ScienceNews for Students

TECHNICALLY FICTION

Here's why Rapunzel's hair makes a great rope ladder

Hair is much, much stronger than you might expect

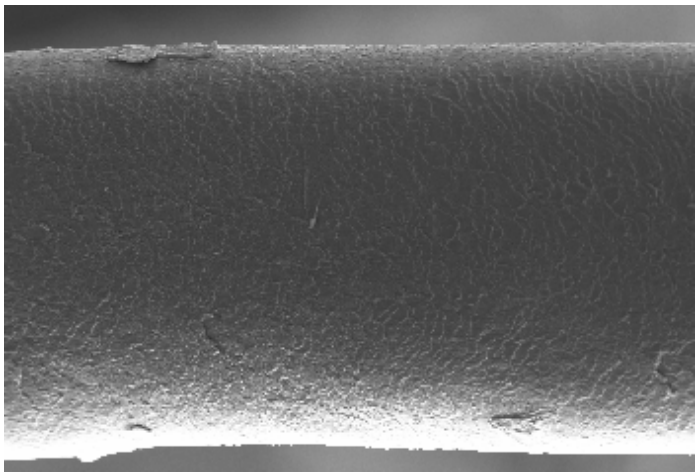
BY **BETHANY BROOKSHIRE** MAR 8, 2019 — 6:30 AM EST

Rapunzel's incredibly long hair makes a great rope ladder in the fairy tale. But could that work in reality?
cookgraphi/iStock/Getty Images Plus

In the classic fairy tale, the princess Rapunzel is trapped high in a tower. A dashing prince comes to rescue her. "Rapunzel, Rapunzel, let down your hair," he calls. She unfurls her lengthy locks, draping them out the tower window. The prince then climbs up that magic hair to rescue his lady love. The story is obviously fiction. (If Rapunzel had such a handy ladder, one wonders why she didn't just rescue herself.) But there may be a little truth behind a human hair-based escape. Science, it turns out, has found that hair is some super strong stuff. A prince (or princess) would actually have few problems climbing a rope made of human hair. The challenge would be growing such a lengthy mane in the first place.

Hair is strong. Really strong. A single human hair can take a force of 200 megapascals. This is its *tensile strength* — how much load it can take before breaking. Pressure is measured in pascals. A pascal is the amount of mass something can take per square meter of material. One megapascal is 1,000,000 pascals. In the case of a human hair, 200 megapascals is 20,000,000 kilograms of force per square meter of human hair.

Those are some big numbers. They mean that a single strand of hair is about half as strong as a piece of steel the same size, notes Ray Goldstein. He studies biological physics — the physics of living materials — at the University of Cambridge in England. Among the things he's studied is the physics of ponytails.



This is an image of a human hair under a microscope. The cuticle has tiny scales, like those on a fish.
Vader1941/Wikimedia Commons (**CC0 (https://creativecommons.org/share-your-work/public-domain/cc0/)**)

Wen Yang is a materials scientist at the University of California in San Diego. She's performed studies on the strength of human hair. She has compared hair's strength to a finger lifting a loaded shopping bag. Not just any bag of food. If your finger were as strong as a bundle of human hair the same size, that one bag could hold 11,340,000 kilograms (2,500,000 pounds)!

Hair's buffness comes from its structure, Yang explains. "You might [use an] example of the Russian matryoshka doll," she says. "Inside the biggest doll (the hair), there are millions or more of the smaller dolls." Those smaller dolls are tiny protein chains. They're contained within an area called the cortex. The chains are layered together and covered with an outer coating called the cuticle (KEW-tih-kul). "The cuticle looks like a fish scale," Yang says. It holds the protein bundles of the cortex together.

Beyond strength

Rapunzel's hair is not only strong but also very long. That length might make her mane overall a little weaker, Rhett Allain notes. He's a physicist at Southeastern Louisiana University in Hammond. Hair's protein chains, he says, "are little atoms connected by springs. If you pull too strongly, the spring breaks." No chain is perfect. In fact, a longer chain is more likely to have a weak point that snaps under the load. Rapunzel gets around this problem by throwing down a big braid or ponytail of hair, instead of a single strand. The individual protein chains might be weak, but they're strong when bound together.

So strong, in fact, that Yang and Goldstein both estimate that some 500 to 1,000 hairs could support a full-grown human weighing about 80 kg (176 lbs). That's not much hair. "A typical human head has about 50,000 to 100,000 hairs," Goldstein notes.

