

# Computer Graphics

## Procedural Geometry Using Fractals

Based on slides by James Kuffner (CMU) and Li Zhang (WISC)

# Procedural Shape Modeling



Simple procedure



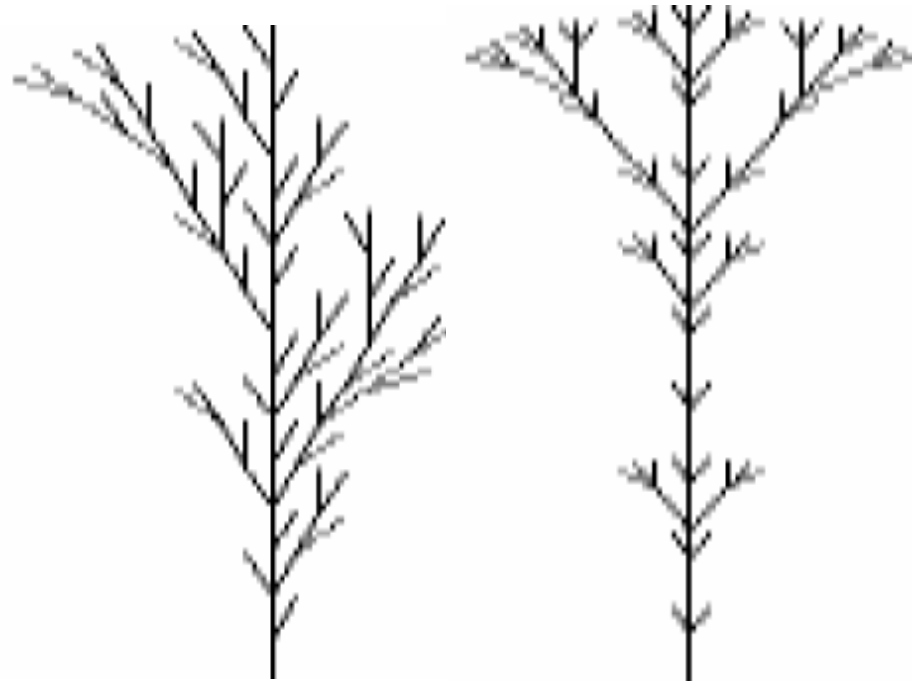
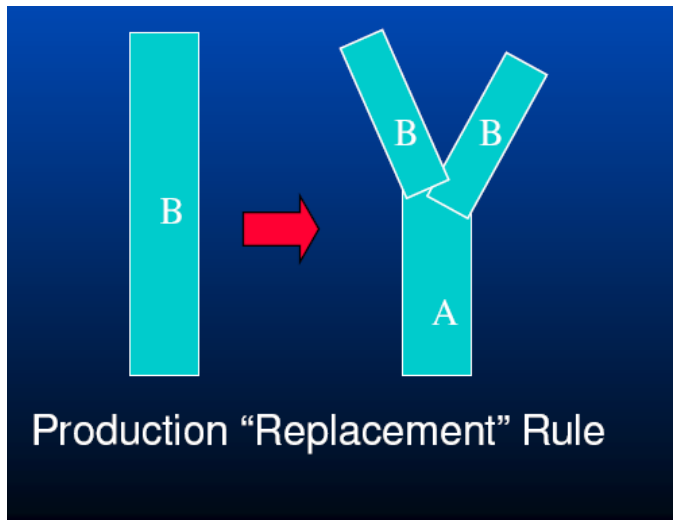
# Fractal Plants (L-Systems)

- Uses “production rules” applied to a seed “axiom”

