



GenoSensor Corporation

EduPrimer™ DNA Profiling Kit

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User Manual

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Literature Citation

When describing a procedure for publication using these products, we would appreciate that you refer to them as the EduPrimer™ DNA Profiling Kit.

Trademarks

EduPrimer™ is a trademark of GenoSensor.

Product Overview

The EduPrimer™ DNA Profiling Kit introduces Polymerase Chain Reaction (PCR) techniques to students, or anyone wishing to learn PCR and its uses. It contains all reagents necessary for DNA isolation and PCR. PCR is an extremely important and valuable skill to have in contemporary biological and related sciences. In this particular kit, the experiment generates varying results from person to person, demonstrating the basis for the process of creating DNA profiles that are used to differentiate one person from another. After completing this experiment, one should be able to proficiently perform a PCR and understand the concepts behind it.

Kit Components and Storage Conditions (for a lab of 24 students)

Component	Amount (30 rxn's)	Storage
Solution A	6 mL	Room temp.
Solution B	0.6 mL	Room temp.
Cotton Swabs	28	Room temp.
2X PCR Master Mix	300 µL	-20°C
Positive Control DNA (Heterozygous)	30 µL	-20°C
Negative Control	30 µL	-20°C
DNA ladder	30 µL	-20°C

Shipping and Storage

EduPrimer™ DNA Profiling kits are shipped on blue ice. Components should be stored at temperatures shown in the above table. At proper storage conditions, components are stable for 1 year from the date received. Expiration dates are also noted on product labels.

Safety Warnings and Precautions

This product is intended for research use only. It is not recommended or intended for the diagnosis of disease in humans or animals. Do not use internally or externally in humans or animals. Consider all chemicals as potentially hazardous. Only persons trained in laboratory techniques and familiar with the principles of good laboratory practice should handle these products. Wear suitable protective clothing such as laboratory overalls, safety glasses, and

gloves. Exercise caution to avoid contact with skin or eyes: if contact should occur, wash immediately with water (Material Safety Data Sheet for products is available upon request).

Additional Required Materials

- Thermal Cycler
- Heat Block
- Microcentrifuge
- Vertex
- Micropipettes (p10, p200, p1000)
- Pipette tips
- PCR tubes
- Tube Racks
- Electrophoresis equipment
- Agarose gel and dye (eg. Sybr safe) / DNA Loading dye / Running buffer
- Scissors and tweezers
- UV light

EduPrimer™ DNA Profiling Kit: Protocol

DNA Preparation

Wear gloves and handle solutions carefully

1. Set heat block to ~95°C before beginning.
2. Add 200µL of **Solution A** to a 1.5mL microcentrifuge tube.
3. Collect cheek cells with provided swab. Do not eat or brush teeth one hour prior to collection. Thoroughly roll and swab inside cheek for 15 seconds.
4. Cut swab above tube to a length that will fit and let it fall into the 1.5mL microcentrifuge tube containing 200µl of **Solution A** so that the cap will shut properly.
5. Vortex or shake/invert thoroughly to mix, for at least 10 seconds.
6. Boil sample in the pre-heated 95°C heat block for 5 minutes
7. Spin briefly (~10 seconds) to pool condensation.
8. Remove swab with tweezers. (Tweezers should be rinsed with ethanol between samples to prevent contamination.)
9. Add 20µl **Solution B** to the sample tube. Vortex or invert to mix for at least 10 seconds.
10. Spin sample for 1 minute at 12,000rpm. A cellular pellet should be visible after spinning.
11. Decant supernatant (clear liquid) to a clean 1.5mL tube. The supernatant contains the genomic DNA template for PCR. Be sure not to disturb the cellular pellet at the bottom of the tube while decanting.

12. Use 10 μl of supernatant for standard PCR (see next page).

PCR Reaction Mixture

Wear gloves and handle solutions carefully

1. Well vortex 2X PCR Master Mix for 10 seconds before use.
2. Prepare a PCR tube per student for the test.
3. (optional or based on instructor) Prepare two PCR tubes per group for controls (positive and negative).
4. Add 10 μl from "2x PCR Master Mix" and 10 μl from the previous "genomic DNA template" into a the PCR tube labeled by student own name using a P10 or P20 Pipette (pref. on ice). Total volume is 20 μl as indicated in the table below.

