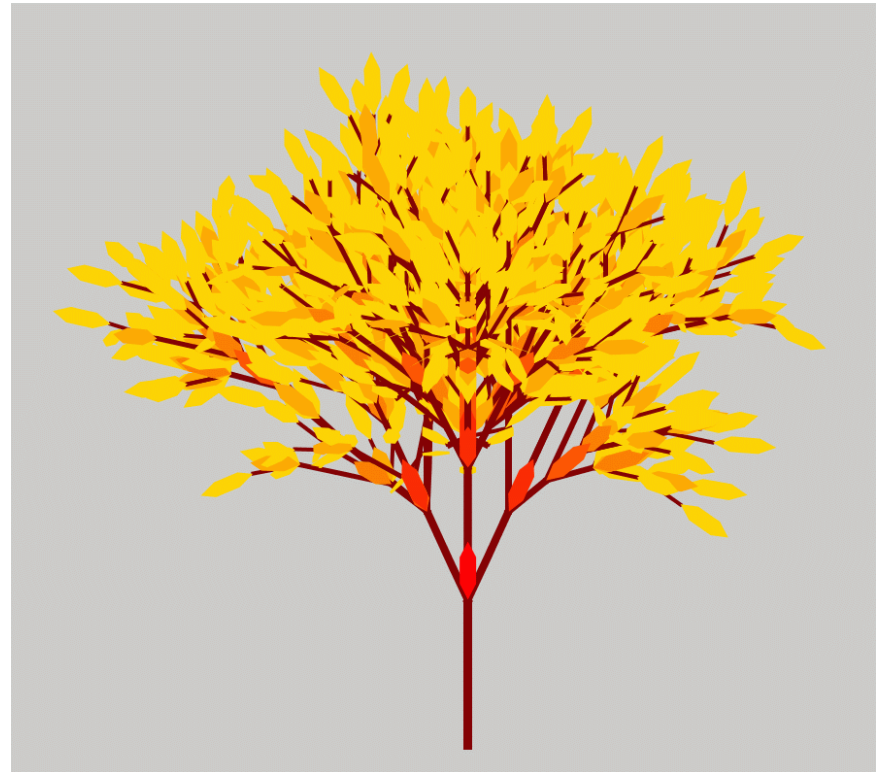# Experimenting with Grammars to Generate L-Systems – in JFLAP March 29, 2012
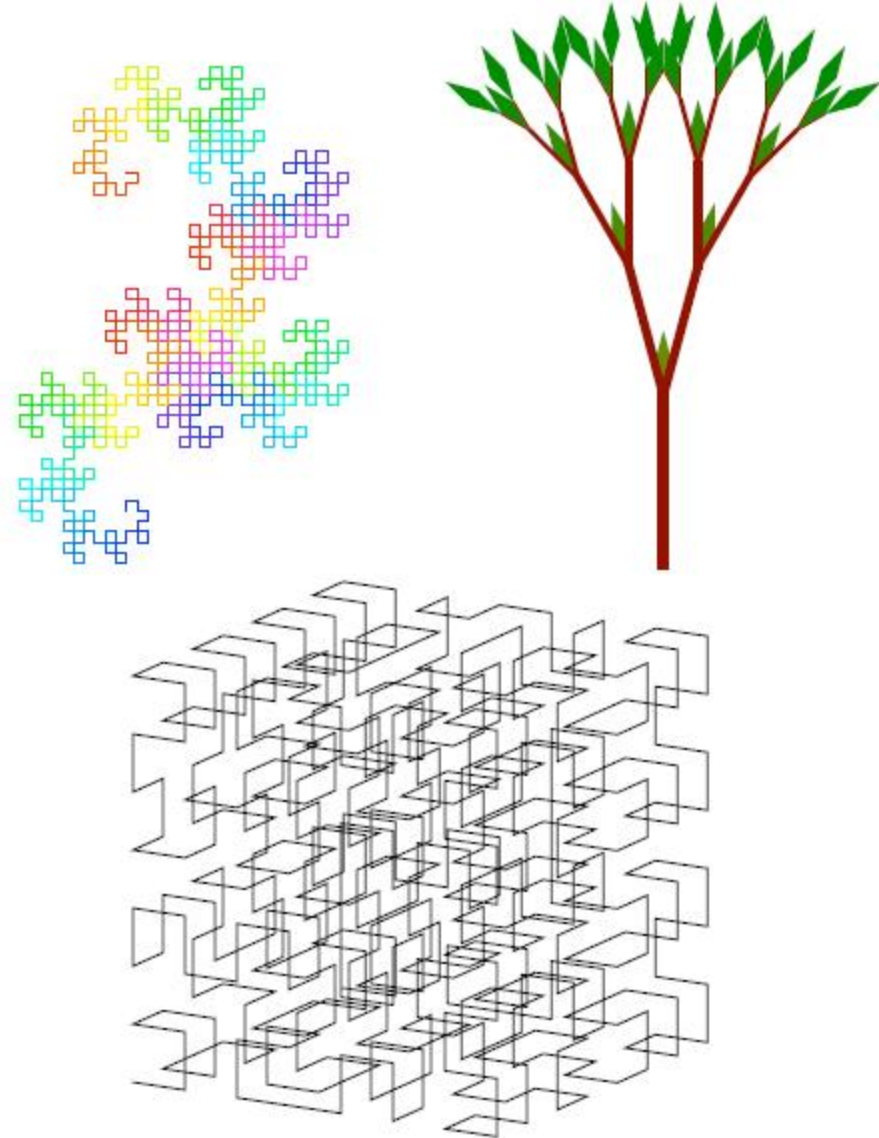
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L-Systems

