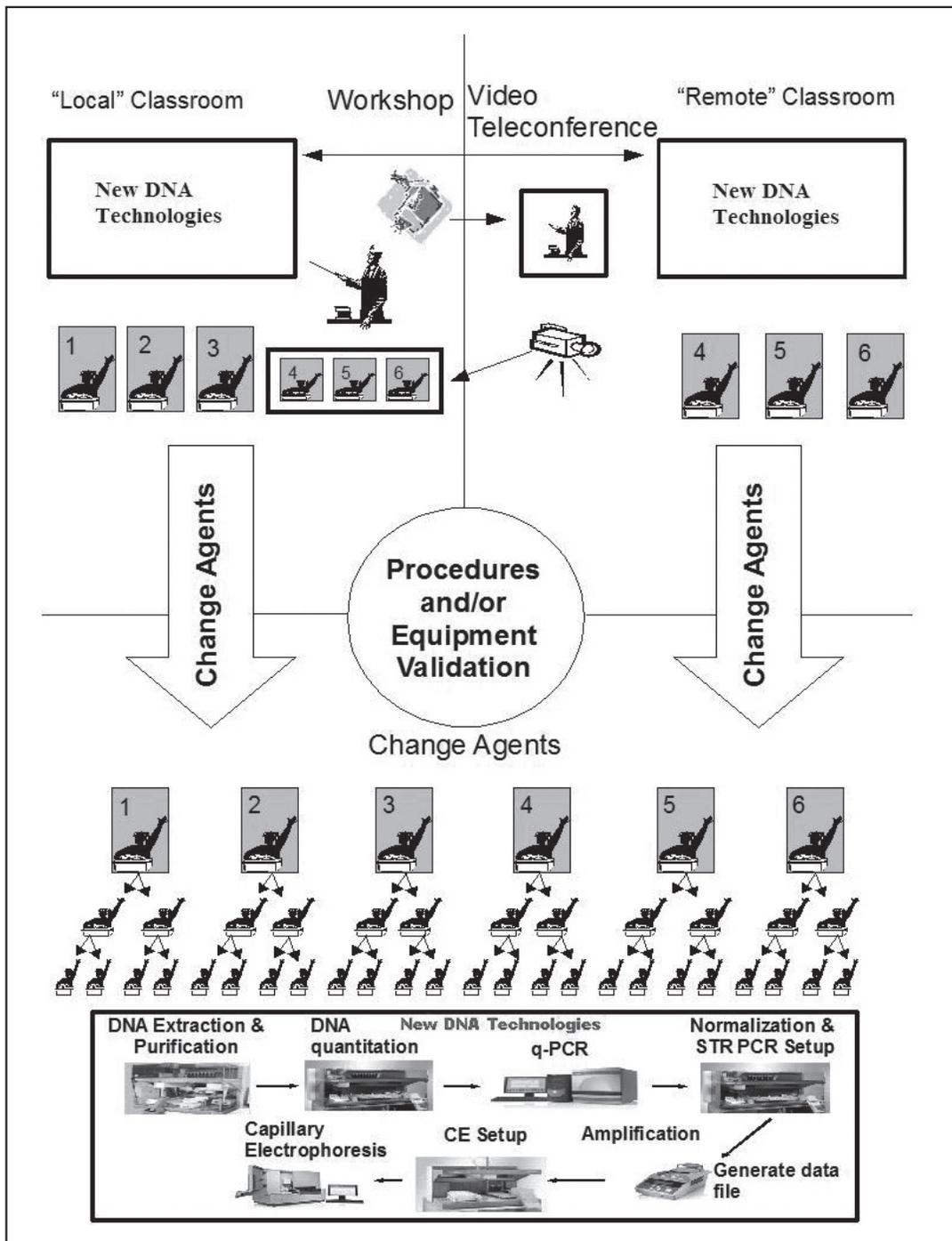
Fig.1 Forensic DNA scientists are instructed to become first generation PCR change agents (trainers) by attending a forensic DNA workshop in person. The trainers return to their respective crime laboratories to train other forensic DNA scientists to be second generation PCR change agents. The first generation PCR change agents (trainers) will communicate with the workshop mentors via video-teleconferencing if problems are encountered in their validation. The second generation PCR change agents in turn train third generation PCR change agents and so on. New equipment and procedures such as q-PCR (Real-Time PCR), Capillary Electrophoresis (CE), Short Tandem Repeats (STR) PCR and others are shown in the bottom rectangle as an example.

