

# The Fractal Structure of the Universe

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The Discovery Center June 2011

# Outline

- 1 The Fractal World
- 2 Erosion
- 3 River Basins
- 4 River Flow

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# Most things made by nature are fractals



What do a fern and  
stock market fluctuations  
have in common?

picture  
of a  
cauliflower

stock  
market  
chart

Fractal geometry is based on the repetition of the same pattern at smaller and smaller scales (look carefully at the fern). Such a self-similar structure can be found almost everywhere. It describes the shape of cauliflowers, clouds, lungs, coastlines, the distribution of galaxies throughout the cosmos, and even the way stock prices evolve over time.

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# Most things made by nature are fractals



What do a snail and  
the number  $(1+\sqrt{5})/2$   
have in common?

picture  
of a  
violin



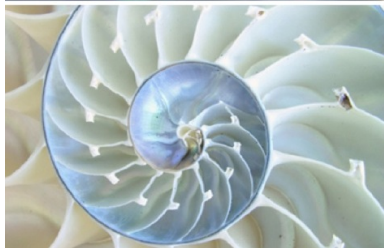
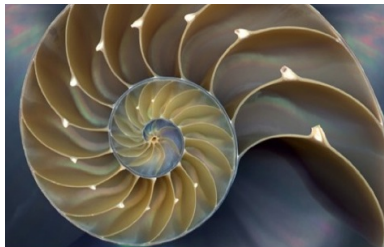
The number  $(1+\sqrt{5})/2$  is the golden mean which is found in many parts of nature. The spiral shell of the nautilus is an example of a geometric construction based on this number. Even Stradivarius used it when constructing his famous violins.

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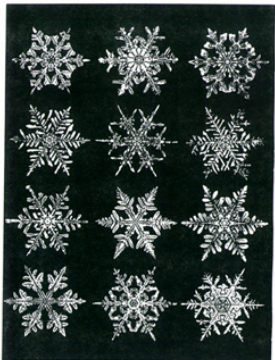
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# Fractal Nautilus Shell



# They come in beautiful self-similar shapes



What do a snowflake  
and a heart attack  
have in common?



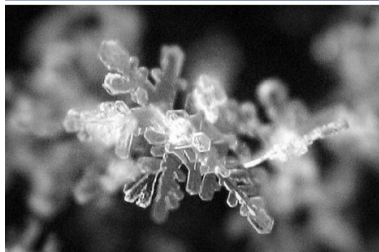
The formation of snowflakes, the fluctuations of some animal populations, the frequency of volcanic eruptions, the propagation of epidemics, variations in climate, irregularities of heart beat, all these phenomena are described by chaos theory, a branch of mathematics which looks for order in chaos – and chaos in order.

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# Real Snowflakes

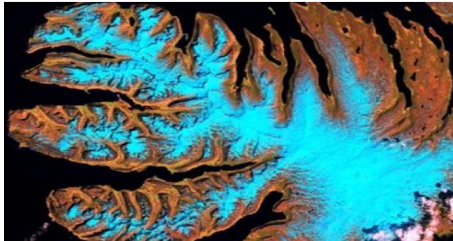




# Fractals Shorelines



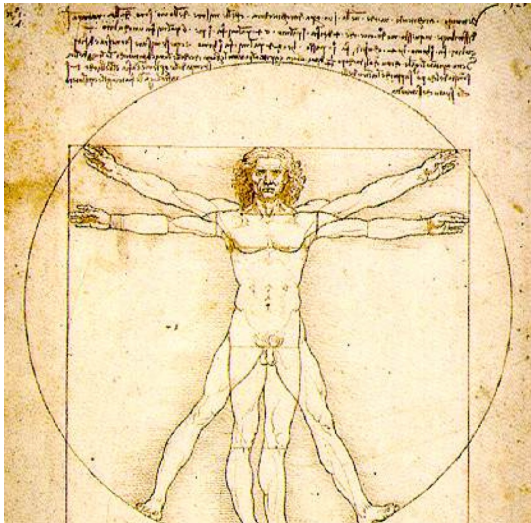
# Fractal Shorelines and Fjords



# Our Man-made World Consists of Boxes



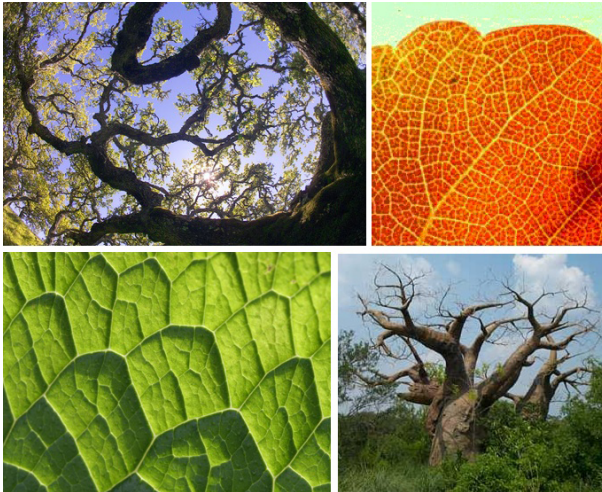
We even tried to put the human body into a rectangle



