How Much Variation?
Beta Globin Gene—Person A

This page contains the DNA base sequence for *part* of a gene called *beta globin*. Hemoglobin, the oxygen carrier in blood, is composed of four polypeptide chains, two alpha polypeptide chains, and two beta polypeptide chains. The *beta globin* gene encodes the amino acid sequence for the beta chain. The complete gene is about 1,700 DNA bases long.

Read the sequence from left to right across the page.

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ATG GTG GAC CTG ACT CCT GAG GAG AAG TCT GCC GTT ACT GCC CTG TGG GGC AAG GTG
AAC GTG GAT GAA GGT GGT GTT GAG GCC CTG GGC AGGTTGGTATCAAGGTTACAAGACAGGTTTAAG
GAGACCAATAGAAACTGGGCATGTGGAGACAGAGAAGACTCTTGGGTTTCTGATAGGCACTGACTCTCTCTGCCTATT
GGTCTATTTTCCCACCCTTAG G CTG CTG GTG GTC TAC CCT TGG ACC CAG AGG TTC TTT GAG
TCC TTT GGG GAT CTG TCC ACT CCT GAT GCT GTT ATG GGC AAC CCT AAG GTG AAG GCT
CAT GGC AAG AAA GTG CTC GGT GCC TTT AGT GAT GGC CTG GCT CAC CTG GAC AAC CTC
AAG GGC ACC TTT GCC ACA CTG AGT GAG CTG CAC TGT GAC AAG CTG CAC GTG GAT CCT
GAG AAC TTC AGG GTGAGTCTATGGGACGCTTGATGTTTTCTTTCCCCTTCTTTTCTATGGTTAAGTTCATGTC
ATAGGAAGGGGAGAAGTAACAGGGTACAGTTTAGAATGGGAAACAGACGAATGATTGCATCAGTGTGGAAGTCTCA
GGATCGTTTTAGTTTCTTTTATTTGCTGTTCATAACAATTGTTTTCTTTTGTTTAATTCTTGCTTTCTTTTTTTTTCT
TCTCCGCAATTTTTACTATTATACTTAATGCCTTAACATTGTGTATAACAAAAGGAAATATCTCTGAGATACATTAAG
TAACTTAAAAAAAAACTTTACACAGTCTGCCTAGTACATTACTATTTGGAATATATGTGTGCTTATTTGCATATTCAT
AATCTCCCTACTTTATTTTCTTTTATTTTTAATTGATACATAATCATTATACATATTTATGGGTTAAAGTGTAATGTT
TTAATATGTGTACACATATTGACCAAATCAGGGTAATTTTGCATTTGTAATTTTAAAAAATGCTTTCTTCTTTTAATA
TACTTTTTTGTTTATCTTATTTCTAATACTTTCCCTAATCTCTTTCTTTCAGGGCAATAATGATACAATGTATCATGC
CTCTTTGCACCATTCTAAAGAATAACAGTGATAATTTCTGGGTTAAGGCAATAGCAATATTTCTGCATATAAATATTT
CTGCATATAAATTGTAACTGATGTAAGAGGTTTCATATTGCTAATAGCAGCTACAATCCAGCTACCATTCTGCTTTTA
TTTTATGGTTGGGATAAGGCTGGATTATTCTGAGTCCAAGCTAGGCCCTTTTGCTAATCATGTTCATACCTCTTATCT
TCCTCCCACAG CTC CTG GGC AAC GTG CTG GTC TGT GTG CTG GCC CAT CAC TTT GGC AAA
GAA TTC ATC CCA CCA GTG CAG GCT GCC TAT CAG AAA GTG GTG GCT GGT GTG GCT AAT
GCC CTG GCC CAC AAG TAT CAC TAA GCTCGCTTTCTTGCTGTCCAATTTCTATTAAAGGTTCCTTTGTT
CCCTAAGTCCAACTACTAAACTGGGGGATATTATGAAGGGCCTTGAGCATCTGGATTCTGCCTAATAAAAAACATTTA
TTTTCATTGCAATGATGTATTTAAATTATTTCTGAATATTTTACTAAAAAGGGAATGTGGGAGGTCAGTGCATTTAAA
ACATAAAGAAATGATGAGCTGTTCAAACCTTGGGAAAATACACTATATCTTAAACTCCATGAAGAA
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How Much Variation?
Beta Globin Gene—Person B

This page contains the DNA base sequence for *part* of a gene called *beta globin*. Hemoglobin, the oxygen carrier in blood, is composed of four polypeptide chains, two alpha polypeptide chains, and two beta polypeptide chains. The *beta globin* gene encodes the amino acid sequence for the beta chain. The complete gene is about 1,700 DNA bases long.