PCR reaction mixture table

2x PCR Master Mix	10 μl
Genomic DNA Template	10 μl
<hr/>	
Volume total	20 μl

5. For positive and negative control tubes, below is the control PCR reaction mixture table.

Control PCR reaction mixture table

Positive control		Negative control	
2x PCR Master Mix	10 μl	2x PCR Master Mix	10 μl
Positive control DNA	10 μl	Negative control	10 μl
<hr/>		<hr/>	
Volume total	20 μl	Volume total	20 μl

Positive and negative controls give guidelines or boundaries to the experimental results.

Negative control show the result if no DNA is present for the PCR.

Positive control shows the result of PCR with purified DNA with a heterozygous genotype. PCR products for the TPA-25 gene are 136 and 436 base pairs in length, for PV-92 180 and 480 base pairs.

DNA ladder is a standard which is used like a ruler to show how DNA of a certain length will migrate through a gel during electrophoresis.

(+)- Each class will prepare 3 positive control reactions and 1 negative control reaction. Use 10 µl of provided positive control DNA (purple-red label) in 10 µl Master Mix (blue label.)

(-)-Substitute 10 µl of DNase free water (black label) for the template in a negative control PCR.

PCR Parameters

Program your thermal cycler as follows:

1. 94°C – 2 minutes
2. 94°C denaturing – 30 seconds}
3. 58°C annealing – 30 seconds} **repeat steps 2, 3, & 4 for 35 cycles**
4. 72°C extension – 30 seconds}
5. 72°C – 5 minutes
6. 4°C – finished / hold

Agarose Gel Electrophoresis

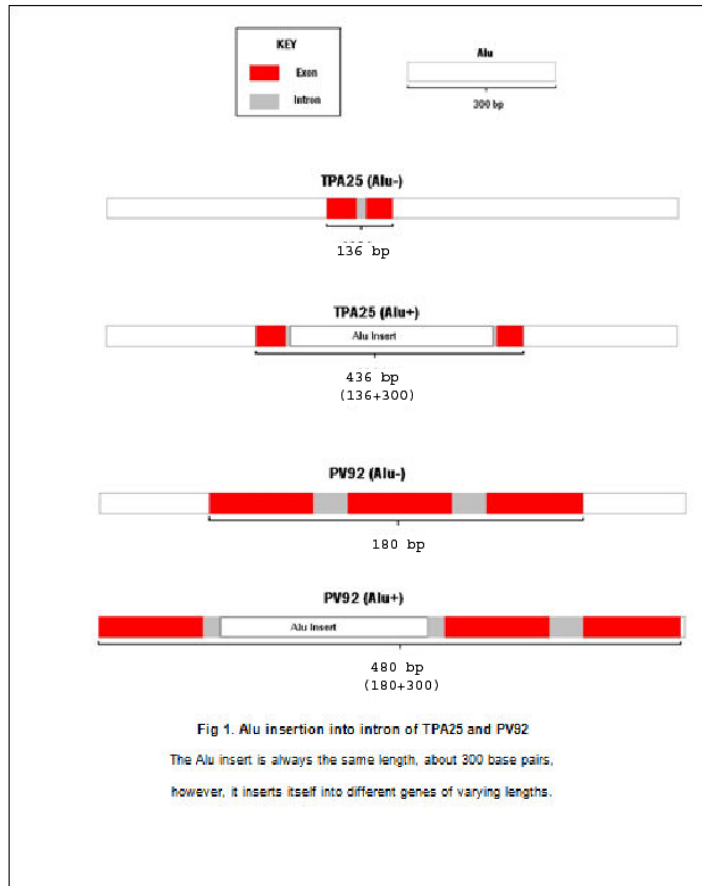
- Pour 1% agarose gel
- Use your preferred staining method
- Use 10 µL of PCR product to visualize on gel
- Run at ~100V for 10-20 minutes and stop before loading dye has run off gel
- Visualize under UV and record the results manually or by photography
- Compare individual experimental bands to positive control DNA.

Results and Discussion

The TPA-25 gene, as well as PV92, is in the Alu family of genes. Genes in this group may contain a 300 base pair sequence that has inserted itself into an unexpressed (intron) portion of

the gene. This does not change the original flanking sequence of the gene so the same primers will allow replication of either or both the longer or shorter version of the gene (see Figure 1.)