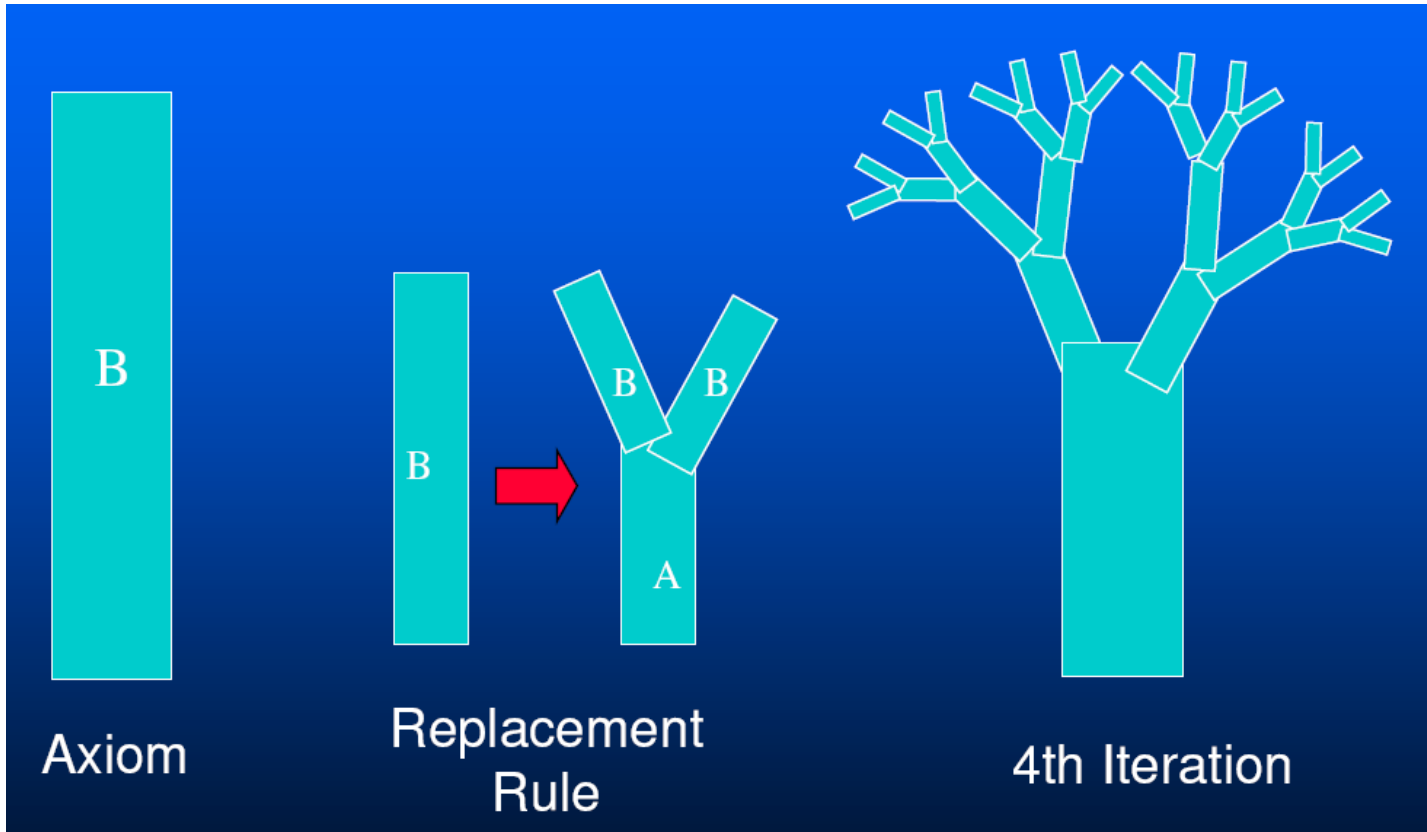
- Example:

Axiom: B

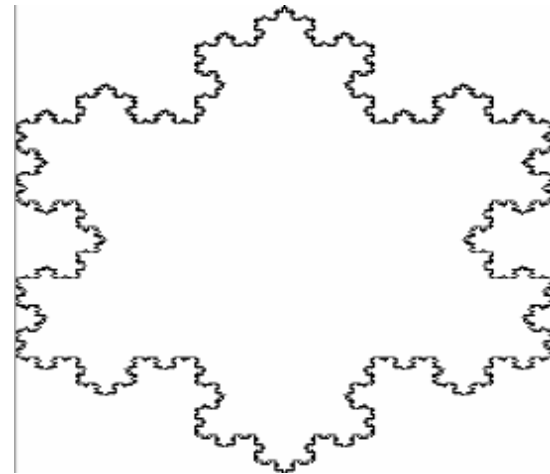
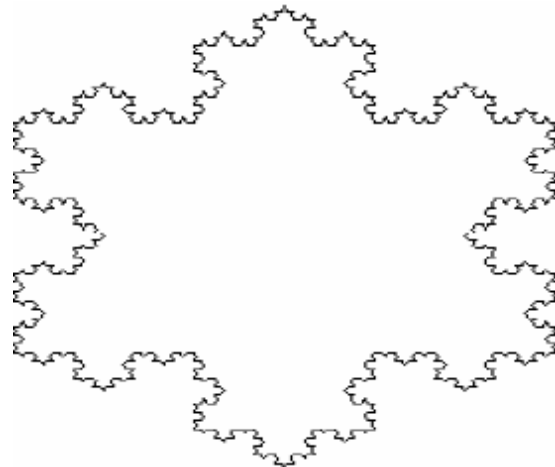
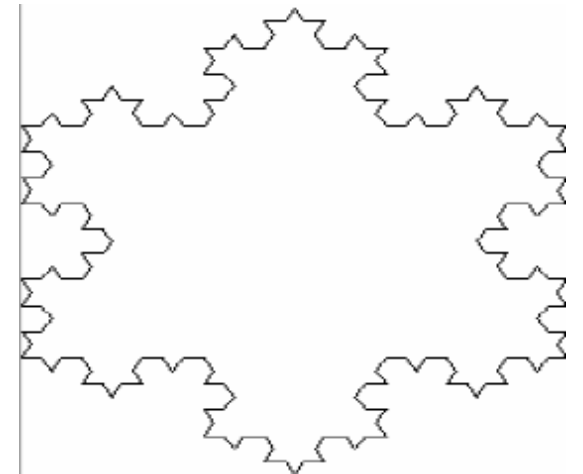
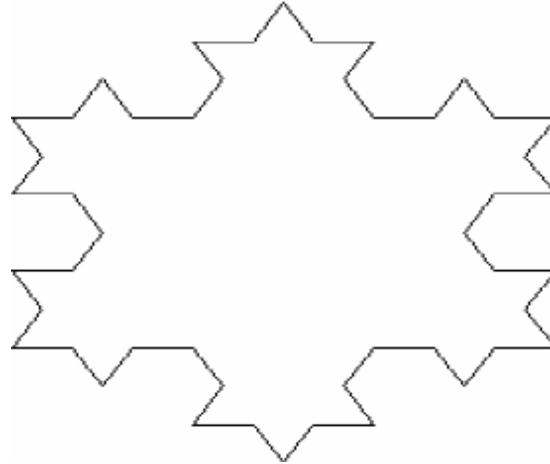
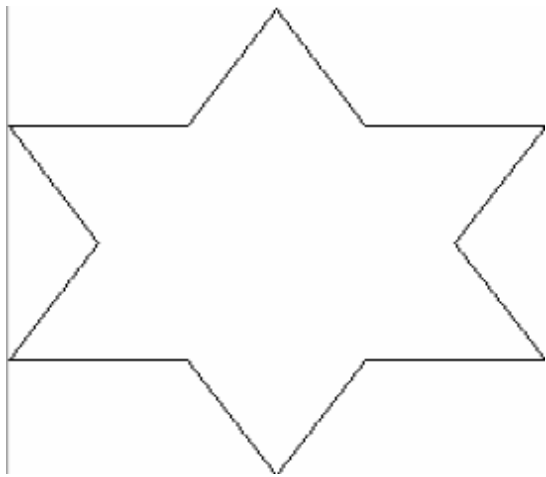
Rule:  $B \rightarrow A[-B][+B]$