Read the sequence from left to right across the page.

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ATG GTG GAC CTG ACT CCT GTG GAG AAG TCT GCC GTT ACT GCC CTG TGG GGC AAG GTG
AAC GTG GAT GAA GGT GGT GTT GAG GCC CTG GGC AGGTTGGTATCAAGGTTACAAGACAGGTTTAAG
GAGACCAATAGAAACTGGGCATGTGGAGACAGAGAAGACTCTTGGGTTTCTGATAGGCACTGACTCTCTCTGCCTATT
GGTCTATTTTCCCACCCTTAG G CTG CTG GTG GTC TAC CCT TGG ACC CAG AGG TTC TTT GAG
TCC TTT GGG GAT CTG TCC ACT CCT GAT GCT GTT ATG GGC AAC CCT AAG GTG AAG GCT
CAT GGC AAG AAA GTG CTC GGT GCC TTT AGT GAT GGC CTG GCT CAC CTG GAC AAC CTC
AAG GGC ACC TTT GCC ACA CTG AGT GAG CTG CAC TGT GAC AAG CTG CAC GTG GAT CCT
GAG AAC TTC AGG GTGAGTCTATGGGACCCTTGATGTTTTCTTTCCCCTTCTTTTCTATGGTTAAGTTCATGTC
ATAGGAAGGGGAGAAGTAACAGGGTACAGTTTAGAATGGGAAACAGACGAATGATTGCATCAGTGTGGAAGTCTCA
GGATCGTTTTAGTTTCTTTTATTTGCTGTTCATAACAATTGTTTTCTTTTGTTTAATTCTTGCTTTCTTTTTTTTCT
TCTCCGCAATTTTTACTATTATACTTAATGCCTTAACATTGTGTATAACAAAAGGAAATATCTCTGAGATACATTAAG
TAACTTAAAAAAAAACTTTACACAGTCTGCCTAGTACATTACTATTTGGAATATATGTGTGCTTATTTGCATATTCAT
AATCTCCCTACTTTATTTTCTTTTATTTTTAATTGATACATAATCATTATACATATTTATGGGTTAAAGTGTAATGTT
TTAATATGTGTACACATATTGACCAAATCAGGGTAATTTTGCATTTGTAATTTTAAAAAATGCTTTCTTCTTTTAATA
TACTTTTTTGTTTATCTTATTTCTAATACTTTCCCTAATCTCTTTCTTTCAGGGCAATAATGATACAATGTATCATGC
CTCTTTGCACCATTCTAAAGAATAACAGTGATAATTTCTGGGTTAAGGCAATAGCAATATTTCTGCATATAAATATTT
CTGCATATAAATTGTAACTGATGTAAGAGGTTTCATATTGCTAATAGCAGCTACAATCCAGCTACCATTCTGCTTTTA
TTTTATGGTTGGGATAAGGCTGGATTATTCTGAGTCCAAGCTAGGCCCTTTTGCTAATCATGTTCATACCTCTTATCT
TCCTCCCACAG CTC CTG GGC AAC GTG CTG GTC TGT GTG CTG GCC CAT CAC TTT GGC AAA
GAA TTC ATC CCA CCA GTG CAG GCT GCC TAT CAG AAA GTG GTG GCT GGT GTG GCT AAT
GCC CTG GCC CAC AAG TAT CAC TAA GCTCGCTTTCTTGCTGTCCAATTTCTATTAAAGGTTCCTTTGTT
CCCTAAGTCCAACTACTAAACTGGGGGATATTATGAAGGGCCTTGAGCATCTGGATTCTGCCTAATAAAAAACATTTA
TTTTCATTGCAATGATGTATTTAAATTATTTCTGAATATTTTACTAAAAAGGGAATGTGGGAGGTCAGTGCATTTAAA
ACATAAAGAAATGATGAGCTGTTCAAACCTTGGGAAAATACACTATATCTTAAACTCCATGAAAGAA
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How Much Variation?
Doing the Math

Calculate the amount of variation in the DNA in the *beta globin* gene between person A and person B. If you need help, use the example below as a guide.