ALU Elements



Individuals may have inherited two copies of the gene with no insert and be homozygous. In this case a single band on the gel at 136bp for TPA-25(Alu-), or 180bp for PV92 (Alu-) is expected.

Individuals may have inherited two copies of the gene with the 300bp Alu insert and be homozygous. In this case a single band on the gel at 436bp for TPA-25(Alu+), or 480bp for PV92 (Alu+) is expected.

Individuals may have inherited one copy of the gene with no insert and one copy of the gene with the 300bp Alu insert and be heterozygous. In this case two bands on the gel at 136bp and 436bp for TPA-25(Alu), or 180bp and 480bp for PV92 (Alu) is expected.

EduPrimer™ DNA Profiling Kit: Technical Manual

Introduction to PCR

In 1983, during his time working at Cetus Corporation, Kary Mullis developed a technique that has changed the field of genetics and biological science in general. This revolutionary process was termed “polymerase chain reaction,” or PCR. He earned the Nobel Prize in Chemistry in 1993 due to his innovation. His technique enabled researchers, besides a few expert microbiologists, to amplify DNA. Before that, amplification of DNA was extremely difficult and time consuming. Now, scientists in any field can incorporate molecular biology into their research with PCR.

Currently, PCR is used in a wide variety of areas, for example, gene mapping, DNA sequencing, gene expression, gene detection, forensics, criminal investigation, medical diagnostics, and genome sequencing. Very few of these applications were practically possible before PCR. The experiment does require an initial investment in specially made machinery, but with the proper equipment, nearly anyone can perform a successful PCR experiment without significant cost.

PCR and Biotechnology — Revolutionizes an Entire Research Community

PCR is capable of producing large amounts of targeted DNA from an extremely small amount of starting material, known as your template. DNA can be obtained from any cell such as blood cells, hair cells, cheek cells etc., and after proper treatment to isolate DNA, PCR can be applied to create millions of copies of virtually any desired DNA sequence. That is one of the most significant powers of PCR, specificity. Although you may put an entire genome worth of DNA into a PCR, it amplifies the exact piece of DNA desired and leaves the rest out.

The basic components of PCR:

- Reaction Buffer
- DNA nucleotides (dNTP's) of each adenine, guanine, thymine and cytosine
- DNA polymerase
- 2 DNA oligonucleotide primers
- Template DNA (starting material)

PCR Makes Use of Two Basic Processes in Molecular Genetics

1. Complementary DNA strand hybridization

For DNA to be amplified, one must have a known sequence which flanks the gene of interest upstream and downstream. These sequences are used to create what are known as 'oligonucleotide primers,' meaning a short ~20 base pair nucleotide sequence which is used as a starting point for DNA replication. The primers are said to be complementary to their target regions, so they will anneal (attach) to those regions specifically. Primers are required by DNA polymerase because it cannot add nucleotides without a preexisting chain.

Complementary Strand Hybridization occurs when two different oligonucleotide primers anneal to each of their respective complementary base pair sequences on the template. They are designed specifically to anneal at opposite ends of opposite strands of the specific sequence of DNA that is desired to be amplified.

2. DNA strand synthesis via DNA polymerase

In a PCR, a special type of DNA polymerase is used that is able to withstand the temperature fluctuations required for thermal cycling. Most DNA polymerases cannot tolerate the high temperatures and fluctuations from ~60°C-94°C. The breakthrough in PCR came with the isolation of DNA polymerase from a thermophilic bacterium known as *Thermus aquaticus*. This bacterial species lives in high temperature steam vents and therefore its DNA polymerase evolved to withstand extremely high temperatures.

During PCR, DNA is synthesized and multiplies by 2 each cycle, thus the growth of DNA copy # over the reaction is exponential. In theory, after 30 cycles there will be 2^{30} . This is over a billion copies of DNA. Yielding this amount of DNA allows the possibility of visualization through a variety of means. One of the most popular visualization methods is agarose gel electrophoresis.

