



GenoSensor Corporation

EduPrimer™ VNTR DNA Profiling Kit

Catalog # 3003

Version B
June 2015

User Manual

EduPrimer™ VNTR DNA Profiling Kit Manual

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Literature Citation

When describing a procedure for publication using these products, please refer to them as the EduPrimer™ VNTR DNA Profiling Kit.

Trademarks

EduPrimer™ is a trademark of GenoSensor.

Notes for Instructors

Kit Components and Storage Conditions:

Component	Storage
Solution A	Room temp.
Solution B	Room temp.
Cotton Swabs	Room temp.
2X PCR Master Mix	-20°C
Positive Control DNA	-20°C
Negative Control (DNase- RNase-free H ₂ O)	-20°C
DNA ladder	-20°C

Preparation for DNA isolation and PCR for up to 24 students

Set heat block or water bath to 90°C

Instruct the students in cheek cell collection step to make sure proper technique and timing is used to ensure sufficient collection for DNA isolation.

Thaw 2X PCR Master Mix on ice. Before opening tube, spin 10 sec at 6,000 rpm or greater in a microcentrifuge. Vortex 10 seconds, then spin again for 10 seconds.

Aliquot the 2X PCR Master Mix as necessary *after* doing the above preparation.

Each package contains enough 2X PCR Master Mix for 30 reactions. Use 10 ul of 2X PCR Master Mix with 10 ul isolated DNA for a final PCR volume of 20 ul.

Include materials for 3 positive and 3 negative controls (10 ul from Control tube + 10 ul 2X PCR Master Mix for one reaction).

Electrophoresis

Electrophoresis reagents are not provided in the kit. Please refer to the required materials list.

Best results are obtained by adding DNA dye (i.e., Gel Red, Sybr Safe) to molten agarose.

Avoid exposing the agarose gel to light, if possible perform gel polymerization and electrophoresis in the dark.

DNA ladder supplied is enough for 3 lanes with 10 uL each.

Positive control supplied is enough for 6 lanes with 10 uL each after PCR.

Negative control supplied is enough for 6 lanes with 10 uL each after PCR.

After PCR, load up to 20 ul of student PCR reaction into a lane.

Shipping, Storage and Safety

Shipping and Storage

EduPrimer™ VNTR 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 (Safety Data Sheets for products are available upon request).

Suggestions for Teachers

This kit is technical in nature and an excellent tool for teaching techniques, and has real links to DNA Forensics. Students will enjoy extracting their own DNA and seeing their individual band separation. Should you want to, there are other ways to spice things up even more. Here are a few possible suggestions:

Smooth Criminal

1. Secretly pick two students to be the criminal. This can be done by collecting all of the student supernatant DNA samples after students are done with them and selecting two of the tubes from the whole class. Make note of which student's samples you selected. Alternatively, collect swabs from the "criminal" students' cheek cells ahead of the class period and have them prepared alongside the rest of the class.
2. Run the "criminal" samples through the PCR process alongside the rest of the class.
3. Run the criminal samples on the same gel (or gels) as the rest of the class for easy comparison. Each PCR reaction can be split into two gels, with a 20 µl PCR product split in half into two gels.
4. Have the students compare bands and identify the "criminals."

EduPrimer™ VNTR DNA Profiling Kit Overview

The EduPrimer™ VNTR 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 important and valuable skill to have in contemporary biological and related sciences. In this 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, students will be able to proficiently perform 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	30 µL	-20°C
Negative Control	30 µL	-20°C
DNA ladder	30 µL	-20°C

Additional Required Materials

- Thermal Cycler
- Heat Block or (heat plate, Beaker with de-ionized water; water bath, Tube floater; Thermometer)
- Microcentrifuge
- Microcentrifuge tubes
- Vortexer (optional)
- Micropipettes (p10, p100)
- Pipette tips
- PCR tubes (1/reaction)
- Tube Racks
- Ethanol or ethanol wipes
- Electrophoresis equipment
- Electrophoresis supplies: agarose, TBE buffer, , gel dye (eg., Sybr safe, Gel Red)
- Scissors and tweezers
- UV light box or “Gel Doc” equipment and program
- Permanent marker

