Fractal Beauty[1]

Rev. Myke Johnson
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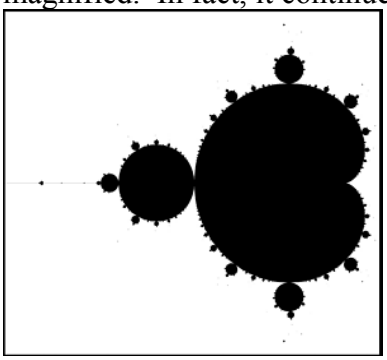
Allen Avenue Unitarian Universalist Church

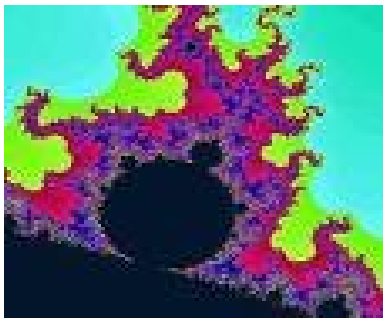
Introduction

Benoit Mandelbrot was the mathematician who first coined the word *fractal*, and brought to our attention the possibility of exploring the geometry of the natural world. Fractal comes from the word for broken, and Mandelbrot wanted to explore the rough shapes of nature. Traditional Euclidean geometry could not describe these shapes. Mandelbrot wrote: "Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in straight lines."[2]

Fractal geometry enables scientists to describe the world through complex mathematical formulas. I am not a mathematician, but I was curious to see if I could make sense of the connection. In a few minutes we are going to show a video of what is called the Mandelbrot set. It has a dark area that looks a bit like the shape of a bug, with a large round spot, and a small attached round spot. But the edge is what makes it fascinating. It is filled with beautiful complex curlicues that continue to be complex curlicues no matter how much the set is magnified. In fact, it continues infinitely, no matter much it is magnified.



But "What is it?" I wondered. If you have math anxieties, I promise you, I am only going to give a simple explanation with ten sentences.[3] You are also welcome to take a little nap for one minute.



A Mandelbrot Set is a diagram of a mathematical equation. The equation is: $Z = Z^2 + C$. What happens is that you insert a number into the equation, and then the equation computes it to a new number. Then you start the equation all over again with the new number. Now here's the interesting part—we don't care about the answer. We care about how many times you can repeat the equation, with the number you started with. If you can repeat it only a limited amount of times, that number is part of the Mandelbrot set—and it becomes a black dot on your diagram, part of the black spot. If you could repeat it an infinite amount of times, that number is outside the Mandelbrot set. Depending on how quickly it gets to be infinite, it can be given a different color. Only computers could actually do all of these calculations, but they do them very well, and so we can see the images formed by the equation.

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[2] From *The Fractal Geometry of Nature*, (Updated and augmented) (Freeman & Co., 1977, 1983), p. 1.

[3] For those who are interested in more details, a good explanation is at *Introduction to the Mandelbrot Set: A guide for people with little math experience* by David Dewey, at: http://ddewey.net/mandelbrot/

Okay, I'm done with the math part now. I didn't go into complex numbers or imaginary numbers, so my apologies to anyone who really knows about all of this. But for the rest of us, it is probably more than enough anyway. The thing is, when Mandelbrot computed his formula, it created a picture filled with beautiful complex curlicues. And no matter how many times you magnify the picture, you will continue to see similar complex curlicues.

To watch the YouTube video we watched in church, The Fractal Zoom Mandelbrot Corner, (created by Gaurav Vohra) click on the following link:
http://www.youtube.com/watch?v=G_GBwuYuOOs

Sermon
So why does it matter? Why should fractals matter to those of us who are not mathematicians? First of all, fractals give human beings a new way to look at the universe. When we can describe something, we can see it better than if we cannot describe it. Fractals give us a way to measure and describe the complex patterns in the natural world. So fractals enable us to have a deeper relationship to the natural world.

It reminds me of learning to read a book. In order to read, we need to understand the patterns of squiggly lines that form the letters of the alphabet. And then we need to understand how those squiggly lines are combined in multiple ways to form words, and then sentences, and so on. A person who cannot read may look at a book, and it might seem beautiful, or there might be pictures in it to be curious about, but that person cannot understand what it means. When we learn to read the patterns of squiggly lines, the book becomes a doorway into a whole story, and suddenly we have access to a wealth of ideas and thoughts and understandings.

