FRACTAL POETRY: A STEP-BY-STEP GUIDE

1. Write a poem whose last line loops back into its first line, so that it can be repeated over and over again.

   ▷ Your poem does not need to be long; five to ten lines is fine.

   ▷ Each repetition can be the same, or repetitions can all be slightly different.

2. Pick a simple shape related to the theme or idea of your poem. Draw it on the back of this sheet.

3. Think of a way to arrange your poem within that shape, and make a draft on the back of this sheet.

   ▷ Your poem should start and end on the edge of the shape. Mark the place where the poem starts with an *X* and the place where it ends with an *O.*

   ▷ You can draw the shape and place the words inside of it, or have the words themselves form the shape.

4. Create a fractal.

   ▷ Use scratch paper first.

   ▷ To make a fractal, take a smaller copy of your shape, and connect the *X* on the smaller shape to the *O* on the larger shape. Then repeat.

   ▷ Once you have an arrangement you like, create your final fractal poem!

LEAVING SPACE AND TIME

Thinking about space and time in new ways can inspire great stories. Use another sheet of paper for your answers as needed.

Part 1: Bending the Rules of Geometry

1. Pick a shape or a way of gluing a shape that interests you. Describe or draw it here.

2. How would life be different if this shape were your world?

- What would be good about it?

- What would be bad about it?

- Who would be most affected by it?

Part 2: Time for Time

3. Pick a twist in time that interests you. Describe it here.

4. How would life be different if time worked this way in your world?

- What would be good about it?

- What would be bad about it?

- What types of people would be most affected by it?

Part 3: Story Time

Pick whichever of the two preceding ideas interests you most. Or combine both ideas!

5. Develop your characters.

- Pick one or two people in your world, and describe them in more detail (personalities, jobs, names, where they live, hobbies, and so on).

6. Outline the plot of your story.

- How do the changes you made to space and/or time in your world introduce conflict into your characters' lives?

- How do the characters react to the conflict?

- How can you resolve that conflict?

STEM@HOME: BENDING THE NUMBER LINE

STEM @ HOME

Can you imagine a world where the rules of math as you learned them don't apply? What if 2 plus 2 did not equal 4?

Can you believe that there is an entire branch of math, called **modular arithmetic,** that describes a completely different way (from the way you learn in school) of adding and subtracting—and that when you do modular arithmetic, you often get completely different answers? (What a great way to confuse your brother or sister.) In some instances of modular arithmetic, 2 plus 2 does not equal 4! We could have 2 + 2 = 1, or even 2 + 2 = 0!

Let's Get Started!

Before we continue, consider the number line. If you were to figure out 2 + 2 on the number line, you would start with the number 2 and move two spaces to the right—this would take you to 4, so 2 + 2 = 4. What would happen, though, if the number line weren't a line? We'll explore exactly this scenario.

To do modular arithmetic, you must first pick a number (the fancy term for this number is the **modulus**). The example that follows shows you how 2 plus 2 might not equal 4. We'll pick the number 3 as the modulus.

1. Draw a circle.

2. Draw three evenly spaced notches on the circle (the modulus you pick determines the number of notches you draw on the circle). Label the notches 0, 1, and 2, Like so:
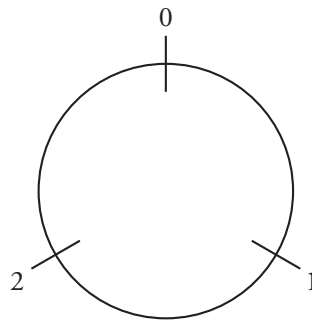
3. Counting and adding in modular arithmetic are the same thing as moving around the circle. Counting upward starting at 0, we'd have 0, 1, 2, 0, 1, 2, and so on.

4. Start at 2.

5. Now add 2 by moving from 2 to 0 to 1.

6. We added 2 to 2 and got 1 instead of 4!

(*continued*)

There actually is no 4 in this number system! A mathematician might say that 1 = 4 (mod 3). Can you figure out why?

You can also do modular subtraction. What do you think 1 – 2 might be in our example?

What other numbers would you like to try?

