



Knot Theory

Be a topologist today! In this activity, you are going to create knots, untangle knots, and find out how knots relate to biology and the human body.

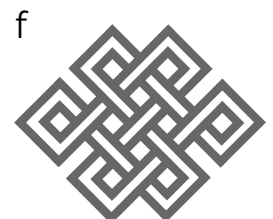
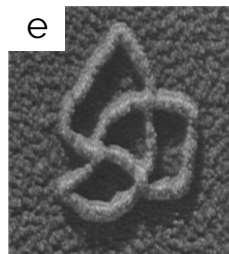
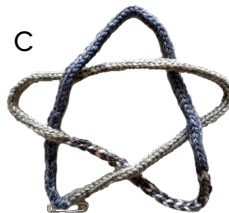
Why are we doing this activity?

What is a knot? Well, you might think about tying a rope into a shape with a funny name, like cowboy bowline or buntline hitch. In math and science, on the other hand, a knot has a slightly different meaning. A knot can be as simple as taking that rope and forming it into a circle, the "unknot." Or it can contain several twists and turns, such as the three-twist knob. Like those other knots, they still have funny names! Topologists study these knots and other shapes that occur in nature. The study of knots can help us to understand complicated molecules like DNA, and the proteins that help untangle it. Proteins act like scissors and safety pins--they cut and reattach DNA to make the knots simpler, so that it can do its job in our bodies more easily.

Proteins themselves don't often knot, but they do tangle into complicated shapes that are important for them to do their jobs in our bodies. This is called "protein folding." You can help scientists study protein folding by playing games or running applications on your computer. Meet the scientists and get involved at <https://fold.it/portal/info/about> or <https://foldingathome.org/> to be part of important research.

Supplies Needed

- Length of thick yarn, twine, ribbon, wire, shoelace, or similar. It should be about twice the length of your arm
- Safety pin, paper clip, tape, something that you can use to connect the ends of your yarn or similar
- Device with internet access (optional)



DNA knot as seen under the electron microscope. Javier Arsuaga, CC BY-ND



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What to do

1. Take your length of yarn, twine, wire, or whatever you have on hand. Form it into a circle and attach the ends. You've made your first knot, the unknot (a)!
2. Detach the ends of the yarn, and this time, tie a simple overhand knot, as if you were starting to tie your shoelaces. Keep the knot very loose, and attach the ends of the yarn. Twist and move the yarn around so that you can easily see how many times the yarn crosses over itself. Did you count three? This knot is called the trefoil (b). Twist and turn your knot around to create different shapes. Even if you twist the yarn over itself, you can always reduce it back to only 3 crossings.
3. Ready for a more complicated knot? Try the cinquefoil, a knot with 5 crossings. If you can draw a star without lifting your pencil, you can easily create the cinquefoil with your yarn. Look at the image (c), and be sure to pay close attention to where the yarn crosses *over* and *under* itself. Attach the ends of the yarn. Again, twist and turn your knot. See what different shapes you can make. You should always be able to reduce it back to 5 crossings.
4. The three-twist knob (d) also has five crossings, but it's shaped a little bit differently. Can you re-create this one?
5. Have you noticed that once you make the knot, you can't undo it unless you disconnect the ends of your yarn? Inside our bodies, DNA is tangled into knots like these (e). How many knots (crossings) can you see in this image?

Want to go further?

- Science and art go hand-in-hand. Do you knit, or do you know someone who does? Read about a physicist who explores and explains her work with knitting here: <https://matsumoto.gatech.edu/research.html>
- Knots, as we're studying them here, have been a subject of interest, intrigue, spiritual symbolism, and beautiful artwork for centuries (f). What kind of artwork can you create that involves knots?