As Unitarian Universalists, we consider the natural world to be our sacred book. The universe is where we search for truth and beauty and goodness. We might say that the universe itself is our holy bible. We don't have to understand the world to appreciate its beauty. Even a baby can laugh with delight at the bright colors of flowers, or try to catch a butterfly. But the more we understand the natural world, the deeper can be our appreciation, and the more its mystery opens up to us. Fractals help us to read the book of the universe.

This has both practical and mystical applications. I recently saw a NOVA documentary about fractals, which explored some of these applications.[4] In one segment, a group of scientists concerned about global warming was trying to determine how much carbon dioxide was absorbed by trees in the rain forest. They could measure the carbon capture of a single leaf, but how could they count the number of leaves in the forest?

They had an idea. They started by measuring the circumference of all of the branches on a single tree. Because of the fractal nature of the tree, the branches form a regular pattern, dividing at certain intervals into smaller and smaller branches. By measuring every branch, they could determine the ratio between branch sizes. Then they took it one step further. They measured the trunks of all of the trees within a given area.

[4]To watch the NOVA Documentary, *Hunting the Hidden Dimension*, go to: http://www.pbs.org/wgbh/nova/fractals

Imagine it with me if you will. If we walk through a forest we see trees of all sizes—small saplings, huge old giants—there is an endless variety of sizes all around us, seemingly in a random pattern. But it turns out it is not so random. The ratio of tree sizes in an area of forest is approximately the same as the ratio of branch sizes on a single tree. There is a pattern to it. And by learning the patterns, the scientists could compute how many leaves were in the forest, and how much carbon dioxide they would absorb.

Now when I walk through the forest near my home, I remember this experiment, and look with wonder at the trees around me. What seemed chaotic and random before, is now bursting with new meaning, full of patterns that start to reveal themselves to me, as I gaze with deeper insight. My experience of the trees' beauty expands, and I feel a growing sense of awe. I find myself looking for fractal patterns everywhere. This new understanding has changed the way I see the world. And it is not only visual. I can feel the patterns in bark with my fingertips, and I start to listen for patterns in the sounds I hear as well. Next time you look out the window at our dawn redwood tree, or gaze into the clouds in the sky, watch for the fractal patterns.

Our ability to measure fractal patterns in the natural world has also given us the ability to create digital worlds that remind us of our own. Fractal formulas are used to generate computer graphics that look realistically like mountain ranges, and rivers, and forests, and clouds. That wasn't possible just a few decades ago. Fractals have been used to design antennas in greatly reduced sizes, which enabled the creation of the next generation of cell phones and other electronic communicators. Fractal geometry is enlarging our ability to create new devices that work better, because they follow patterns that resonate with the natural patterns around us.

A second reason that fractals matter, and why I wanted to explore them in church, has to do with a very old spiritual and theological quandary. Human beings have long imagined the possibility of an infinite being, a divine being, who is creator and sustainer of the universe, commonly known in our culture as God. Not all human beings resonate with this idea, and the details vary as to what God might be like, but most peoples have some sort of divine being or beings as a part of the stories and values of their culture.

Many human beings have also imagined that they can have a personal relationship with a divine being. Most cultures have forms of prayer to entreat help from God, and forms of prayer to thank God for help given. Many people also directly experience the presence of the divine in their hearts, and the help of the divine in their lives.

I know that I have had moments in my life when I felt held in the arms of divine love, that I felt cared for by a power greater than myself. Those feelings are so tangible, that they help me get through my most difficult days. When I feel afraid, I can trust that all will be well, because of that tangible presence of love. When I feel overwhelmed, I can keep on walking forward, held in the memory of that love. But if God is infinite, how can that be? How can a God larger than the universe connect to a being like me, small as a speck of dust?

Fractals have given me a new way to think about spirituality. A fractal is a pattern that repeats itself, from an infinitely large scale to an infinitely small scale. What if God is a fractal? Here is how I imagine it. There is a divine pattern—a pattern of love and life and creativity—that expresses itself in the creative unfolding of the universe. It repeats in the attractions of planets and stars, and the evolution of life itself. Because fractals continue to repeat in self-similar ways at all scales of size, the same divine pattern emerges at the size of human consciousness—we can find that pattern in our hearts, the expression of love and life and creativity.

So fractals offer a solution to the old quandary of an infinite God relating to a tiny human being. A fractal God engages my intellect as well as my heart. It helps me to make sense of the tender feelings I experience, and to welcome their help for the troubles that life brings. I feel less lonely, when I feel connected to the divine love. It becomes possible to believe that I matter, that I am not just a speck of dust in a vast uncaring universe. I have within me the fractal beauty of the infinite divine.