1. How many bases are different between the sequence shown for person A and the sequence shown for person B? _____

   How many total bases are in the sequence? _____ (Your teacher will give you this number.)

   Divide the number of different bases by the total number of bases in the sequence.

   $$\frac{\text{number of different bases}}{\text{total number of bases}} = \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$$

2. The percentage difference is _____ × 100 = _____ %.

3. The human genome has about 3 billion bases. Assume that the degree of difference you just calculated applies across the entire genome. How many total base differences would you expect to find between person A and person B?

   3,000,000,000 × _____ = _____ total differences

   or, in scientific notation, $3 \times 10^9 \times$ _____ = _____

Example

The sophomore class at Roosevelt High School in Metropolitan City is one of five high schools that conduct two community service projects each year, one in the fall and one in the spring. This fall, 150 students from Roosevelt High signed up to help. The same number signed up in the spring, but 30 of the students were different. What percentage of the students was different between the fall group and the spring group?

1. To calculate the percentage difference, first divide the number of different students in the spring by the total number of students in the group:

   $$\frac{\text{number of different students}}{\text{total number of students}} = \frac{30}{150} = .2$$

2. Convert this result to a percentage by multiplying by 100: .2 × 100 = 20%

3. The sophomore classes at all five high schools combined include about 3,000 students. Assume that the degree of difference between the students who signed up for the community service projects in the fall and spring across all five high schools is the same as it was at Roosevelt High. How many different students would you expect to find in total between the fall and spring projects?

   3,000 × 20% = 600 different students

Exploring Sickle Cell Disease

Imagine that you are a family practice physician and that an African-American woman, Audrey Lindsey, and her family are your patients. Just before her twins, Sondra and Jason, were born, Ms. Lindsey's husband, also African-American, died in an automobile accident. His parents were physiologically normal, but he had a brother who died of sickle cell disease at the age of 19. Ms. Lindsey explains to you that it is important to her to know whether her twins carry the allele associated with sickle cell disease.

1. Study the minidocumentary *What Is Sickle Cell Disease?* on the CD-ROM. Use the *Reference Database* (also on the CD-ROM) and any other resources that are available to you (for example, your textbook) to answer the following questions:

   a. What are the primary symptoms of sickle cell disease? What happens in a person's body to cause these symptoms?

   b. How is Hb S (sickle hemoglobin) different from Hb A (normal hemoglobin)?

   c. How can this difference in hemoglobin be detected in the laboratory?

   d. What does this difference in hemoglobin tell you about the DNA of people whose cells make Hb S as compared with people whose cells make normal hemoglobin?

   e. What is the difference between sickle cell disease and sickle cell trait? Demonstrate in your answer that you understand how sickle cell disease is inherited.

2. Use what you learned about sickle cell disease and trait to propose a way to determine whether Ms. Lindsey's twins have sickle cell trait. Explain your procedure to your teacher, then use the information provided on the handout your teacher will give you to determine the results of the test.

3. Write the dialogue for a brief (2–3 minute) scene in which you explain to Ms. Lindsey the results of the tests you ran on the twins, what these results say about the inheritance of the sickle cell trait in her family, and the implications of your findings for the twins' health.

Results of the Lindsey Test

Examine the following results to determine Sondra's and Jason's status with respect to sickle cell trait.
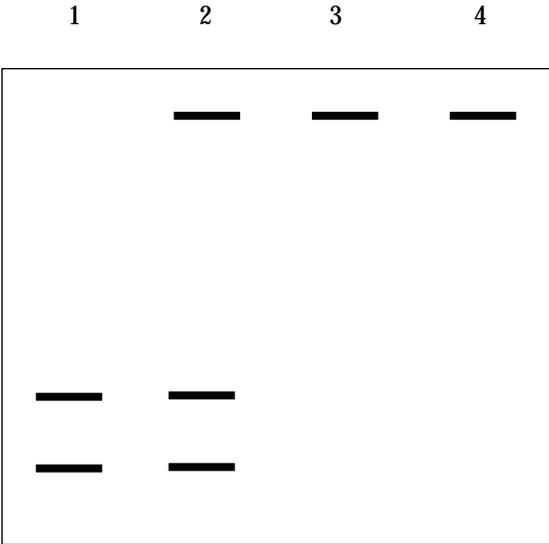
Lane

1   Standard—DNA from allele for Hb A

2   DNA from Sondra Lindsey

3   DNA from Jason Lindsey

4   Standard—DNA from allele for Hb S