ASHG Staff

Human Identification Using Short Tandem Repeats (STRs)

Adapted from “Short Tandem Repeats...and Murder!,” available at www.ashg.org/LessonPlans.

1) Set up table tents with sample numbers 1-15 around the room with enough space for 2-3 students to group around each number. As students enter, sort them into 15 groups of 2-3 and direct them to a table tent.
2) Introduce students to DNA identification using slides 2-6. Make sure to note that each person has two copies or alleles for each locus/marker. 5 min
    a. Before showing the video embedded in slide 4, ask “How many of you have heard of PCR before?”. Emphasize that the point of PCR is to copy a portion of DNA that is of interest many times over so it can be analyzed.
    b. Provide each group with the corresponding FGA locus packet (numbered sample sheet for FGA locus [Appendix I], 2 forward FGS primer strips [Appendix II], 2 reverse FGS primer strips [Appendix II], and tape) while the video is playing.
    c. Ask students to look at their FGA sample sheet. Use slide 6 to explain how DNA sequence is represented on their sample sheet.
3) Have students simulate PCR in their groups by aligning and taping down the primers to the primer binding sequences in the alleles. Students should then count and record the number of repeats. Use the following guided inquiry questions with each group as necessary. See Appendix III for the sample key. 15 min

    Totally stuck: Try to find one end of where the primer binds first instead of the whole thing. If you’re trying to find where [6 nts] binds, what sequence do you need to look for? [prompt to write out complement]

    Has aligned primers to exact rather than complementary sequence: Can G and G base pair with each other? [continue down sequence until student realizes something is wrong] What do these nucleotides pair with? [prompt to write out complement if necessary] Where do you think that sequence is? Is it on this strand? What about the other strand?

    Primers are correctly aligned, having trouble with repeat: Can you visually see sequence that looks repetitive? Ok, follow that to its beginning. What is the repeat unit? How big is it? Remember, you’re looking for the smallest possible unit. Hash marks can help you count the number of repeats.

4) When most groups have finished, use slide 7 to review the simulation PCR. Use slide 8 to discuss what real DNA profiles include. 5 min

Appendix I - FGA Sample Sheets

Sample # 1

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:_________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Allele 2 Number of repeats:_________

5’-...cctgtaagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttcttt

3’-...ggacattcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 2

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagaccca...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggt...-5’

Allele 2 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Sample # 3

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Allele 2 Number of repeats:__________

5’-...cctgtaagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttcttt

3’-...ggacattcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 4

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Allele 2 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Sample # 5

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...tagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttcttt

3’-...atcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Allele 2 Number of repeats:__________

5’-...taagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttcttt

3’-...attcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 6

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...tagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttcttt

3’-...atcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Allele 2 Number of repeats:__________

5’-...gccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttctttct

3’-...cggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaaga

ttctttctttctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaa...-3’

aagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagctt...-5’

Sample # 7

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...ccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctt

3’-...ggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaa

tctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaag...-3’

agaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattc...-5’

Allele 2 Number of repeats:__________

5’-...taagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttcttt

3’-...attcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 8

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:_________

5’-...tagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttcttt

3’-...atcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Allele 2 Number of repeats:_________

5’-...gccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttctttct

3’-...cggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaaga

ttctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaa...-3’

aagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcatt...-5’

Sample # 9

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:_________

5’-...gccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttctttctttct

3’-...cggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaaga

ttctttctttctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcac...-3’

aagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtg...-5’

Allele 2 Number of repeats:_________

5’-...ccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttctt

3’-...ggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaa

tctttctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaag...-3’

agaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattc...-5’

Sample # 10

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:_________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Allele 2 Number of repeats:_________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Sample # 11

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagaccca...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggt...-5’

Allele 2 Number of repeats:__________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Sample # 12

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...tagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttcttt

3’-...atcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaaga...-3’

gaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattct...-5’

Allele 2 Number of repeats:__________

5’-...taagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttcttt

3’-...attcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 13

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:_________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Allele 2 Number of repeats:_________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 14

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:__________

5’-...gccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttctttctttctttct

3’-...cggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaaga

ttctttctttctttctttctttctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaatt...-3’

aagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaa...-5’

Allele 2 Number of repeats:__________

5’-...cctgtaagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttcttt

3’-...ggacattcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Sample # 15

STR Region: FGA (Chromosome 4q28)

Allele 1 Number of repeats:_________

5’-...ctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttctttctttcttt

3’-...gacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Allele 2 Number of repeats:_________

5’-...cctgtaagctgccagatagccccataggttttgaactcactttctttctttctttctttctttctttctttctttcttt

3’-...ggacattcgacggtctatcggggtatccaaaacttgagtgaaagaaagaaagaaagaaagaaagaaagaaagaaagaaa

ctttctttctttctttctttctttctttctttgctggcaattacagacaaatcaattcgaatcacgtaagacccaattt...-3’

gaaagaaagaaagaaagaaagaaagaaagaaacgaccgttaatgtctgtttagttaagcttagtgcattctgggttaaa...-5’

Appendix II - FGA Primers (Print on colored paper and cut on the grey lines into individual strips.)

FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer
FGA F Primer: 5'-GCCCCATAGGTTTTGAACTCA-3'	3'-CGACCGTTAATGTCTGTTTAGT-5':FGA R Primer

Appendix III—Sample Key

Marker Alleles
(# of Repeats)

Sample	FGA	
#1	18	20
#2	21	22
#3	18	20
#4	22	22
#5	19	24
#6	24	27
#7	19	23
#8	24	25
#9	23	26
#10	22	22
#11	21	22
#12	19	24
#13	20	20
#14	18	28
#15	18	20