Genes and DNA

The human genome contains 23 pairs of chromosomes that contain a total of thirty to fifty thousand genes, most of which generally code for proteins. However, those genes only comprise about 5% of the genome, leaving 95% as so-called non-coding DNA. This noncoding DNA is found not only between, but within genes, splitting them into segments. In eukaryotes, non-coding DNA found within genes is known as **introns**. The sequences that do code for proteins are called **exons**. In eukaryotes, genomic DNA is transcribed into RNA molecules containing both introns and exons for a particular gene. While the RNA is still in the nucleus (before being transported out of the nucleus), the introns (in = stay within the nucleus) must be removed from the RNA while the exons (ex = exit the nucleus) are spliced together to form the complete coding sequence which will soon be translated into the protein. This process

is called RNA splicing. Some genes may contain a few introns, others may contain dozens. Interestingly, it is the non-coding 'junk' DNA that is useful to us when considering a DNA profile of an individual, instead of the DNA that actually codes for life.

As discussed, functional segments of genes (exons) code for proteins. Proteins are molecules that carry out most cellular functions. Exon sequences are therefore very similar among individuals, because even slight difference can change the function of the protein in a potentially harmful way (many diseases are caused by mutated proteins). Introns, however, often vary in size and number among individuals. Intron sequences are thought to be the result of the differential accumulation of mutations throughout evolution that are silently passed to descendants through the hereditary code. It is this difference in intron sequences that allows us to determine human genetic diversity. The identification of these distinctive characteristics in DNA represents the molecular basis for human identification and population genetics. Throughout evolution, intron sequences have been the target of random insertions by short repetitive interspersed elements, also known as SINEs. SINEs have become randomly inserted within our introns over millions of years.

One such repetitive element is called the **Alu element** (Figure 1). The Alu element is a DNA sequence about 300 base pairs long that is repeated; one copy at a time, almost 500,000 times within the human genome. The origin and function of such randomly repeated sequences is not yet known. The Alu name comes from the Alu I restriction enzyme (enzymes that cut DNA at specific sequences) recognition site that is found in this sequence. The following section reviews the Alu element in more detail.

PCR Stages

The machinery required to perform PCR is known as a thermal cycler. The thermal cycler enables the steps of PCR to be automated. The reaction involves a repetitive series of cycles, each of which consists of template denaturation, primer annealing, and extension of the annealed primer by Taq DNA polymerase. Before beginning DNA amplification, genomic DNA is prepared from students' cells. The students' DNA is then added to a mixture of the necessary reagents: oligonucleotide primers, thermostable DNA polymerase (Taq), the four deoxynucleotides (A, T, G, C), and reaction buffer. These reagents are pre-mixed as a 2X PCR Master Mix in the EduPrimer™ DNA profiling kit. The tubes are placed into the thermal cycler. These thermal cyclers contain an aluminum block that holds the samples and can be rapidly heated and cooled across extreme temperature differences. The rapid heating and cooling of this thermal block is called temperature cycling or thermal cycling.

The first step of the PCR temperature cycling procedure involves heating the sample to 94°C. At this high temperature, the template strands separate. This is called the denaturation step.

The thermal cycler then rapidly cools to 60°C to allow the primers to anneal to the separated template strands. This is called the annealing step. The two original template strands

may reanneal to each other or compete with the primers for the primers complementary binding sites. However, the primers are added in excess such that the primers actually out-compete the original DNA strands for the primers' complementary binding sites.

Lastly, the thermal cycler heats the sample to 72°C for Taq DNA polymerase to extend the primers and make complete copies of each template DNA strand. This is called the extension step. Taq polymerase works most efficiently at this temperature. Two new copies of each complementary strand are created. There are now two sets of double-stranded DNA (dsDNA). These two sets of dsDNA can now be used for another cycle and subsequent strand synthesis. At this stage, a complete temperature cycle (thermal cycle) has been completed.

Each step takes about 30 seconds to 1 minute, and this process continues for roughly 30-40 cycles depending on how the user has programmed the thermal cycler. Each step is repeated in that order each cycle until it is completed. At the end, the product is put on hold at a low temperature, generally 4°C, until the user is ready to proceed to the analysis of the product.