Introduction: Theory and Background

We are very different from each other on many levels, but not as much as you might think on the genetic level. In fact, a large portion of the genetic makeup from one person to the next may differ by as little as 0.1%! Our genome consists of over 3 billion base pairs, and that 0.1% still makes a big difference. The differences between genomes underlies the theory behind DNA profiling. There are a number of specific regions on our genomes that reliably vary between individuals. For this experiment, the focus will be on a "Variable Number Tandem Repeat (VNTR)" region. Throughout the genome there are segments that feature small repeating sequences of DNA. A repeated sequence is generally the same between individuals, but the number of times it repeats can vary. Analyze enough of the VNTR segments, and a genetic "fingerprint" for an individual can be generated.

In the EduPrimer VNTR DNA Profiling kit, we focus on the Penta E "microsatellite" region, a VNTR region with a repeating sequence 2-5 base pairs long, which features a sequence of "AAAGA" that can repeat anywhere from 5 to 26 times. This means that when a region flanking and including this repeating sequence is amplified by PCR using our primers the region will be between 246 – 351 base pairs long. Each individual will have two bands on the final gel, one inherited from each of their parents, apart from individuals who might have identical repeating numbered sequences from both parents.

For a single VNTR site there can be a wide degree of variation and it is unlikely that any two non-related persons will share the same band pattern. In a real forensic analysis using DNA profiling or fingerprinting, many variable regions are used to accurately distinguish one individual.

EduPrimer™ VNTR DNA Profiling Kit: Protocol

Preparation

1. Set heat block or water bath to 90 °C. For a heat block, it is recommended to add water or sand to ensure proper heat transfer. For a water bath, be sure tubes are tightly sealed and not fully submerged to avoid contamination.
2. Thaw 2X PCR Master Mix on ice. Before opening tube, spin 10 sec at 6,000 rpm or greater in a microcentrifuge. Vortex 10 seconds, then spin again for 10 seconds.

DNA Preparation

****Do not eat or brush teeth one hour prior to cheek cell collection. Wear gloves and handle solutions carefully****

1. Add 200µl of **Solution A** (red label) to a marked microcentrifuge tube.
2. To collect cheek cells, **thoroughly** roll provided cotton swab inside cheek for at least **10 seconds**.
3. Place swab into marked tube with Solution A.
4. Cut swab stem so it will fit inside the tube. Make certain the cap will shut tightly.
5. Vortex for at least 10 seconds. *Solution A contains components which chemically disrupt cell membranes and begin to unravel proteins. Under these conditions, the cheek cells will begin to lyse or break open, spilling cell contents into the solution in the tube.*
6. Place sample in heat block to incubate at 90 °C for 5 minutes. Immediately place tube in ice until ready for next step. *This process continues to destroy proteins, particularly, those that damage DNA.*
7. Load sample into a mini or microcentrifuge taking care that there is another sample directly across from your sample to keep the centrifuge in balance as it spins. Close internal and external centrifuge lids.
8. Spin briefly (~10 seconds) to pool condensation that has collected on the cap.
9. Remove and dispose of swab using forceps (rinse forceps between each sample to prevent contamination).
10. Add 20 µl **Solution B** (green label) to the sample tube. *Solution B neutralizes the harsh conditions needed for lysis, preparing the solution for DNA isolation and PCR to follow.*
11. Close the tube lid tightly and vortex to mix for at least 10 seconds.
12. Load sample into microcentrifuge with the tube hinge pointing out, balancing out your sample tube, and closing the lids.
13. Spin sample for 1 minute at 12,000 rpm.
14. Look for a small clear round pellet near the bottom of the tube under the hinge. The pellet contains cellular debris. The aqueous solution (supernatant) that has not precipitated into the pellet contains cellular DNA.