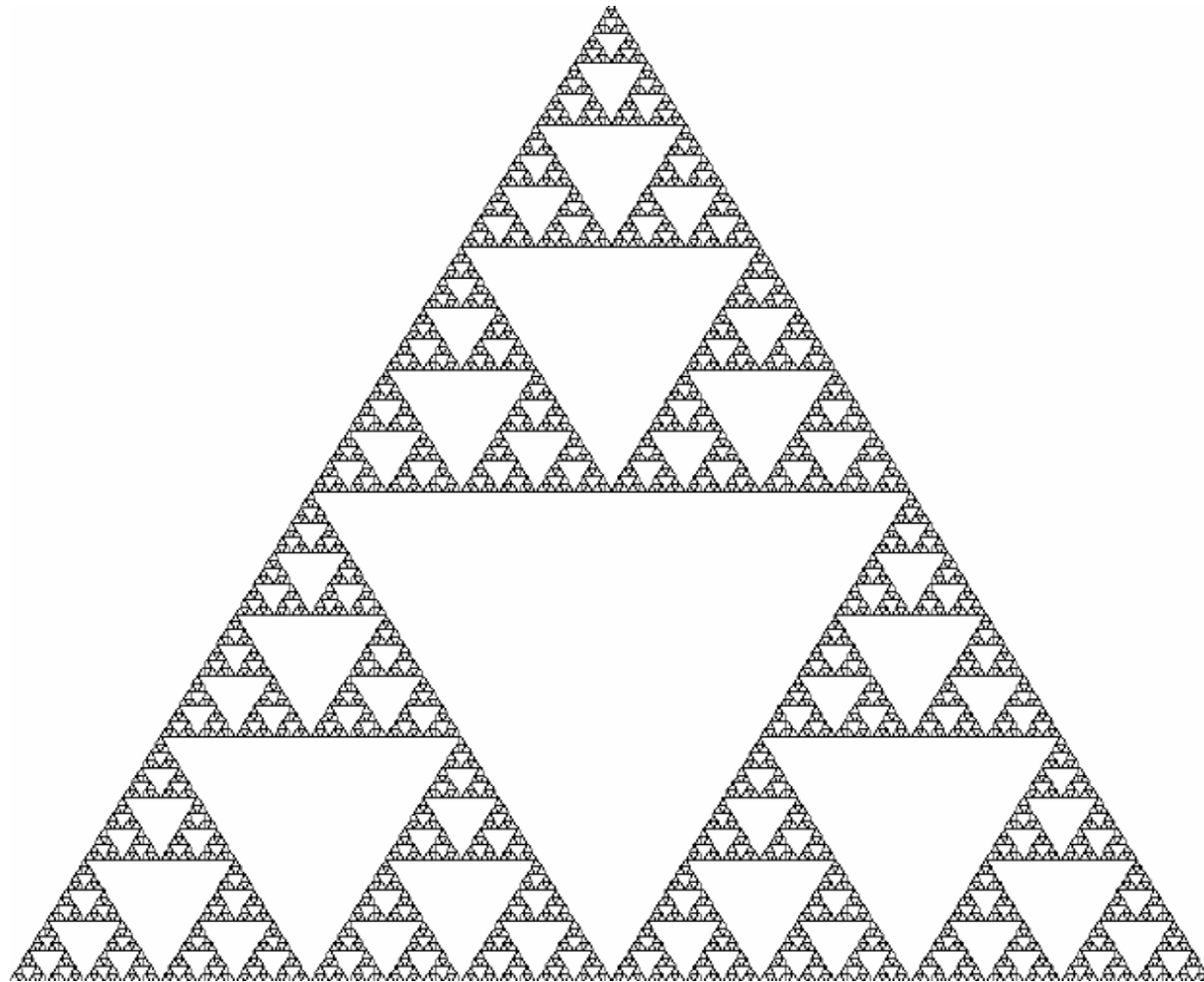
# L-system Example



# L-systems example: Koch snowflake

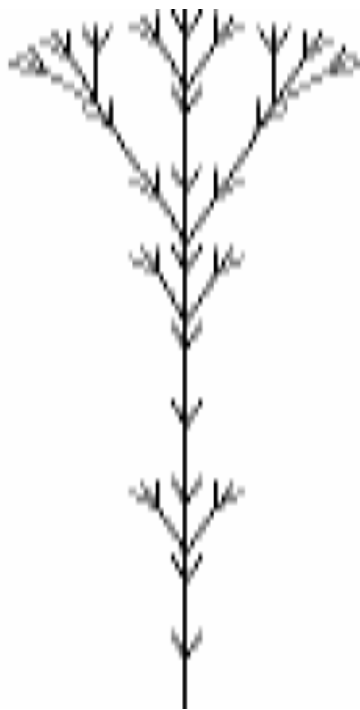


# L-systems example: Sierpinski Triangle

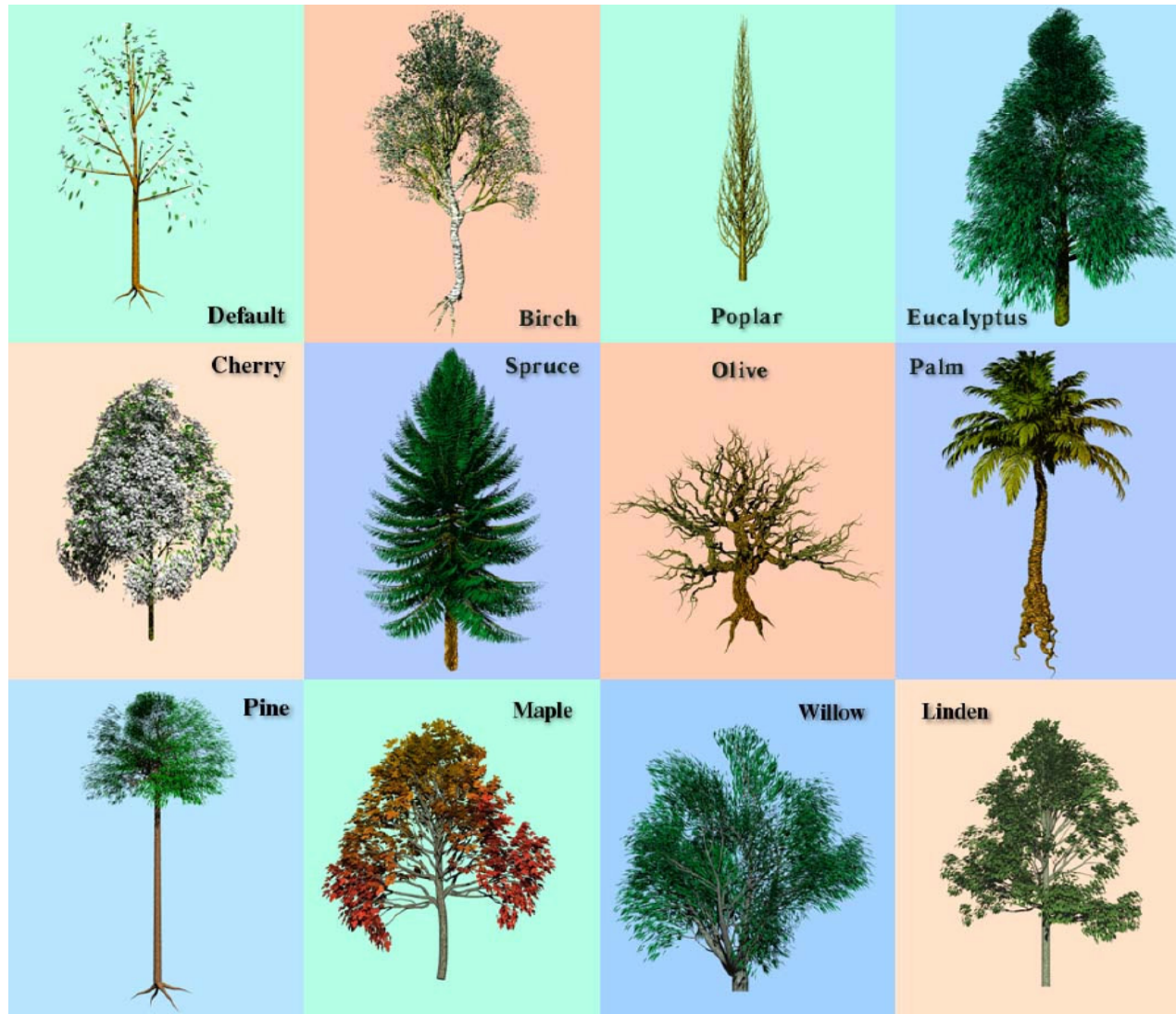


# Procedural Trees and Bushes

- Define a branch structure
- Define a leaf



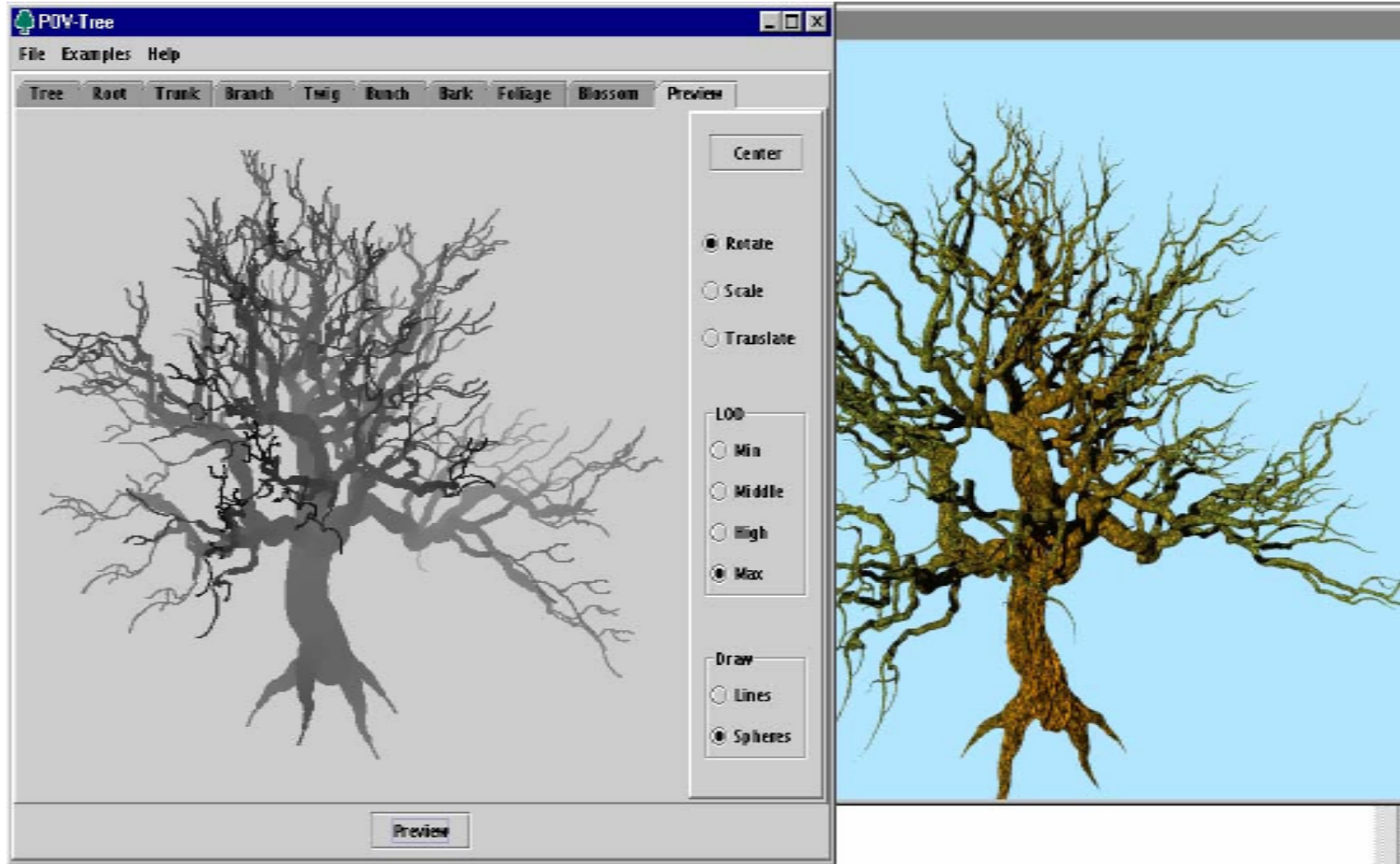