- 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

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

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, $h : \Sigma \to \Sigma^*$.

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

- $h^0(w) = w$
- $h^1(w) = h(w)$
- $h^2(w) = h(h(w))$
- $\ldots$

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

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

$$a \rightarrow bb$$

Example:

Σ **alphabet:** $\{a, b\}$

h   **rules:**   **a $\rightarrow$ aa**

                         b $\rightarrow$ 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
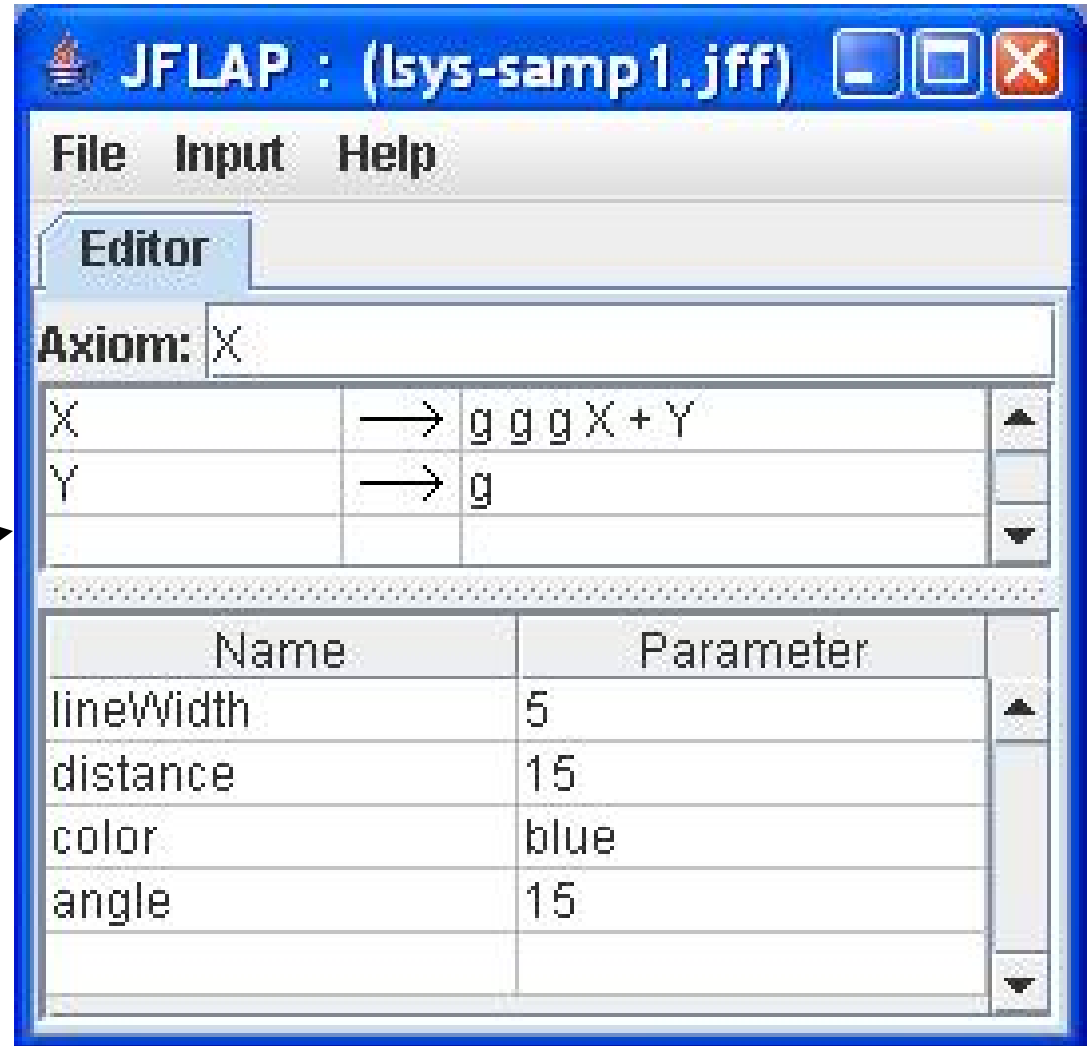
NOTE: Must use spaces as separator between symbols

