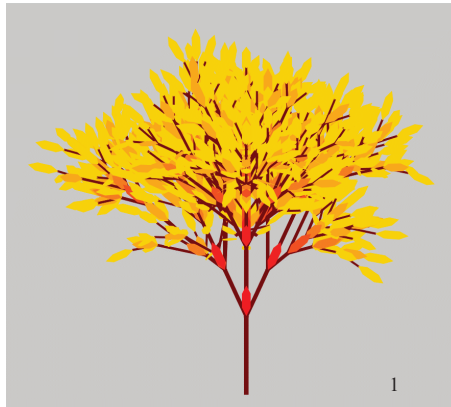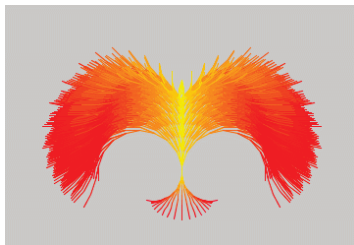# Experimenting with Grammars to Generate L-Systems – in JFLAP
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L-Systems

- Grammatical systems introduced by Lyndenmayer
- Model biological systems and create fractals
- Similar to Chomsky grammars, except all variables are replaced in each step, not just one!
- Successive strings are interpreted as strings of render commands and displayed graphically
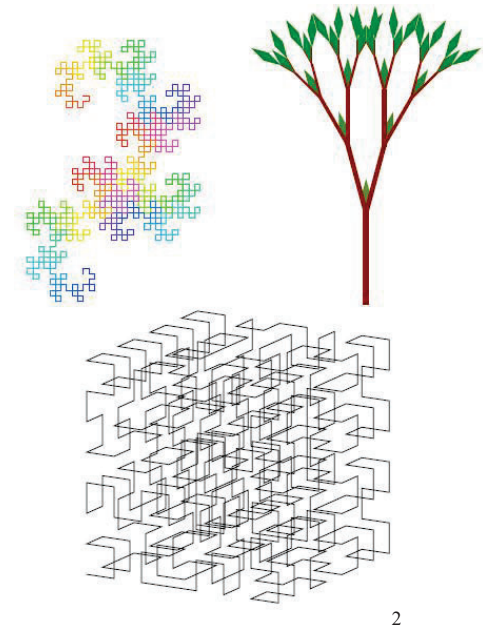
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Parts of an L-System
(a type of grammar)

- Defined over an alphabet
- Three parts
  - Axiom   (starting place)
  - Replacement rules (replaces all variables at once)
  - Geometric rules (for drawing)
    - g   means move forward one unit with pen down
    - f   means move forward one unit with pen up
    - +   means turn right by the default angle
    - -   means turn left by the default angle

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L-System

An L-system is composed of three parts (Σ, h, w)

Σ	finite alphabet	set of symbols
h	rewriting rules	each symbol is replaced by string of symbols
w	axiom	starting point

h is finite substitutions, h:$\Sigma \to \Sigma^*$.

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h(w)

h(w) is computed by replacing every symbol in w that has a rewrite rule by that rule.

A language L of an L-system is the word sequence generated by

- $h^0(w) = w$
- $h^1(w) = h(w)$
- $h^2(w) = h(h(w))$
- ...

$$\mathbf{L} = \{h^i(w) \mid i \geq 0\}$$

NOTE: If h(a)=bb we will write this as a rule

$$a \to bb$$

Example:

Σ alphabet: $\{a, b\}$
h   rules: a → aa
                    b → ab
w   axiom: ab

What is the language L of strings represented by this L-system?

L =

Drawing a picture of an L-system

Defining an L-system: (3 parts in this order)

- Axiom definition: This must be the first line of the file
- Production rules: Defines the replacement rules.
- Geometric rules: Defines colors, widths, etc.

Graphically represent

Symbols for drawing and moving:

- g: draw a line one step in the current direction
- f: move forward one step in the current direction

Example: example1

axiom X

X -> g f g X

distance 15
lineWidth 5
color black

L =
What does this draw?

Geometric rules

- +   change direction to the right
- −   change direction to the left
- %   change direction 180 degrees
- ~   decrement the width of the next lines
- [save in stack current state info
-]   recover from stack state info
- {   start filled in polygon
- }   end filled in polygon

Example – lsys-samp1

- Axiom
- Replacement Rules
- Geometric Rules

JFLAP : (lsys-samp1.jff)
File Input Help
Editor
Axiom: X

| X | → g g g X + Y |
| Y | → g |

Name	Parameter
lineWidth	5
distance	15
color	blue
angle	15
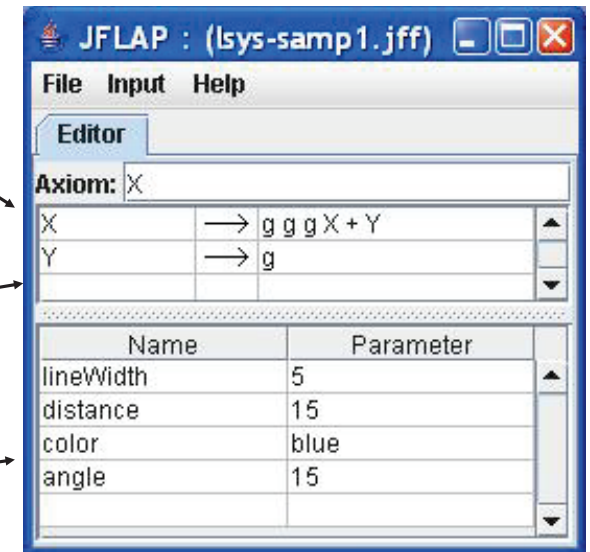
NOTE: Must use spaces as separator between symbols

Example – lsys-samp1

- What are the strings?