# Procedural Trees from PovTree



<http://propro.ru/go/Wshop/povtree/tutorial.html>



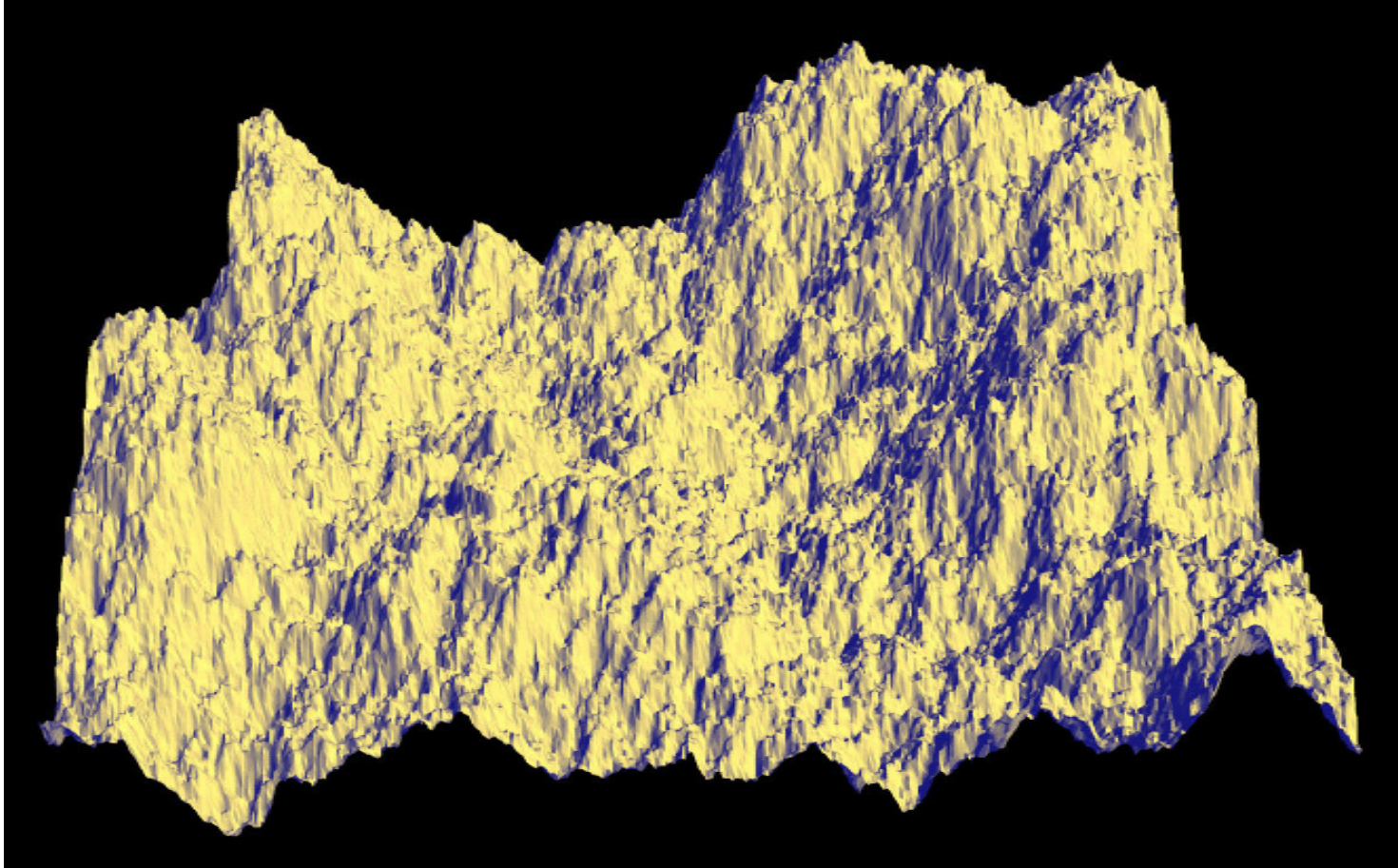
# Interactive Fractal Tree Design



# Algorithmic Plants

- Excellent web resource with a free online book:  
<http://algorithmicbotany.org/>
- Numerous papers by Przemyslaw Prusinkiewicz and colleagues

# Procedural Terrain Modeling



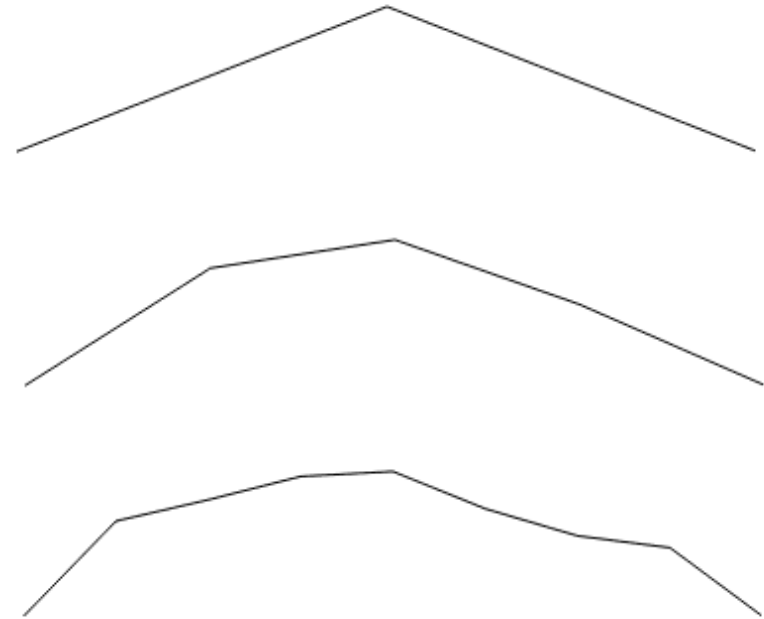
- Has a gross structure
- Also with some randomness
- Want a height map  $z=h(x,y)$

F.K. Musgrave

# 1D case



Want a function  $y=h(x)$



Start with a single horizontal line segment.

Repeat for a sufficiently large number of times

{

Find the midpoint of the line segment.

Displace the midpoint in Y by a random amount.

Recursively apply this operation for the resulting two segments

with reduced range for the random numbers (by a factor  $0 < f < 1$ ).

}

# 1D case



Want a function  $y=h(x)$

Results with different  $f$



Start with a single horizontal line segment.

Repeat for a sufficiently large number of times

{

Find the midpoint of the line segment.

Displace the midpoint in Y by a random amount.