To think about how this works, imagine the number line. If we make it into a loop, and have the 3 meet the 0, we get the circle we just created!
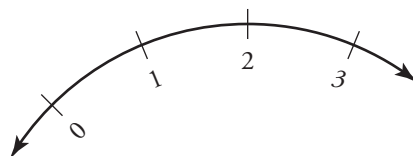
As you might guess, the way that you add and subtract clock times is like modular arithmetic, using the numbers 60 (for minutes and seconds) and 12 (for hours) instead of 3. There are several other examples of ways to replace the rules of math to go to strange, exotic places. For instance:

- ▸ Some types of arithmetic have addition but no multiplication, or multiplication but no division.

- ▸ In the regular arithmetic you know, A plus B always equals B plus A; this (the commutative property) is not true in other kinds of arithmetic.

- ▸ There are kinds of geometry with no straight lines!

STEM@HOME: MATH, LOGICALLY

You may remember learning that division by the number 0 is undefined—that's because there is no answer that fits the rules of arithmetic. (A quick refresher: Division is the inverse, or opposite, of multiplication. $10 \div 2 = 5$ because $5 \times 2 = 10$. You can't multiply any number by 0 to make 10, so the answer to the corresponding division problem is undefined.) This principle also explains why the square root of 4 is +2, even though $(-2)^2$ is also 4; mathematicians need standard rules and definitions.

Mathematicians are often very interested in finding where the rules break, or in coming up with new sets of rules that also work. (Modular arithmetic, from the "Bending the Number Line" STEM@Home sheet, is one.) Often, seeing where the rules break leads to new rules. The square root of 9 is 3, but –9 doesn't have a square root in the real numbers most of us use. And so the real numbers were extended to include the imaginary and complex numbers, where –9 does have a square root: 3i.

To see where rules break, mathematicians start with basic rules, use logic to find more and more new rules, and see if any of those rules **contradict** each other. We won't get into mathematical logic and finding contradictions here; what we will do is explore contradiction in the rules of imaginary worlds.

What Is Logic?

Logic can be defined informally as a way of reasoning that makes sense. Here, we'll explore logical reasoning and illogical reasoning through a classic example: syllogisms.

A **syllogism** is a way of combining two statements that are true to create a third statement that is also true. For example:

All humans must breathe to live.

You are a human.

Therefore, you must breathe to live.

Makes sense, right? This is definitely logical. But sometimes people don't combine statements correctly. Think about this example:

All humans must breathe to live.

You must breathe to live.

Therefore, you are a human.

This time, the third statement is not true! You might actually be an alien, a puppy, or a redwood tree, as they all have to breathe, too.

(*continued*)

STEM@HOME: MATH, LOGICALLY (continued)

People make lots of logical mistakes, unfortunately. Being logical and correct in your thinking is a huge skill in the STEM fields, but also in writing, and in life in general. Here's one last example.

The president is an outstanding person.

Outstanding people are usually right.

Therefore, the president is always right.

Again, untrue! In logic, it's important to differentiate between things being never true, sometimes true, or always true. This particular example relates to something called an ad hominem argument, whereby someone makes an argument for or against the person claiming something, instead of arguing the logic of the claim itself. Even if the president is an outstanding person, and outstanding people are usually right, we should look at what the president says, logically, and not assume things are okay because the president says so!

Logic and Stories

Consider this scenario: You rub an old-fashioned oil lamp, and a genie comes out. The genie says, "I will grant you three wishes and only three wishes. You can wish for anything you want." There's actually a contradiction here! If you wish for more wishes, you can get more wishes than the genie says you get. Now, if the genie instead says, "I will grant you three wishes and only three wishes. You can wish for anything you want, except things that will get you more wishes," there would be no contradiction. A lot of fiction, especially that involving magic or time travel, has rules. Why are rules important in these stories?

Let's have some fun with this. Your goal is to imagine a world like our own, but with one of the fundamental rules—like gravity—changed. What other rules would have to change so that the world would make sense? (In the case of a change to gravity, what new rules would there need to be so that we wouldn't all fly off into space?)

