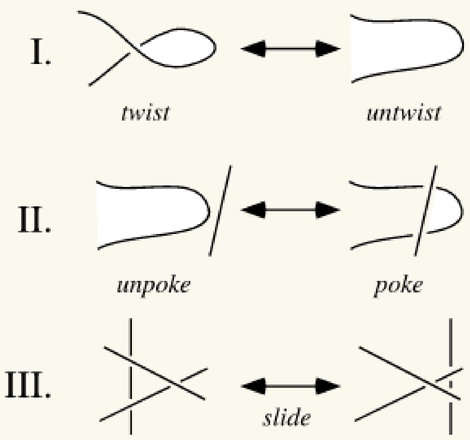
Unraveling Knot Theory Through Knitting

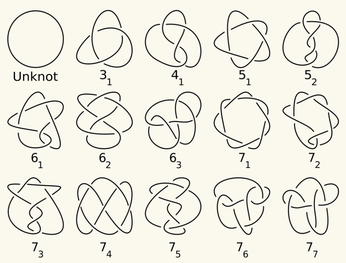
Anna Center
Carleton College

What is knot theory?

Knot theory was born out of a want to understand our universe through a scientific lens. There was a theory in the 1860s that all the elements in the universe were made up of tiny knots, and thus mathematicians began to attempt to understand knots better. It quickly became evident that elements were not knots, but people were already looking into the fascinating field of knots.



A knot is a closed loop in 3d space that does not intersect itself. To define two knots as being the same, one must be able to transform one knot into the other through a combination of a series of three Reidemeister moves.



The thing about knot theory is it is hard and can be confusing, and we are still in its early years (in comparison to the grander mathematical timeline). It took approximately 50 years to categorize all the knots with up to 10 crossings. There are geometric, algebraic, and topological ways of looking at knots and all provide different insights.

So now the knitting:

The mathematics of knitting has long gone under studied. The process of knitting is using incredibly simple tools (two knitting needles or a looped cable) to create incredibly complex shapes from balaclavas that make your head look like a dragon to a terrifyingly realistic dalmatian puppy, all from a series of simple moves with a single strand of yarn.

Recently, a few mathematicians have begun to research fiber arts in the context of knot theory. Knitting can provide insight into how large knotted structures function as knitted objects are significantly more complex than categorized knots.

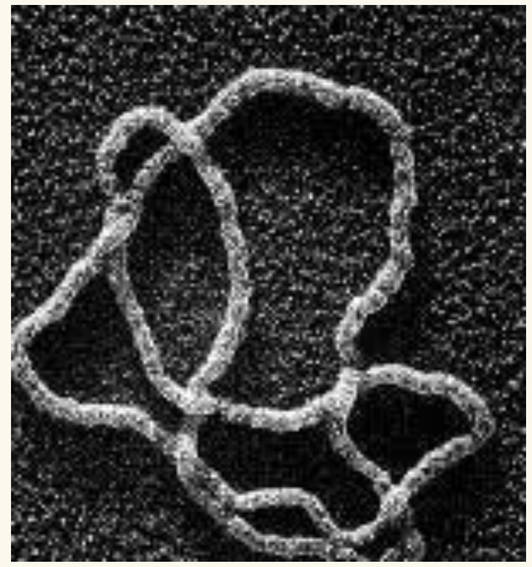
Specifically, Dr. Matsumoto has conducted research in the past few years around the properties of knitted fabrics and is examining how a taut piece of string can create flexible and stretchy fabric from a series of slip knots. She has also looked into how the properties of the string (from fluffiness to size to stretchiness) can significantly impact the properties of a fabric. Dr. Matsumoto's team is looking specifically at the elasticity of knits and is slowly applying knot theory to understand how these properties develop from different stitches. The team has a conjecture that all knits are ribbon knots; however, it is unclear if there is an unknittable ribbon knot.

What can we do with knot theory?

In the 1990s, geneticists began looking at knotted DNA and proteins through the lens of topology. They realized that since DNA is a long string that is clumped within the nucleus, there must be many twists and folds so that it all fits. Enzymes must be able to locally unwind a specific area of the DNA so that it can perform transcription, but then be able to rewind the DNA.

Examining DNA from the view of knot theory may allow us to understand exactly how recombination (the process of moving the relative location of DNA to influence how genes are expressed) occurs.

Fascinatingly, the number of crossings on a knotted loop of chemically identical circular DNA substrates determine how far it can move through gel electrophoresis.



Better understanding of DNA is a truly fascinating application of knot theory, however researchers believe that we will be able to use knot theory for plastic surgery techniques, creating tissue scaffolding, aerospace engineering, and so much more that has yet to be conceived of.