L = {X,

JFLAP : (lsys-samp1.jff)

File   Input   Help

Editor

Axiom: X

| X | → | g g g X + Y |
| Y | → | g |

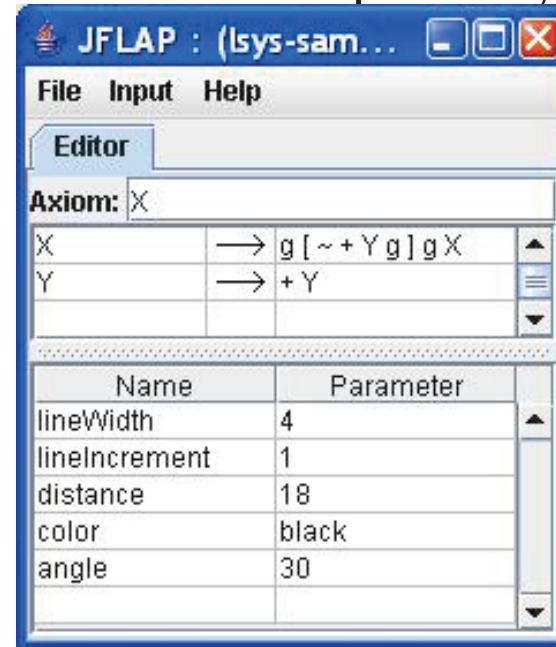| Name	Parameter
lineWidth	5
distance	15
color	blue
angle	15
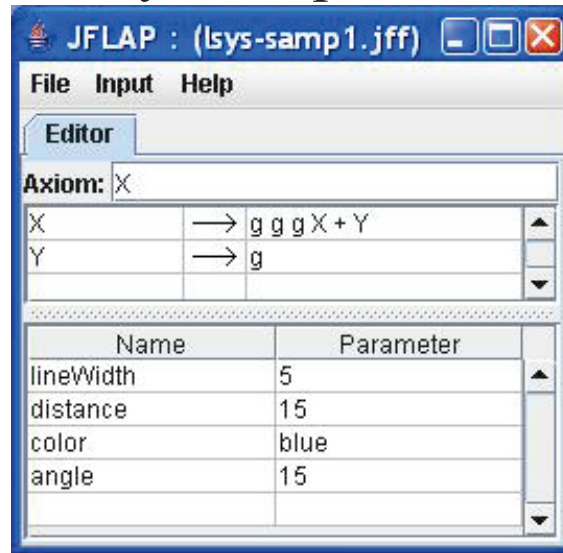
NOTE: Must use spaces as separator between symbols

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Example – lsys-samp2

- What are the strings?

L = {X,

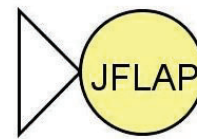**JFLAP : (lsys-sam...)**

File   Input   Help

Editor

Axiom: X

| X | → | g [~ + Y g] g X |
| Y | → | + Y |

Name	Parameter
lineWidth	4
lineIncrement	1
distance	18
color	black
angle	30

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Example - tree

JFLAP : (tree.jff)

File   Input   Help

Editor

Axiom: R ~## B

B	→	[~## T L - B + + B]
L	→	[{ - g + + g % - - g }]
R	→	! @@ R
T	→	T g

Name	Parameter
color	brown
polygonColor	forestGreen

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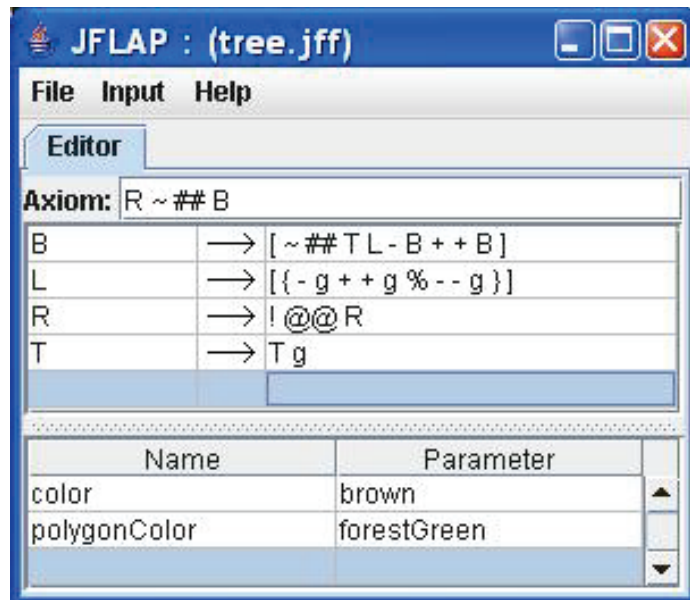
JFLAP

JFLAP

- JFLAP is available for free:
  - www.jflap.org
- Duke School of Environment uses L-systems to model pine needles in Duke Forest

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