The prince couldn't just yank on the hair, though. "Keep in mind the hair is attached to the head via biological structures," Goldstein says. Those structures are called follicles. And these aren't as strong as hair. A single hair can easily be yanked out. So while the hair could take the weight, the scalp might suffer. The solution is to loop the long hair around a pole or hook, creating a pulley that keeps Rapunzel's hair attached to her head.

Hair is both strong and flexible, and clearly would make a climbable rope. (The Mythbusters **tried this (https://mythresults.com/motorcycle-flip)** successfully.) Why don't we use it that way? In the past, Yang notes, people did use human hair for some things, such as sewing skin closed in surgery. But as a natural material, hair easily breaks down in the environment, Yang says. Not only that, the proteins in hair can be affected by temperature and the amount of water in the air (summer humidity can wreak havoc on a hairdo). Artificial materials are more consistent.

Hair also is pretty slick, Goldstein notes. There's not a lot of *friction* — the resistance an object encounters moving against another object. Even when twisted into rope, he says, hair might be too slippery to hold together well. Regular rope make for an easier climb.

And of course, there's the cultural aspect. "I think people would be squeamish about using human parts for anything like that," Goldstein says.

But hair's final weakness is that it grows slowly. The average human hair grows about 15 cm (or 6 inches) per year. At that rate, if Rapunzel were trapped in a tower 10 meters (32.8 feet) tall (about as tall as a four-story building), it would take 66.6 years for her hair to grow long enough to reach the base. That's a long time to wait for a rescue.

Power Words

(more about Power Words (https://www.sciencenewsforstudents.org/power-words-aid-stem-literacy))

atom The basic unit of a chemical element. Atoms are made up of a dense nucleus that contains positively charged protons and uncharged neutrons. The nucleus is orbited by a cloud of negatively charged electrons.

average (in science) A term for the arithmetic mean, which is the sum of a group of numbers that is then divided by the size of the group.

cortex The outermost part of an organ, such as the kidney or brain. Or the outer part of some microbes or plant, such as a tree's bark or a mango's rind. (in hair) The protein-based layer of a hair shaft (the layer responsible for a hair's color) that is below the cuticle.

cuticle Term for a tough but bendable protective outer shell or cover of some organism, or of parts of an organism.

follicle The cells and other tissues that surround hair at its root.

force Some outside influence that can change the motion of a body, hold bodies close to one another, or produce motion or stress in a stationary body.

friction The resistance that one surface or object encounters when moving over or through another material (such as a fluid or a gas). Friction generally causes heating, which can damage a surface of some material as it rubs against another.

humidity A measure of the amount of water vapor in the atmosphere. (Air with a lot of water vapor in it is known as humid.)

materials science The study of how the atomic and molecular structure of a material is related to its overall properties. Materials scientists can design new materials or analyze existing ones. Their analyses of a material's overall properties (such as density, strength and melting point) can help engineers and other researchers select materials that are best suited to a new application. A scientist who works in this field is known as a **materials scientist.**

pascal A unit of pressure in the metric system. It is named for Blaise Pascal, the 17th century French scientist and mathematician. He developed what became known as Pascal's law of pressure. It holds that when a confined liquid is pressed, that pressure will be transmitted throughout the liquid in all directions, without any losses.

physics The scientific study of the nature and properties of matter and energy. Classical physics is an explanation of the nature and properties of matter and energy that relies on descriptions such as Newton's laws of motion. Quantum physics, a field of study that emerged later, is a more accurate way of explaining the motions and behavior of matter. A scientist who works in such areas is known as a **physicist**.

pressure Force applied uniformly over a surface, measured as force per unit of area.

protein A compound made from one or more long chains of amino acids. Proteins are an essential part of all living organisms. They form the basis of living cells, muscle and tissues; they also do the work inside of cells. Among the better-known, stand-alone proteins are the hemoglobin (in blood) and the antibodies (also in blood) that attempt to fight infections. Medicines frequently work by latching onto proteins.

resistance (in physics) Something that keeps a physical material (such as a block of wood, flow of water or air) from moving freely, usually because it provides friction to impede its motion.

tensile strength The maximum lengthwise stress a material can take without breaking.

Readability Score:

6.0

1719 N Street, NW, Washington, DC 20036-2801
202-785-2255
Contact Us
Legal/**Privacy Policy**

Source URL: https://www.sciencenewsforstudents.org/blog/technically-fiction/heres-why-rapunzels-hair-makes-great-rope-ladder