PCR Reaction

****Wear gloves and handle solutions carefully****

1. Program the thermocycler as indicated below.
2. Prepare and label the top and side of a small PCR tube with your name

3. Ensure that the "2X PCR Master Mix" is on ice and has been spun at 6,000 RPM or greater in a microcentrifuge for 10 seconds, vortexed for 10 seconds, then spun again for 10 seconds before opening the Master Mix tube.
4. Label and prepare PCR tubes for controls (as directed by instructor) following the table below
5. Add 10 μ l of "2X PCR Master Mix" and 10 μ l of supernatant from step 14 above (avoid the pellet) to the labeled PCR tube for a total of 20 μ l as indicated in the table below. *The supernatant contains your genomic DNA for polymerase chain reaction (PCR).* (Note: It is preferred that the PCR reaction mix preparation is done on ice).
6. Mix the 20 μ l PCR reaction mixture by pipetting in and out with the pipette, and then close the lid tightly.
7. Store the sample on ice until it is ready to be loaded into the thermal cycler.

PCR reaction mixture tables

Student Sample PCR Mixture	
2x PCR Master Mix	10 μ l
Genomic Template (Supernatant)	10 μ l
Volume total	20 μ l

Control Samples PCR Mixture			
Positive Control		Negative control	
2x PCR Master Mix	10 μ l	2x PCR Master Mix	10 μ l
Positive control DNA	10 μ l	Negative Control	10 μ l
Volume total	20 μ l	Volume total	20 μ l

The positive control will have widely spaced bands near the upper and lower limits of this VNTR region. The negative control does not contain DNA.

PCR Parameters

Program your thermal cycler as follows:

1. 94°C – 2 minutes
2. 94°C denaturing – 20 seconds}
3. 65°C annealing – 20 seconds} **repeat steps 2, 3, & 4 for 40 cycles**
4. 68°C extension – 30 seconds}
5. 68°C – 5 minutes
6. 4°C – finished / hold

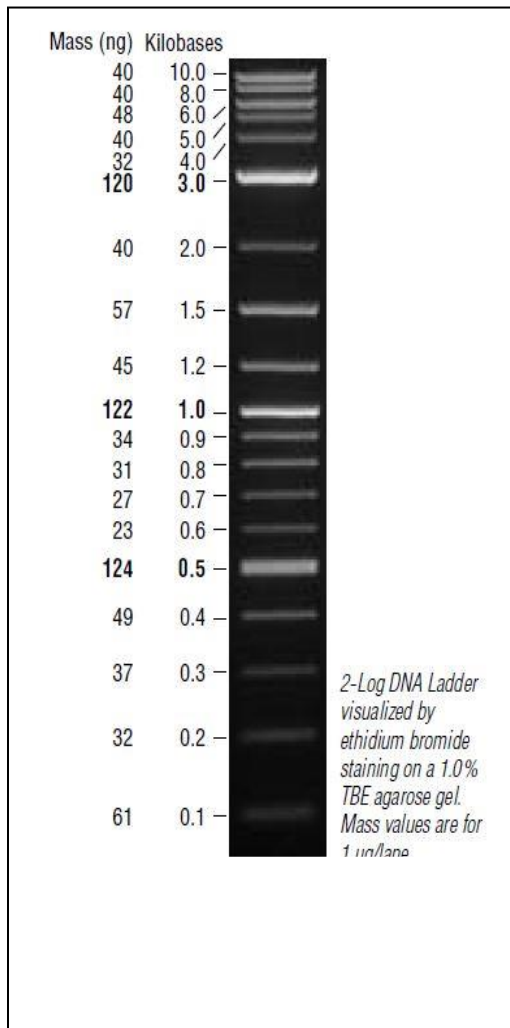
Agarose Gel Electrophoresis

General Procedure, detailed directions as given by instructor

- Prepare 2 – 2.5% agarose.
- Set up electrophoresis apparatus and pour the 2 – 2.5% % molten agarose for gelation.
- For staining, use a DNA dye which is added directly to the molten agarose. For light sensitive dyes, keep the gel in the dark during gelation, either by performing in a dark room or placing a box over the gel.
- Use at least 10 µL of PCR product to visualize results by electrophoresis on agarose gel. If gel well volume will accommodate more than 10 ul, a higher volume is preferred. Loading dye was added to the mastermix to ensure that the sample will sink to the bottom of the well and properly enter the agarose gel.
- Run at ~100V for ~20 minutes and stop before loading dye has run off gel. Depending on the DNA dye used, caution may need to be taken to reduce exposure of gel to light.
- Visualize under UV and record the results manually or by photography
- Compare individual experimental bands to positive control DNA. There are different DNA sizes and most of them are between 240 – 360 bp. Positive control is 87 bp (monitoring PCR performance).

