Fractal PowerPoint

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www.FractalFoundation.org

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Fractals are fascinating patterns that appeal to everyone - scientists, artists, children and more. Even if you've never heard of the word "Fractal", you already know lots about fractals, since you're surrounded by them in the natural world. Shapes such as trees, rivers, mountains and clouds are all examples of fractals, and we'll explore some of these here. In addition, we can make incredible fractal artworks using math, and you'll see some examples of these artworks that children have been making. Hence the slogan: "Fractals are SMART: Science, Math & Art."

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What is a fractal anyway? A fractal is a never ending pattern. It's a shape that is made up of little copies of itself. These shapes keep repeating again and again at smaller scales. A good example is the Sierpinski Triangle, which consists of ever smaller versions of the same shape.

The other important thing to know about fractals is that even though they can be very complicated shapes, they're all very simple to make. A fractal is made by repeating a simple process again and again. In this case, we take a triangle, and remove the middle triangle, leaving behind three triangles, and we remove the middle of each of these triangles, leaving 9 triangles, and so on...

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A fern is a great example of a fractal in nature, and you can see that the whole shape is made up of little copies of itself.

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A tree is another great example of a naturally occurring fractal. A little branch of a tree resembles an entire tree. Furthermore, it's very easy to build a tree - you don't even have to - it builds itself. Here's the key: after a seed is planted, it sends up a sprout, and then the sprout splits into branches. Each of these branches then splits again into more branches, and this keeps repeating. After many years, we end up with a large, complex fractal object like this oak tree.

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We have fractals inside our bodies! We are full of them. Our lungs are a good example. They're shown upsidedown here to show how similar they are to... a tree! Nature reuses its patterns. Why do our lungs have the same shape as a tree? It's no coincidence. It's because they serve the same function. Both are specialized for *breathing*. Plants and animals breathe in opposite directions (we inhale oxygen and give off CO_2, plants do the reverse), but both the lungs and the trees need to contact as much air as possible. This is where the fractal branching pattern is so useful. If you could spread out the surface of our lungs and stretch it out flat, it would cover a surprisingly large area: About 100 square meters, or roughly the size of a tennis court! It's the power of fractal geometry.

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Our brains are also full of fractals. We have about 100 billion of these fractal branching neurons, and they form an incredibly complex interconnected network. It's these interconnections that give us the amazing abilities we have, and this is only possible because of their branching fractal structure.

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Our blood vessels are another great example of fractals inside our bodies. They form a branching network that allows our heart to deliver blood to every single cell in our bodies - quite an impressive engineering feat. And we have A LOT of blood vessels. In fact, if you could stretch out our entire circulatory system and measure the length of all our blood vessels, it would be about 100,000 miles! Enough to stretch around our whole planet, 4 times!

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We can also find fractals on the surface of the Earth, as in this river network or watershed. You can see how a little piece looks like a bigger piece, which looks like the whole pattern. Furthermore, like all fractals, it's made by repeating a simple process. In this case, all that has to happen is for rain to fall, and then flow downhill. The water erodes a channel, and then when the rain falls again it carves it a little deeper. Erosion is very slow - but nature has a lot of patience. After millions of years, we end up with huge, complex, and beautiful canyons.

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The last fractal formed over millions of years. But this fractal forms in a millionth of a second. So we can see that fractals occur in a wide variety of systems, and over a vast range of scales, of both space and time. Some fractals are microscopically tiny, some are gigantic, some are incredibly slow, some are extremely fast.

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We've seen several examples of branching fractals in nature - and there are many more. But now we'll look at another type of fractal - the spiral family of fractals.

A hurricane is a giant, self-organizing spiral storm, that can be hundreds of kilometers across.

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But here is an even larger spiral - this spiral galaxy is much, much larger. These are the largest spirals we know of in nature. We can't even measure this in miles or kilometers, instead, we use light years. It takes a beam of light about 100,000 years to go from one side of this spiral to the other. It's a collection of hundreds of billions of stars - and there are hundreds of billions of spiral galaxies. Truly, the universe is full of spirals.

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Remarkably, we see the same exact shapes right here on earth, in a seashell or a snailshell. These creatures don't have a plan to build a spiral - they just keep doing the same simple thing over and over again: they keep adding a wedge to their shell, and each section is a little bigger - and a little rotated - from the one before. And that's all it takes to create a spiral: twisting and growing, expanding while rotating.

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We also find spirals in the plant kingdom, as in this agave cactus, which also grows by expanding and rotating.

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A very similar pattern occurs in many flowers, such as sunflowers, or this coneflower - as well as in pinecones, pineapples, artichokes, etc.

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Spirals are also often found in artworks - from all cultures - and here is an example of a fractal-inspired flying artwork. Consisting of 168 connected spirals, this flying fractal hotair balloon is the world's largest tiedye.

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The Fractal Foundation is working to produce a fullsize digital fractal balloon, which will be made using algebra in a computer, and then the imagery will be printed onto ripstop nylon and assembled into a balloon. This artwork will contain approximately 100 billion pixels, or roughly the same number of stars as are in a galaxy, and the same number of neurons in our brains...

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You can create algebraic fractals yourself, and explore the infinite beauty of math using XaoS, a fantastic, simple, free program that runs on Mac, windows or Linux.

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This program lets you point and click and zoom into the fractals, allowing you to glimpse the infinite extent of fractal math. You don't need to understand algebra to explore fractals, but you can see here that it only takes a very simple equation to create an infinitely complex fractal like the Mandelbrot Set. The key - as always - is that we repeat a simple process again and again, to create a fractal.

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Students in New Mexico are using this XaoS program to create incredibly beautiful fractals, and the winning artworks from the Albuquerque Fractal Challenge are displayed on billboards, and the sides of buildings as giant public artworks.

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But you don't even need a computer to create fractals. All you really need is a paper and pencil and a good imagination, as shown by this drawing from a 3'd grader of a fractal smiley face.

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Thank you... and remember that fractals are SMART, Science, Math & Art. And enjoy all the fractals!