There are other examples that offer similar metaphors. Each cell of the human body contains the DNA pattern that shapes the whole body. We are like the single cell in the larger body of the universe. God is like the DNA within each cell. Spirituality is a way of connecting our small selves to the mystery and grandeur of the larger whole of which we are a part.

Human beings have always used images to help us understand the mysterious. Many of us carry around images of God that are like bigger versions of human beings—the Nicene Creed says "I believe in God, the father almighty." God is often seen as a father, a king, a ruler, a judge, or a lord. These images work for many people. But when our understanding of the universe grows more complex than these images, we are tempted to give up on the idea of God. For many people, it doesn't make any literal sense to imagine a huge king up in the sky somewhere. And if our experience of these authority figures has been difficult, their images are more likely to inspire fear and guilt rather than help us live our lives.

To imagine God as a fractal pattern, a pattern of love and life and creativity, helps me to be a whole person—to bring together my mind and my heart and my spirit. I am reminded that it is not a new thing to compare God to a geometric shape. The Christian tradition has used the triangle to describe God as trinity. But while the triangle is a static, simple, and smooth figure, a fractal has multiple dimensions, and infinitely complex variations and expressions. That fits my Unitarian Universalist theology—I believe that there are infinite variations in the ways we can experience the holy. As the Sufi poet Rumi has said, "There are hundreds of ways to kneel and kiss the ground."

There is a third reason why fractals matter. Fractals teach us that *we* matter. By becoming aware of the fractal patterns throughout the natural world, we see that all things are connected. The circulatory system of the human body branches out like the limbs on a tree. The circling of electrons around the nucleus of an atom is similar to the circling of planets around the sun. The patterns of waves on the shoreline are similar to the patterns of radio waves beaming through space. Even though we are infinitely small in comparison with the rest of the universe, what happens on a small scale reflects what is happening on a larger scale.

Some of these patterns may seem to be unchanging and eternal, but there is also unpredictability in the system. Scientists use the word *chaos* to describe this unpredictable behavior. Without chaos, there could be no creativity, because creativity means the emergence of something new and unpredicted.

Many of you may have heard of the "butterfly effect." This phrase was used by Edward Lorenz to describe the impossibility of predicting the weather, despite creating complex computer models that looked at multiple variables. But Lorenz found that a small change in the initial conditions would produce large changes when the patterned cycles repeated many times. It was expressed in metaphor as the butterfly effect: a butterfly flapping its wings in South America can change the weather here in Maine.

We have creative power as human beings. That means that what we do within our patterns has an effect on the rest of the fractal network. In our Unitarian Universalist principles we affirm the interdependent web of all existence of which we are a part. If we change a pattern in our lives, it reverberates through the rest of the web; it ripples out like a stone thrown into a pond. We have the power to create more beauty, more love, more truth, and more goodness in the web. We never really know what greater effect we will have on the future of the universe. We cannot control the ripples that flow out. But human beings for centuries have observed that acts of kindness multiply into more kindness in the world.

There is a fable told by the ancient Greek storyteller Aesop:[5]

> A sleeping lion was awakened one morning by a mouse running over his face. The lion became so angry that he grabbed the little mouse in his paws and was about to eat him up. The terrified mouse begged for his life. "Please let me go," he cried. "If you do, one day I will repay you for your kindness." The idea of such an insignificant little creature ever being able to do anything for him amused the lion so much that he laughed out loud and good humouredly let the mouse go.
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> Then, one day the lion got caught in a snare set by a hunter and was unable to get himself free. The mouse heard and recognized the lion's angry roars and ran to the spot where he was. He went right to work gnawing at the ropes with his teeth. Soon the lion was set free. "You laughed at me when I promised to repay you. But now you see that even a little mouse can help a lion." So remember, [the moral goes]: no act of kindness, however small, is ever wasted.

What we do matters. No matter how small we are, we are intimately connected to the vast universe. We are part of its beauty and its creativity and its love. We do not walk alone. These are the lessons I learn from the beautiful geometry brought into the world by Benoit Mandelbrot. May these fractal mysteries teach us ever to be mindful of our power.

Closing Words

Let us close our reflections with the words of Rumi.
Let the beauty we love be what we do: there are hundreds of ways to kneel and kiss the ground.

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[5] This version is from *Fables from Aesop*, adapted and illustrated by Tom Lynch at http://us.penguingroup.com/static/packages/us/yreaders/aesop/index.html