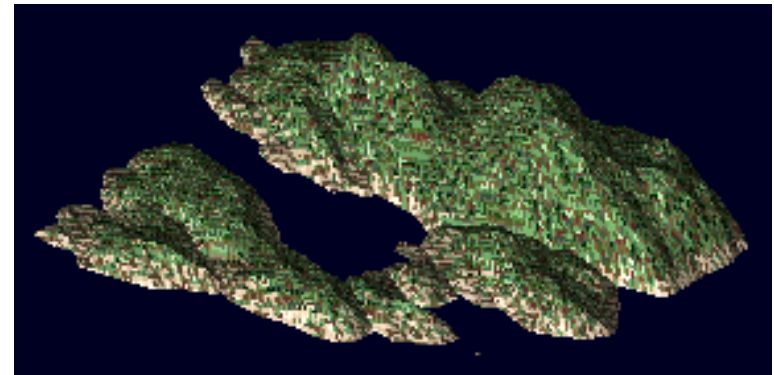
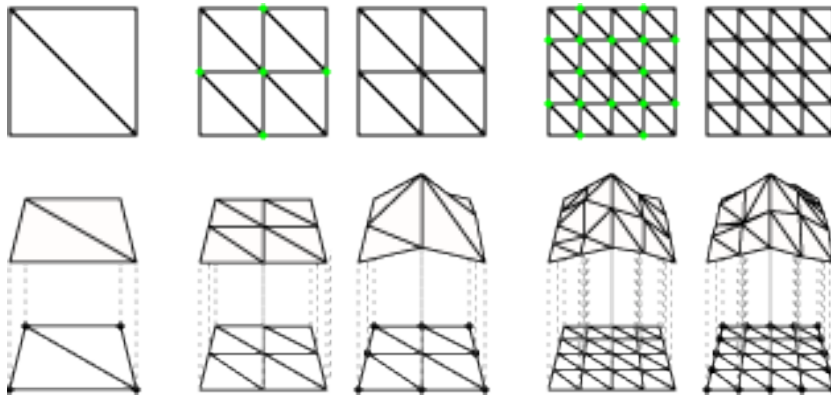
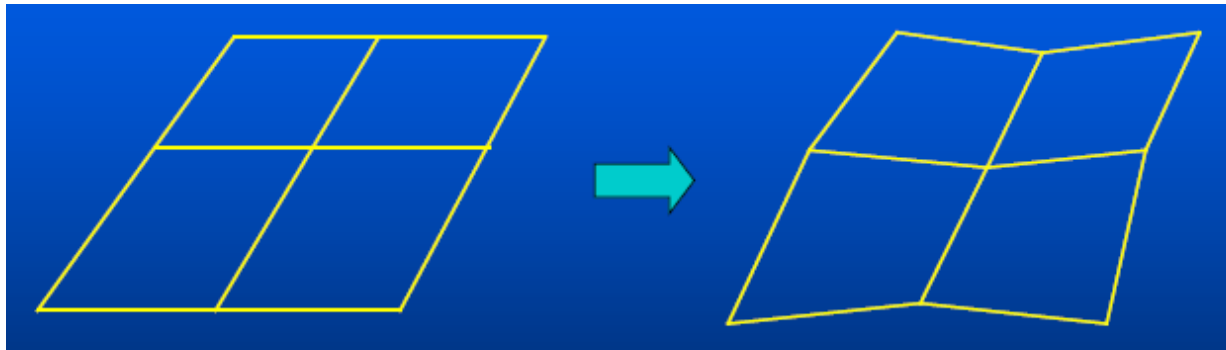
Recursively apply this operation for the resulting two segments

with reduced range for the random numbers (by a factor  $0 < f < 1$ ).