Example – lsys-samp1(cont)

- Derivation of strings

X

gggX+Y

ggggggX + Y + g

gggggggggX+Y+g+g

gggggggggggggX+Y+g+g+g

Note: replace both
X and Y each time

Example – lsys-samp2

JFLAP : (lsys-sam...

File   Input   Help

Editor

Axiom: X

X	$\longrightarrow$	g [~ + Y g] g X
Y	$\longrightarrow$	+ Y

Name	Parameter
lineWidth	4
lineIncrement	1
distance	18
color	black
angle	30
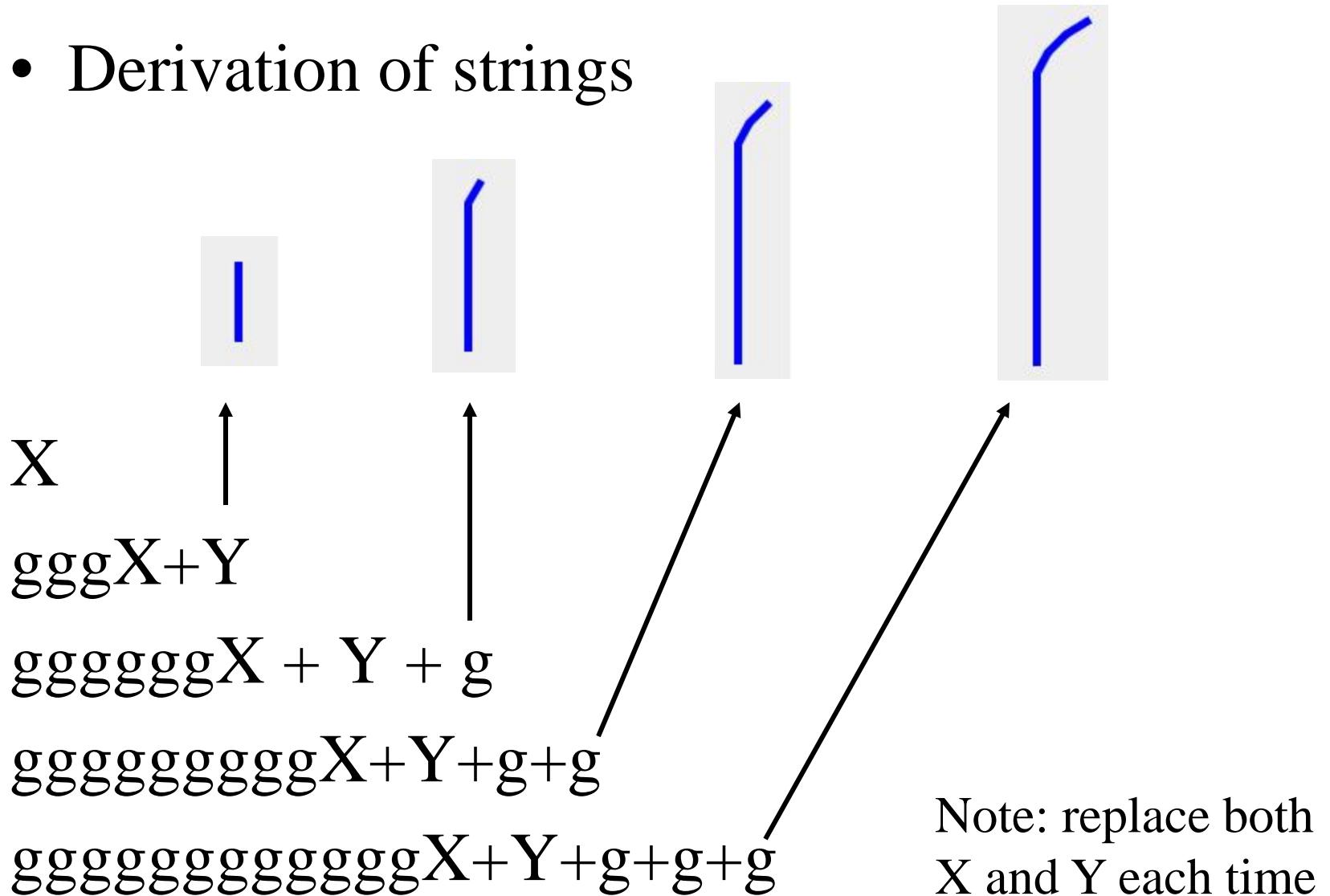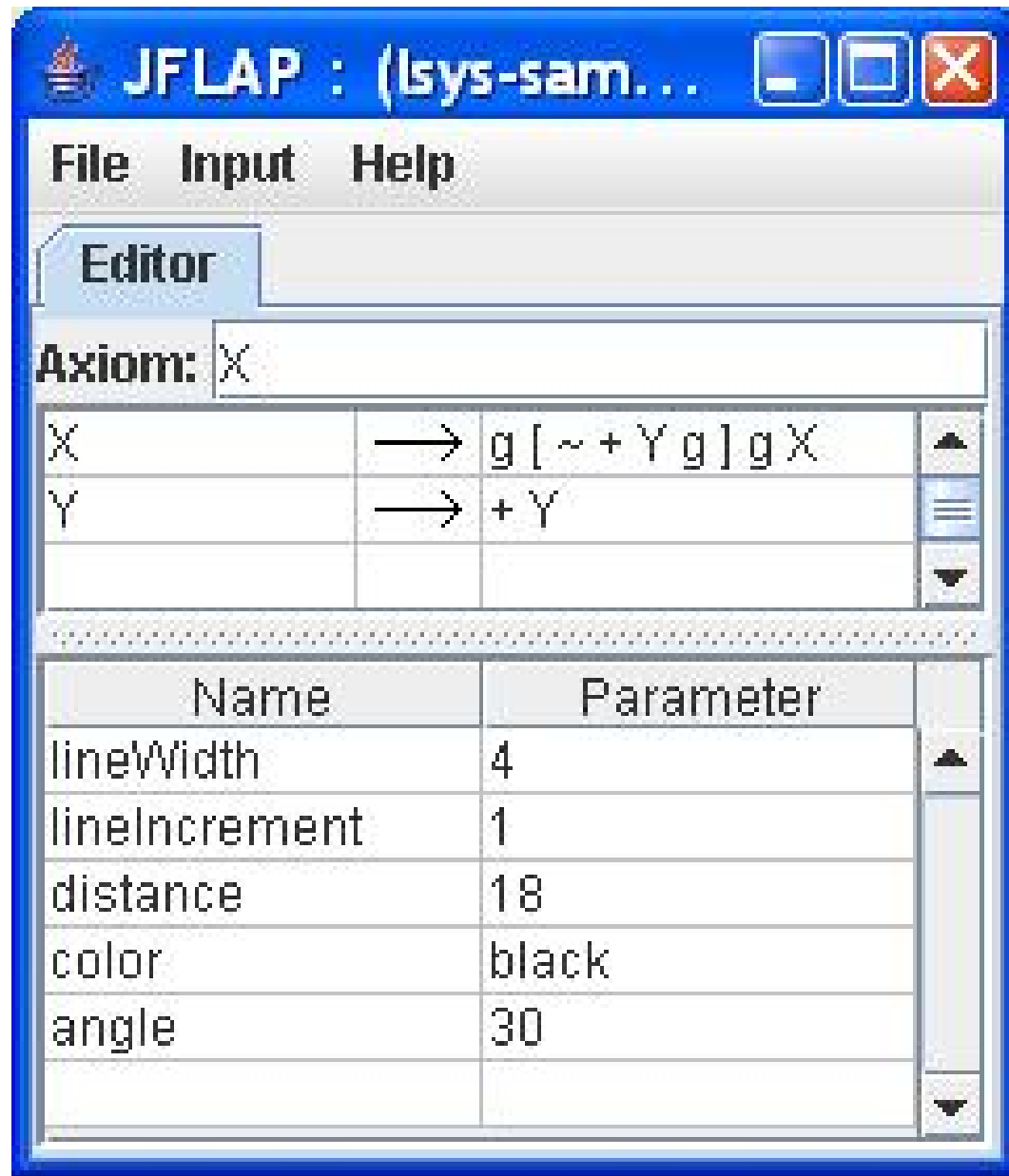
Example – lsys-samp2 (cont)