Example of Gel Setup and Loading: Run 3 gels with 12 wells each to accommodate 24 students and 6 control reactions.

Lane 1:	10 µl DNA Ladder
Lane 2:	10 µl Negative Control
Lane 3:	10 µl Positive Control
Lanes 4 -12	Up to 20 µl of each student sample



Results and Discussion

Observe and record your results. Include a diagrammed picture/photo of your bands.

Compare band pattern with the other students' band patterns. Describe the similarities and differences.

Summarize the process of PCR using correct terminology.

Describe a new experiment you could perform using PCR and DNA gel electrophoresis.

EduPrimer™ DNA Profiling Kit: Background

Introduction to PCR

In 1983, during his time working at Cetus Corporation, Kary Mullis developed a technique that significantly changed the field of genetics and all other biological sciences.. This revolutionary process was termed “polymerase chain reaction,” or PCR, and he earned the Nobel Prize in Chemistry in 1993 due to his innovation. His technique enabled all researchers not just 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 including: 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 process does require an initial investment in specialized machinery, but with the proper equipment, nearly anyone can perform a successful PCR without significant cost.

PCR and Biotechnology — Revolutionizes an Entire Research Community

PCR is capable of producing large quantities of targeted DNA from a very small amount of starting material, known as the template. DNA can be obtained from nearly any cell i.e., blood cells, hair cells, cheek cells, etc., and after proper treatment to isolate the DNA, PCR can be applied to create millions of copies of nearly any desired DNA sequence. The power of PCR is its specificity; using primers to target a known sequence, it will amplify only that segment of DNA even though the entire genome was placed in the reaction tube.

The basic components of PCR:

- Reaction Buffer
- DNA nucleotides (dNTP's) of each adenine, guanine, thymine and cytosine
- DNA polymerase
- Forward and reverse 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 ‘oligonucleotide primers,’ meaning a short ~20 base pair nucleotide sequence which is used as a starting point for DNA replication. The primers are complementary to their target regions so they will anneal

(attach) to those regions specifically. Primers are required because DNA polymerase 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 high temperatures.

During PCR, DNA is synthesized and doubles each cycle, thus the growth of DNA copy # over the reaction is exponential. In theory, after 30 cycles there will be 2^{30} copies ; over a billion copies of DNA. Yielding this much DNA allows the for 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 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 sequences found within genes are 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 the 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 a 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 genetic 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 (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.

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 added to a mixture of reagents: oligonucleotide primers, thermo-stable DNA polymerase (Taq), the four nucleotides (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 contains 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 heats the sample to 94°C causing the template strands separate. This is called the **denaturation** step.

The thermal cycler then rapidly cools to 60°C allowing the primers to anneal to the separated template strands. This is called the **annealing** step. The two original template strands may re-anneal 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 complementary DNA strands of the target sequence. This is called the **extension** step. The two new sets of double-stranded DNA (dsDNA) will be used for another cycle and subsequent strand synthesis. At this stage, a complete temperature cycle (thermal cycle) has been completed.

Each step takes 30 seconds to 1 minute, and will repeat for 30-40 cycles depending on how the user has programmed the thermal cycler. At the end of the cycles, the product is put on hold at 4°C until the user is ready to proceed to the analysis of the product.