without negatively impacting the testing schedules. Another innovation of the PCR change agent model is the PCR change agent (first generation) recruits other PCR change agents (second generation) at his/her DNA section of the crime laboratory. The second generation PCR change agents will teach other forensic DNA scientists about the procedures/equipment and validation process. Thus an exponential growth of knowledge sharing occurs over a period of time. Such a systematic improvement in the validation process of procedures/equipment will result in forensic DNA scientists having more time to work on forensic specimens and consequently a decrease in the backlog.

A third innovation of the PCR change agent model is the use of video teleconferencing to provide support and additional training for the PCR change agents/ trainers. The workshop mentors will provide the online support to the PCR change agents/trainers and create a virtual workshop that does not require trainers to leave their own crime laboratory. Using a personal computer and high speed internet access workshop participants can join the virtual workshop without physically leaving his/her office. Workshop trainers will view, hear and interact with the mentors. To enhance the educational experience, the workshop mentors will not simply demonstrate the equipment. Instead the mentors will first, discuss with the trainers, at the remote site, the activity that is to be done and then perform the actual experimental procedure. The goal is to make the trainers "feel" that he/she is actually doing the procedures and not just watching a mentor do the activity. Virtual labs, used in online courses have proven to be a good tool for distance learning and can be employed for the workshop. This approach will make the virtual workshop dynamic and help achieve the goal of the workshop training a PCR change agent. All validation protocols will be available on the workshop web site to allow trainers to go back and review the procedure(s) step by step.

Survey study

To test the validity of the PCR change agent model, we conducted a short survey of the forensic DNA scientists who work in public and private DNA section of crime laboratories as well as individuals who have worked in public and private DNA section of crime laboratories. E-mail messages were sent to forensic DNA scientists with an introduction of the survey and a link for the online survey. The questions and the answers are summarized in Table 1. Twenty-nine forensic DNA scientists responded to the survey. Fifty-seven percent forensic DNA scientists revealed that their crime laboratories adopted new DNA forensic technologies every few years (Question 1). Sixty-four percent (sum of Strongly agree, Agree and Somewhat agree) forensic DNA scientists strongly agreed that the PCR change agent model will accelerate the adoption of new forensic DNA techniques (Question 2). Seventy-one percent (sum of Strongly agree, Agree and Somewhat agree) of the forensic DNA scientists thought that it would be economical for their, respective crime laboratories to train a PCR change agent (Question 3). For reference only, forensic DNA scientists were asked how many forensic DNA scientists are needed in a crime laboratory and fifty-eight percent stated that more than five forensic DNA scientists were needed (Question 4). Fifty-seven percent (sum of Strongly agree, Agree and Somewhat agree) of forensic DNA scientists agreed that the backlog issue was attributed to technical limitations rather than management (Question 5). Thirty percent of forensic DNA scientists agreed that introduction of PCR change agents will help reduce both the DNA database backlog and forensic DNA casework (Question 6). The survey demonstrates a general agreement among forensic DNA scientists that the DNA backlog can be reduced using PCR change agents.