g[~+Yg]gX

    g[~++Yg]gg[~+Yg]gX

        g[~+++Yg]gg[~++Yg]gg[~+Yg]gX

      …
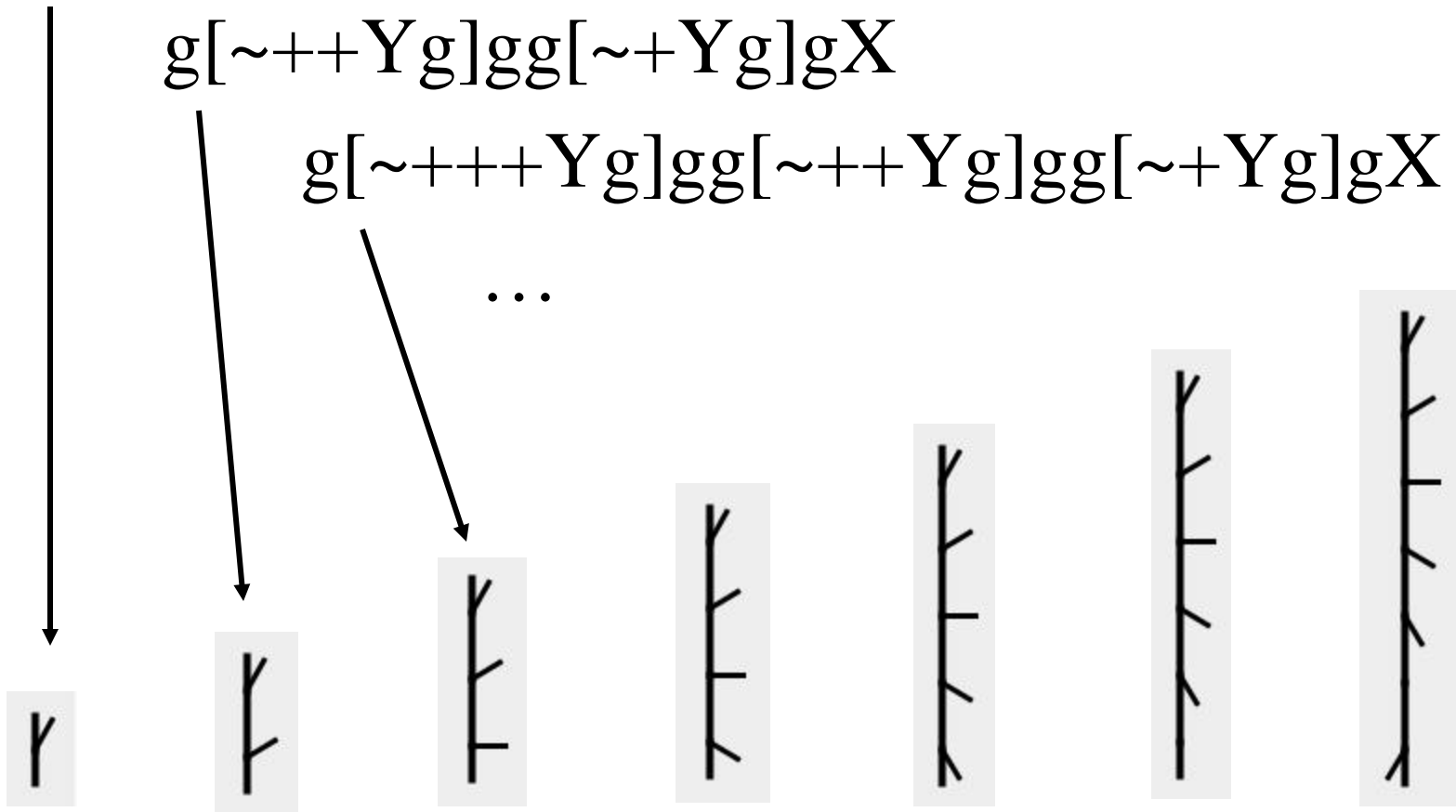
Example - tree

JFLAP : (tree.jff)

File   Input   Help

Editor

Axiom: R ~ ## B