Alternately, you can think of a wildly imaginary world—certainly not limited to a world where magic or time travel exists. Create a bunch of rules for this world, and see if you can find any contradictions! (Your friends and family can help you here.) If there are contradictions, how would you add new rules or change old rules to get rid of them?
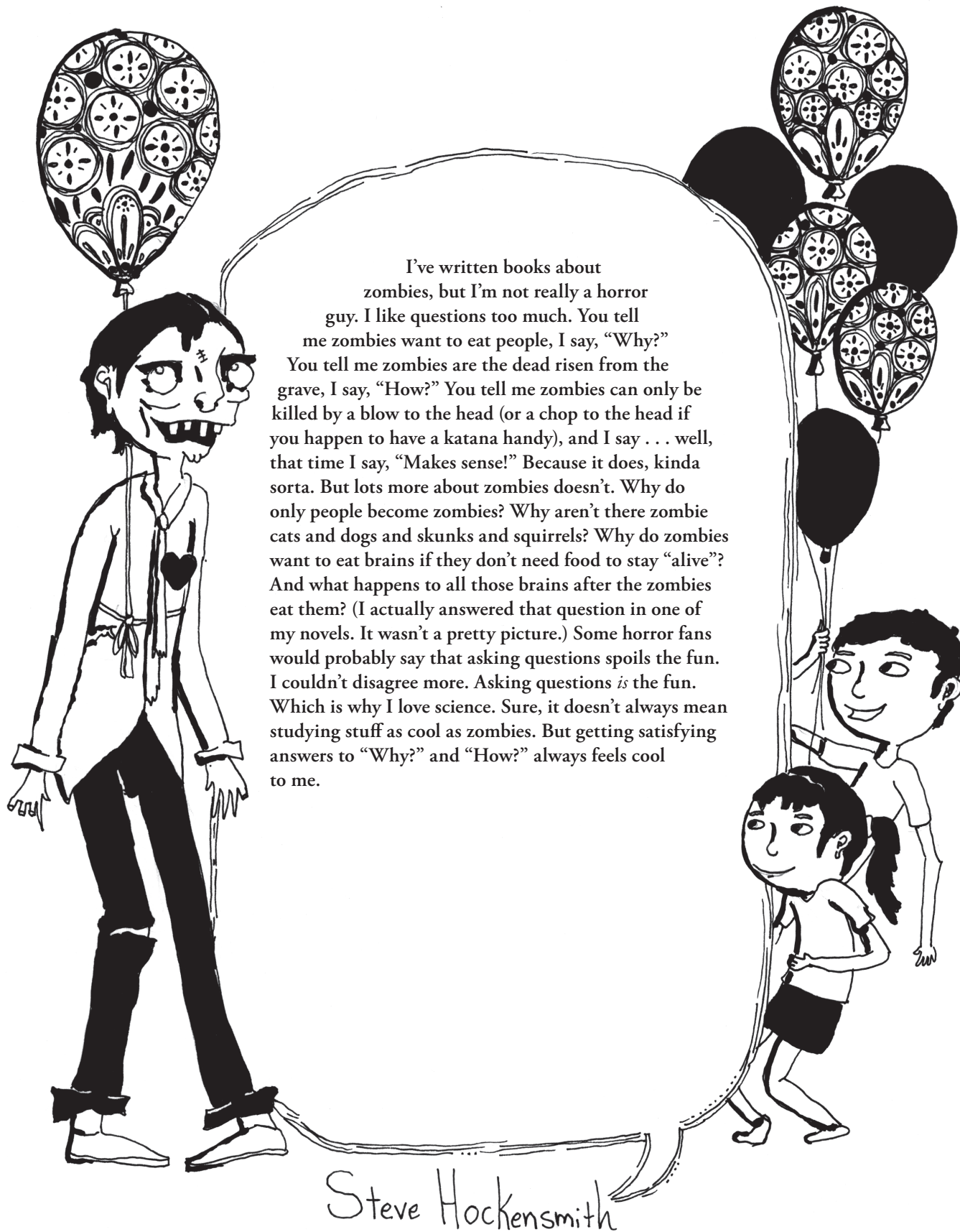
I've written books about zombies, but I'm not really a horror guy. I like questions too much. You tell me zombies want to eat people, I say, "Why?" You tell me zombies are the dead risen from the grave, I say, "How?" You tell me zombies can only be killed by a blow to the head (or a chop to the head if you happen to have a katana handy), and I say . . . well, that time I say, "Makes sense!" Because it does, kinda sorta. But lots more about zombies doesn't. Why do only people become zombies? Why aren't there zombie cats and dogs and skunks and squirrels? Why do zombies want to eat brains if they don't need food to stay "alive"? And what happens to all those brains after the zombies eat them? (I actually answered that question in one of my novels. It wasn't a pretty picture.) Some horror fans would probably say that asking questions spoils the fun. I couldn't disagree more. Asking questions *is* the fun. Which is why I love science. Sure, it doesn't always mean studying stuff as cool as zombies. But getting satisfying answers to "Why?" and "How?" always feels cool to me.

Steve Hockensmith