Most things made by nature are not rectangular or circular



# Leafs and Tree-branches are fractals



# Fractal lightnings and crystals



# Perhaps life itself has a fractal structure



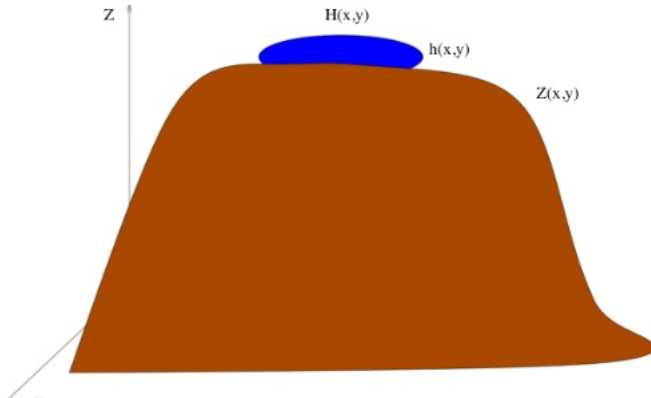


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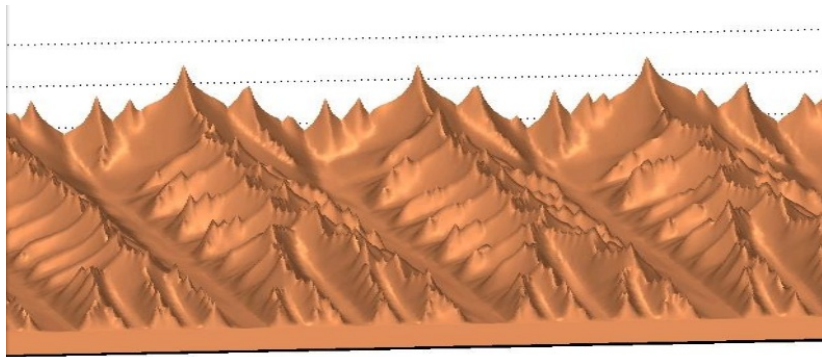
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# Erosion

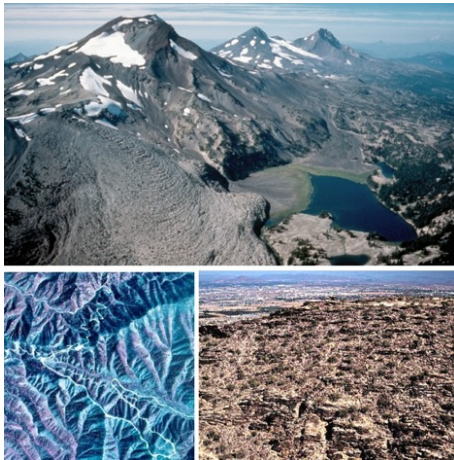
How does the surface of the Earth evolve?



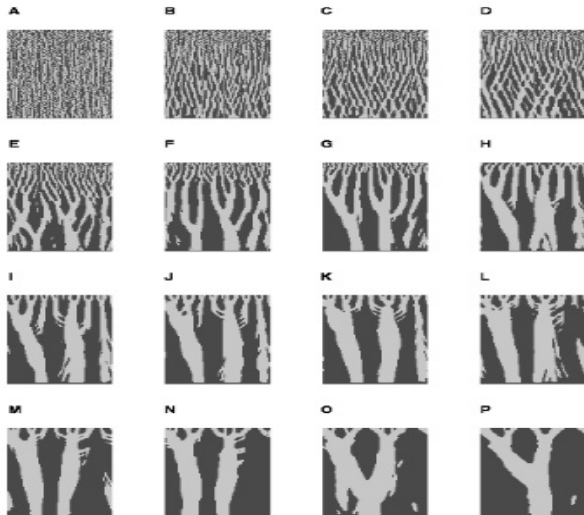
# River Valleys with Uplift



# Mountain Ranges are Fractals



# The Merging of the Rivulets

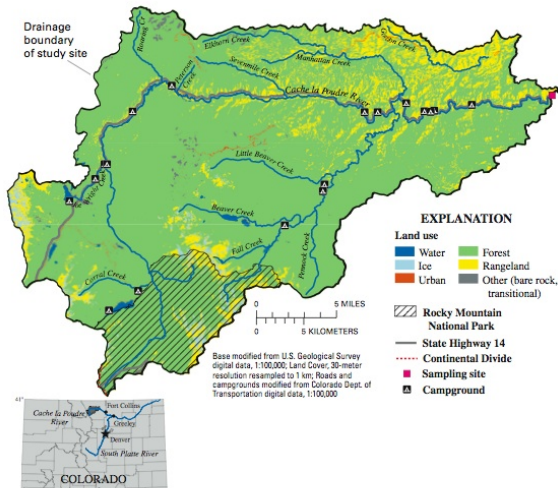


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# The Cache la Poudre River Basin near Ft. Collins, CO

We all live in a river basin



# The Amazon River Basin

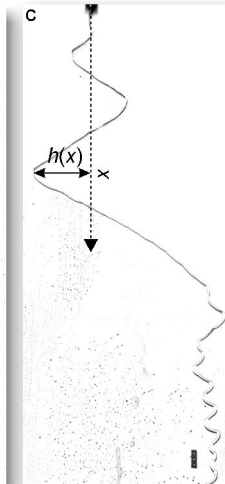
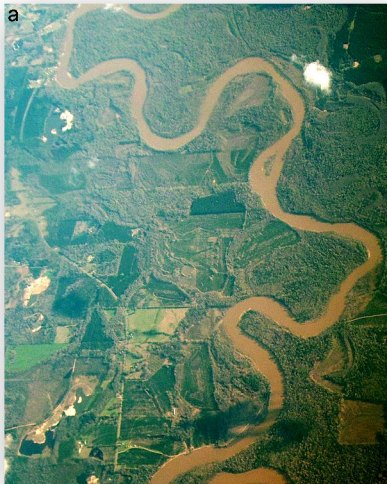




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# Meanderings of the Mississippi



# A Drawing of an Eddy

Studies of Turbulence by Leonardo da Vinci

