Funky Fractals
Grades 3-5

The Big Idea
Today you'll use wax sticks to make wild repeating patterns called fractals. Then you'll make small mazes and finally, you'll combine smaller pieces to make giant mazes. See if you can crack the code and spot the patterns!

Supplies
In your kit:
★ Wax sticks: 192 (4 sheets)

To print (optional):
★ Fractals Found in Nature, 1 copy
See last page of directions

You provide:
★ Paper: 1 sheet per kid
★ Pencils: 1 per kid

Key Prep
★ Have a few hand wipes or damp paper towels available in case kids' hands get sticky from the wax.
★ Make a sample Level 1 design shown on page 2.
★ Make a sample maze using the photo on page 4 as inspiration. You can use a marker or just print one from the internet.
★ Print 1 copy (optional) of Fractals Found in Nature, found on last page of these directions.

Room Set-up
★ Make sure you have a room with lots of open floor space.

What's the Math?
★ Geometry: shapes and scale
★ Pattern recognition
★ Perfect squares and cubes
★ Right angles

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Kickoff

"Does anyone know what crayons and candles are made of?" **Discuss**. "That's right, wax! And if you've ever melted a candle, you know that wax can be sticky. Today we're going to use these wax sticks to make sticky shapes."

Wax to the Max (5-10 minutes)

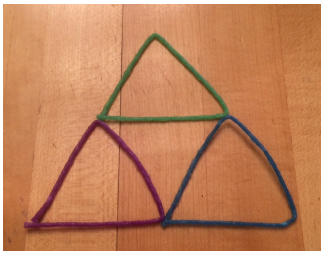
"First, let's see how these wax sticks work."

1. Give each kid 10 wax sticks.
2. Let them play with the sticks, encouraging them to make different geometric shapes, such as squares, hexagons, or spirals.
   - ? "A polygon is a closed shape made up of straight lines. So, a circle isn't a polygon, because it's curved, but a rectangle is. Can you name some other closed shapes with *straight* lines?" **Discuss**. Kids might say squares, rectangles, pentagons, hexagons…
   - ? "Can you use all 10 of your sticks to make a polygon with all equal sides?" **Discuss**. If they never bend the sticks, they can make only pentagons (5 sided-shapes, which could include a tall house) and decagons (10 sided-shapes, which could include a star.)
   - ? "What are all the ways you could make a square?" **Discuss**. Let the kids find ways to allocate their sticks to make 4 equal sides: using just 4 or 8 sticks, or bending to use a fraction of a stick. Can they make a square out of 5 sticks? 6 sticks? All 10?

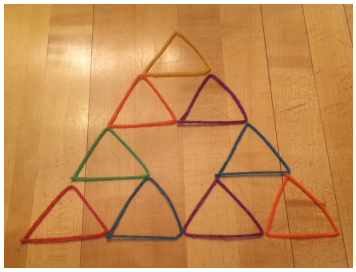
The Facts about Fractals (10-15 minutes)

"Does anyone know what a fractal is?" **Discuss**. "A fractal is a pattern where the tiny shapes in the pattern are exactly the same as the big shapes. There are lots of fractal patterns in nature, including snowflakes, tree branches, leaves, some seashells, flowers, clouds and more!" **Discuss**. Show kids the Fractals Found in Nature photo sheet, if you've printed it. "Let's make some of our own fractals!"

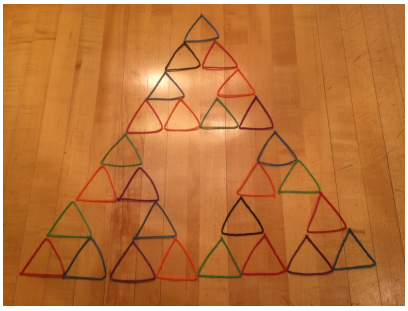
1. Show the kids this triangle made of 3 wax sticks each folded in thirds. This is **Level 1**.
2. Have each kid make a Level 1 triangle.
   - ? "What do you notice about the shape?" (Discuss. It's a big triangle made from 3 smaller triangles. See if the kids notice that the 3 smaller triangles also create an interior upside-down triangle.)
   - ? "How many triangles are in this shape?" (Discuss. See if kids notice that the shape itself is one big triangle to give this shape 5 triangles total.)
   - ★ "Let's see what it would look like to make a repeating fractal pattern using these big triangles."



3. Divide the kids into 3 groups.
4. Ask each group to merge 3 of their Level 1 triangles to create **Level 2** triangles, shown here:



   - ★ "Notice that this bigger Level 2 triangle looks similar to Level 1 with the blank upside-down triangle in the center." **Discuss**. Make sure kids resisted the temptation to fill that space with another little wax-stick triangle.
   - ★ "How many triangles are in this new design?" **Discuss**. It's 17 triangles. See if the kids remember each of the Level 1 designs had 5 triangles, and since Level 2 used 3 Level 1 designs, they can easily solve 3 x 5 = 15, plus the empty triangle in the middle and the shape itself.
   - ★ "We can use this new triangle to make an even bigger pattern! How many wax sticks should the next level use?" **Discuss**. See if anyone realizes that the first triangle used 3 wax sticks, the Level-2 triangle used 9 sticks (3x3), so the next triangle would be 3 times larger again, 9 x 3 = 27 wax sticks
5. Now 3 groups merge their designs to make a **Level 3** shape. The result should look like this – but <u>don't show the photo</u> until they're done!