Conclusions

In conclusion, the authors propose a new model, PCR change agent model, for training forensic DNA scientists in new procedures/equipment and their validation. The PCR change agent model would help crime laboratories reduce their backlog cases by training forensic DNA scientists in the latest procedures/equipment and their validation without sacrificing laboratory productivity. The forensic DNA scientists (first generation PCR change agents) receive training via attending the workshop(s) as well as the

Table 1. Survey Questions and Responses (%)

Questions	Responses						
1. How often does your crime laboratory adopt new DNA forensic techniques, such as Real-Time PCR series: ABI 7000, ABI 7500, ABI 7900, and ABI Capillary Electrophoresis series: ABI 310, ABI 3100 Avant and ABI 3100 16 capillaries instrument?	Rarely	Every few years	When it becomes available	Don't know			
	14	57	21	7			
2. Do you think the usage of a PCR change agent model could accelerate the adoption of new DNA forensic techniques in your crime laboratory?	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
	29	21	14	21	4	7	4
3. Do you think it would be economical for your crime laboratory to train a PCR change agent?	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
	29	21	21	11	7	7	4
4. What is the ideal number of forensic DNA analysts/ scientists that would be required to process the daily DNA evidence case load to prevent a backlog problem if new DNA techniques/ equipment were not adopted?(This question is for reference only)	Three	Four	Five	More than five	Don't know		
	4	4	15	58	19		
5. Do you believe that the backlog problem is due to technical limitations in DNA forensics rather than management issues, such as time control by the laboratory director and/or by the prosecutor's office?	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
	11	25	21	7	11	14	11
6. Do you think the PCR change agent will be more helpful to reduce the backlog problem in DNA database or DNA forensic casework?	Agree both	Agree DNA database	Agree DNA casework	Neutral	Disagree both	Disagree DNA database	Disagree DNA casework
	30	15	22	11	15	0	7

video teleconferencing. The two sources of training complement each other and help ensure that the training is successful and laboratory productivity is not compromised. The forensic DNA scientists who did not attend the PCR change agent workshop(s) will receive training from the first generation PCR change agent(s). The training equips these forensic DNA scientists (second generation PCR change agents) to independently validate the techniques under the auspices of expert supervision (first generation PCR change agent(s)) preventing delays in adoption of new laboratory techniques. The second generation PCR change agents will become the change agents for the third generation of PCR change agents who will be responsible for training other forensic DNA scientists. Ultimately, it is expected that the PCR change agent model will accelerate the adoption of new forensic DNA laboratory techniques and eventually reduce the backlog of forensic DNA cases and DNA database samples as well.

References

1. Nelson, M. Making Sense of DNA Backlogs — Myths vs. Reality, 2010. NIJ Special Report. Retrieved from http://www.ncjrs. gov/pdffiles1/nij/230183. pdf 08/01/2010.

2. Pratt TC, Gaffney MJ, Lovrich NP, Johnson CL. This Isn't CSI: Estimating the National Backlog of Forensic DNA Cases and the Barriers Associated With Case Processing. Criminal Justice Policy Review 2006;17(1):32-47.

3. Reaves BA. Census of State and Local Law Enforcement Agencies, 2004. Bureau of Justice Statistics Bulletin 2007. Retrieved from http://bjs. ojp. usdoj. gov/index. cfm?ty=pbdetail&iid=539 08/01/2010.

4. Jeffreys AJ, Wilson V, Thein SL. Hypervariable 'minisatellite' regions in human DNA Nature 1985;314:67-73.

5. Jeffreys AJ, Wilson V, Thein SL. Individual-specific 'fingerprints' of human DNA Nature 1985;316:76-79.

6. Jeffreys AJ, Brookfield JFY, Semeonoff R. Positive identification of an immigration test-case using human DNA fingerprints Nature 1985;317:818-819.

7. Butler, JM. Forensic DNA Typing Biology, Technology, and Genetics of STR Markers. 2nd ed. Oxford: Elsevier Academic Press 2005.

8. Mullis, KB, Faloona, FA. Specific synthesis of DNA in vitro via a polymerase-catalyzed chain reaction. Methods Enzymol 1987;155:335-350.