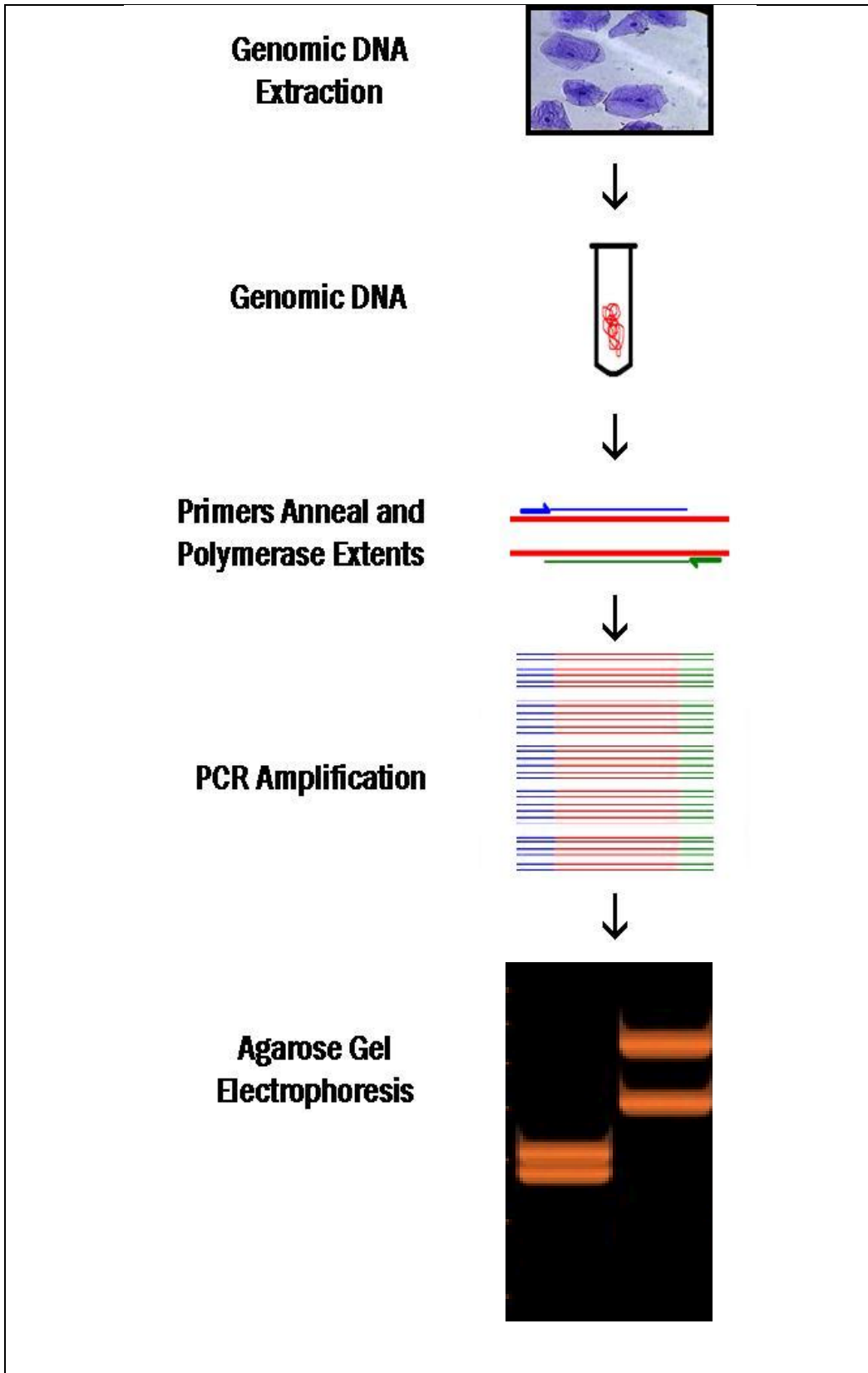


Figure 3. Experiment flowchart from start to finish

Troubleshooting

Symptom	Possible causes	Solutions
No amplification product	Questionable template quality	Analyze starting material
	Inhibitory Substance in reaction	Decrease sample volume
	Insufficient cycle #	Run additional cycles
	Incorrect thermal cycler program	Verify times and temperatures
	Errors in block temperature	Calibrate heating block
	Contaminated tubes/solutions	Autoclave tubes and use filter tips
	Primer annealing temperature too high	Lower annealing temperature in 2° increments
Non-specific amplification product	Premature Taq-polymerase replication	Mix solutions on ice, place rxn directly to 94° thermal cycler
	Primer annealing temperature too low	Raise annealing temperature in 2° increments
	Insufficient mixing of reaction solution	Mix solutions thoroughly before beginning the reaction
	Exogenous DNA contamination	-Wear gloves -Use dedicated area for sample preparation -Use non-aerosol tips

Technical Service

For more information or technical assistance, please call, write, fax, or email.

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