   - ★ "Notice that this Level 3 triangle still mimics our first Level 1 triangles with the blank upside-down triangle in the center."
   - ★ "How many triangles in this new shape?" **Discuss**. 17 x 3 = 51 plus 1 center triangle plus the shape itself = 53

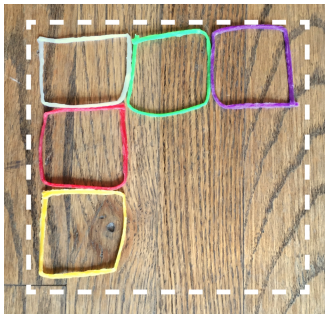
Extra Challenge (optional)

- **?** "How many sticks should the 4th level use?" **Discuss**. Have the kids guess, then try to make it! Answer: 27 x 3 = 81 sticks.

It's Hip to Be Square (10 minutes)

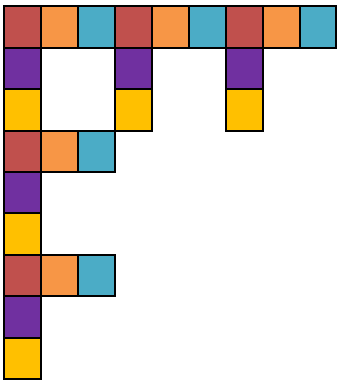
"Those fractals used triangles. Let's see if we can do the same thing with squares!"

1. Have each kid unbend 5 wax-stick triangles and reshape into 5 squares.
2. Help kids make a new **Level 1** shape. Here's an example, but feel free to make any design of 5 squares within a square:



   - ★ "How many sticks does our new Level 1 fractal use?" (Discuss. 5 sticks.)
   - ★ "How many sticks will the next level use?" (Take guesses.)

3. Ask 5 kids to merge their Level 1 shapes to make the **Level 2** design. Here's our example at Level 2:
   - ? "What happened here?" **Discuss**. Let them figure out that the next level shape uses the starting number times itself!
   - ★ "Our sample used 5 sticks, so the next level uses 25!"



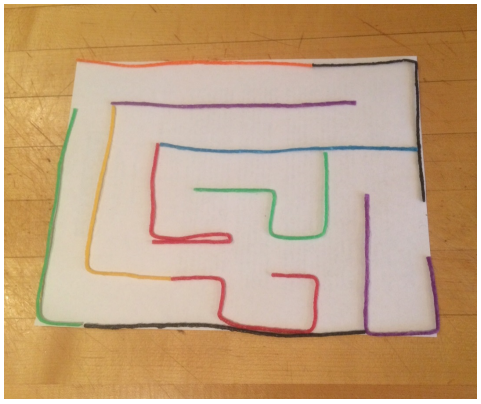
Extra Challenge (optional)

- ? "If you use 4 sticks to make a square design, then use 4 of those to make a bigger design, then use 4 of that to make an even bigger one, how many sticks do you use?" Discuss. Answer: 64 sticks

A-Maze Me (10-15 minutes)

"There are other fun ways we can use wax sticks to make math-y designs called mazes. There are many kinds of mazes, like circular ones and 3D ones. We're going to make mazes with straight sides at right angles, because it turns out the math in them is pretty cool."

1. Each kid grabs 10 sticks and unbends them to reuse.
2. Give each kid 1 sheet of paper and a pencil. Ask them to write their names on the sheet of paper.
3. Using your sample maze, show the kids how to solve it, pointing out forks in the path and dead-end traps along the way.
4. Now the kids make their own mazes! If they need more than 10 sticks, feel free to give a couple extra.
5. Once the kids have completed their mazes:
   - ★ "How many ways can your maze be solved?"
   - ★ "Once you enter your maze, how many right-angle turns does it take to solve your maze?" **Discuss**.



6. Let the kids try to solve each other's mazes using their fingers instead of pencils or crayons so everyone can try multiple mazes.

Extra Challenge (optional)

- ? "How does the number of right-angle turns relate to where you start and finish your maze?" **Discuss**. Compare mazes. When the start and exit are on the same wall or opposite walls, you'll need an even number of turns. If you exit on a wall *next to* the start side, you need an odd number.
- ? "Why?" **Discuss**. If you make a 1 right turn or 1 left turn when you enter the maze, you'll be exiting on a wall next to where you started. You'd need to make a 2nd turn to exit on the same wall as where you started or at least 4 turns to exit on the opposite wall.

Mega-Maze (15 minutes)

"Now that you've made these many mazes, we're going to join them into one giant maze! How will you work this out?"

1. Let the kids self-organize to join their mazes on the floor. Explain that they will need to turn the mazes so the finish from one maze lines up with the start from another. This may take a few minutes and involve some starts and stops, so please give them time!
2. Once they've joined all the mazes, the group can work to solve the entire thing! Again, use fingers so everyone can try.

Wrap Up

"This is like the math we do in class. When we multiply a number by itself, the product is called a perfect square. And if we multiply that product again by the first number, the new product is called a perfect cube."

Fractals Found in Nature