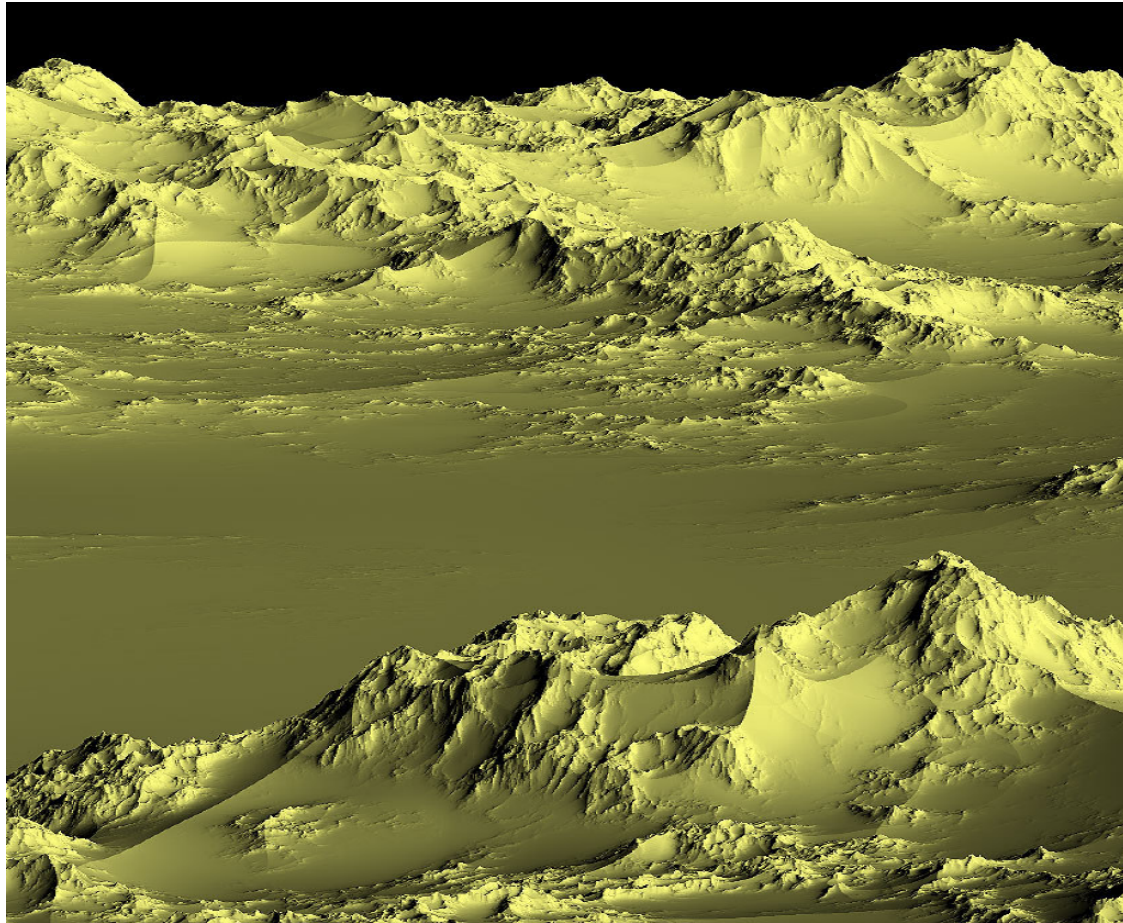
}

# 2D case

- Subdivide and Displace



# 2D case



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# Texture mapping

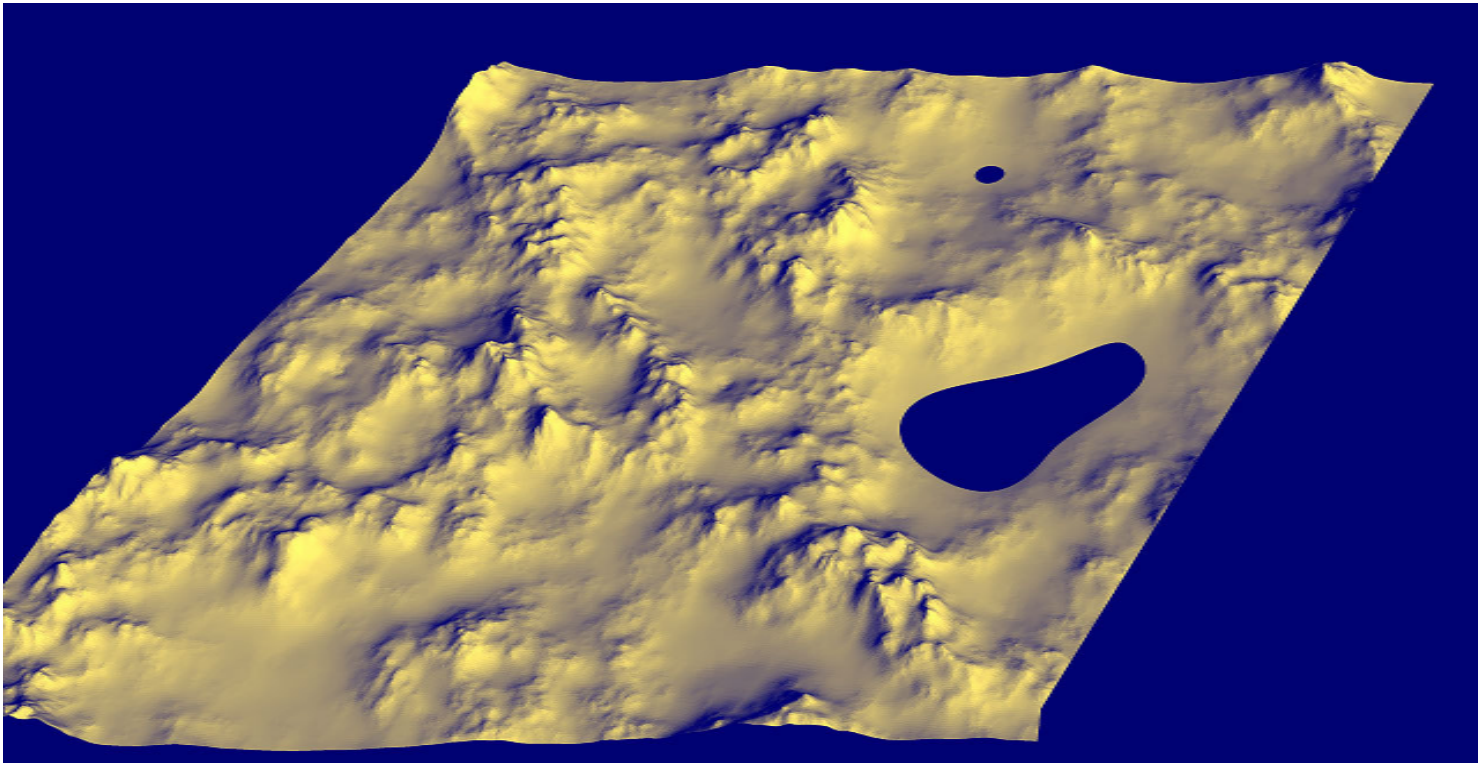


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# Adding water

- Use an elevation threshold ( $z < z_{\text{water}}$ )



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