How a Gene Can Affect Your Body

Your investigation: How could a change in a tiny section of DNA affect something as large as a joint or a blood vessel? Read these pages and complete the separate handout. Work independently using only the two documents and a pencil. Allow about 50-60 minutes.

1 Tiny builders inside your body

Bend your finger. Straighten it. Your muscles pull on your bones, but other tissues help hold the parts together. These **connective tissues** support structures throughout your body, including your joints, eyes, and blood vessels.

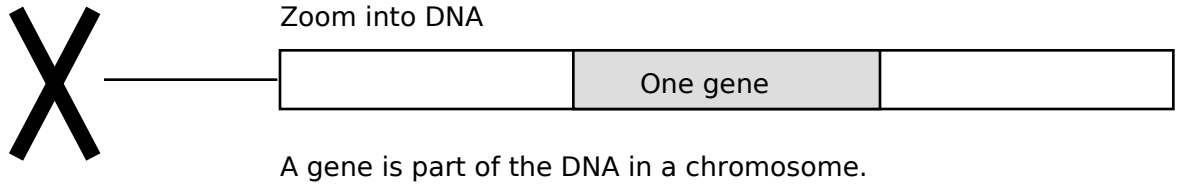
One of their building materials is a protein called **fibrillin**. Cells make fibrillin and release it outside the cell. There, it joins other molecules to form thin strands called **microfibrils**. These strands help tissues stay strong and flexible.

But how does a cell know how to make fibrillin? It cannot look at a picture or follow a video. Its instructions are stored in DNA.

2 Instructions written in four letters

DNA has four types of building blocks, represented by the letters **A, T, C, and G**. Their order carries information. A **gene** is a section of DNA. Genes are located on **chromosomes**, which are long DNA molecules packaged with proteins.

Most body cells contain chromosome pairs, with one member inherited from each parent. The two copies of a gene can have different versions, called **alleles**.



A gene is part of the DNA in a chromosome.

Chromosome

For a protein-coding gene, the DNA sequence provides instructions for arranging smaller building blocks called **amino acids**. Think of assembling beads on a string. Having the right beads matters, but so does putting them in the right order. A protein begins as a chain of amino acids arranged in a particular sequence.

The cell first copies the gene's instructions into RNA. It then uses those RNA instructions to assemble the amino-acid chain. **DNA supplies information; it does not turn into the protein.**

A Chain That Changes Shape

3 A chain that does not stay straight

Here is where things get interesting: the amino-acid chain folds. Some amino acids have positive charges. Others have negative charges. **Opposite charges attract; like charges repel.** These interactions can help bring parts of a chain together or keep them apart.

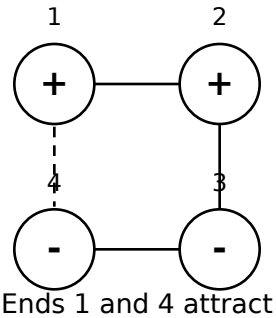
In this investigation, each circle represents an amino acid. A **+** or **-** inside it represents a charge. Solid lines connect neighboring amino acids. Keep the chain connected in the same order, but bend it in your drawing to show a possible effect of attraction or repulsion. You will make **2D drawings directly on your handout**. Do not cut, fold, or build anything.

4 Worked example one changed building block

The first chain has four amino acids: **+ + - -**. Amino acids 1 and 4 have opposite charges. Their attraction could help bring the ends together. The dashed line shows attraction, not another connection in the chain.

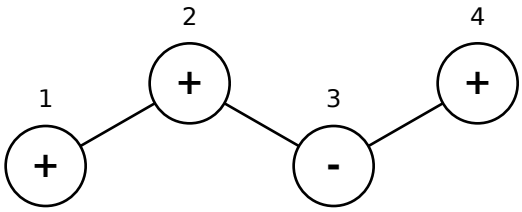
Now a mutation changes the amino acid at position 4 to one with a **positive** charge. The ends now have matching charges. They repel instead of attracting. The second drawing shows one possible arrangement with the ends farther apart.

Before the mutation



Ends 1 and 4 attract

After the mutation



Ends 1 and 4 repel

One changed amino acid can change an interaction and possibly the protein shape.

A model has limits. These are possible arrangements, not measured shapes. Real proteins fold in three dimensions with many more amino acids and interactions. For your drawing, focus on the pair named in the directions.

5 Your turn follow the instructions

A **mutation** is a DNA change. This key uses the DNA **coding strand** and skips RNA. Use it with page 3's fictional gene fragments, not actual fibrillin sequences.

DNA group	Amino acid	Charge
AAA or AAG	Lysine (Lys)	+
GAT	Aspartate (Asp)	-
GAA	Glutamate (Glu)	-

Check the Model Against Evidence

Read each sequence from left to right. Each three-letter group specifies one amino acid. Your drawings will focus on **amino acids 1 and 5**.

Gene version	DNA sequence
Reference	AAA GAT AAA GAA GAT AAA
Mutation A	AAA GAT AAA GAA AAA AAA
Mutation B	AAG GAT AAA GAA GAT AAA

6 Does a different shape change the job

Imagine a key that bends. It still contains the same amount of metal, but its new shape might prevent it from fitting the lock. Proteins also have jobs that depend on shape. Some need to fit against another molecule. If their shape changes, they may attach less successfully.

A drawing alone is not enough. In this fictional investigation, researchers tested attachment to the same partner molecule. Each trial tested **100 proteins** using the same conditions.

Simulated evidence: These numbers were invented for this lesson.

Gene version	Attached Trial 1	Attached Trial 2	Attached Trial 3
Reference	90	92	91
Mutation A	24	26	25
Mutation B	91	90	92

The tests show how many proteins attached. They do **not** show the proteins' shapes directly. Use your model to suggest an explanation, but distinguish that explanation from what was measured.

7 Back to fibrillin

The real gene that provides instructions for fibrillin-1 is called **FBN1**. Some mutations in this gene reduce the amount of working fibrillin or interfere with the assembly of microfibrils. When these supporting strands do not form or work properly, connective tissues can be affected. This helps explain why changes in one gene can contribute to effects on joints, eyes, and blood vessels in **Marfan syndrome**.

The charge model illustrates a possible connection between an amino-acid change and protein shape. It does not show an actual Marfan mutation or the full structure of fibrillin.

Mutations have different effects. A **harmful** mutation interferes with an organism's functioning or success. A **beneficial** mutation improves it in a particular environment. A **neutral** mutation does not affect the trait considered. A changed DNA sequence is the beginning of an investigation, not enough information by itself to determine the outcome.

Science source: NIH MedlinePlus Genetics, Marfan syndrome
medlineplus.gov/genetics/condition/marfan-syndrome/