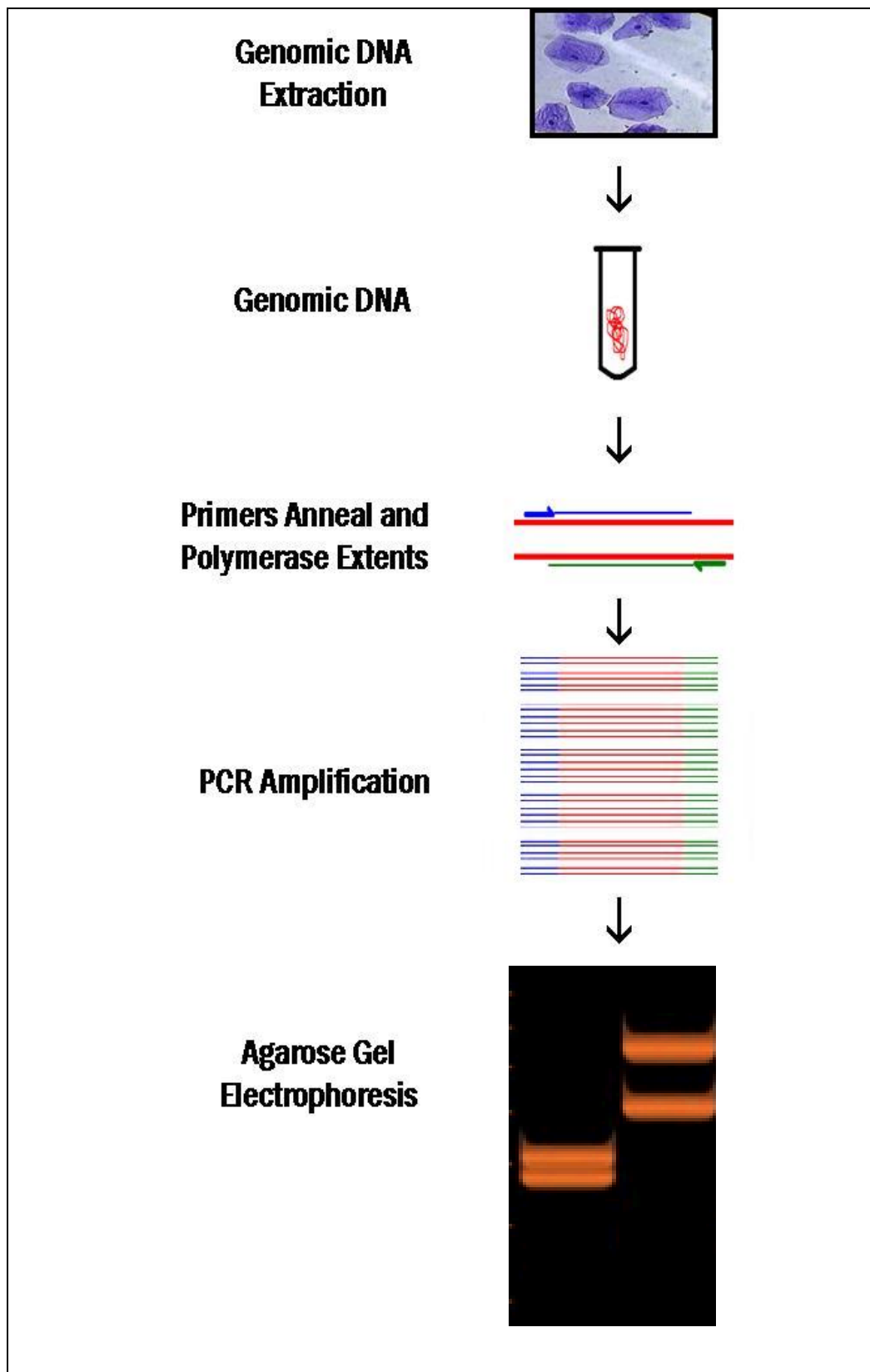


Figure 3. Experiment flowchart from start to finish

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 heat block incubation	Calibrate heating block, use sand or water to maximize contact with tube for proper heat transfer
	Contaminated tubes/solutions	Autoclave tubes and use filter tips
	Primer annealing temperature too high	Lower annealing temperature in 2°C increments
Weak bands/faint signal	Low concentration of DNA template	Increase swabbing time, thoroughly swab.
	DNA Dye degradation during preparation	Light sensitive dyes should be kept in the dark during gel preparation. Prepare in dark room or place a box over the electrophoresis apparatus during gelation and electrophoresis.
	Expired, contaminated or degraded DNA dye	Verify that the DNA dye has not degraded in storage, been contaminated or expired.
Non-specific amplification product	Premature Taq polymerase replication	Mix solutions on ice, place rxn directly into 94° thermal cycler
	Primer annealing temperature too low	Raise annealing temperature in 2°C 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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