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

Name	Parameter
color	brown
polygonColor	forestGreen

Example – tree rendered
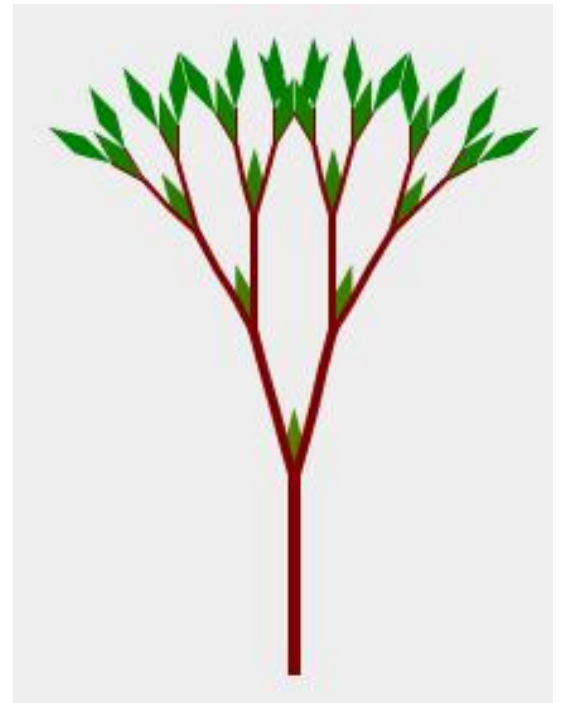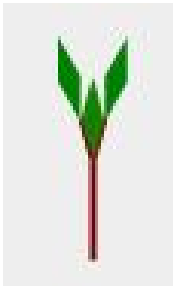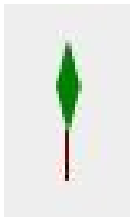
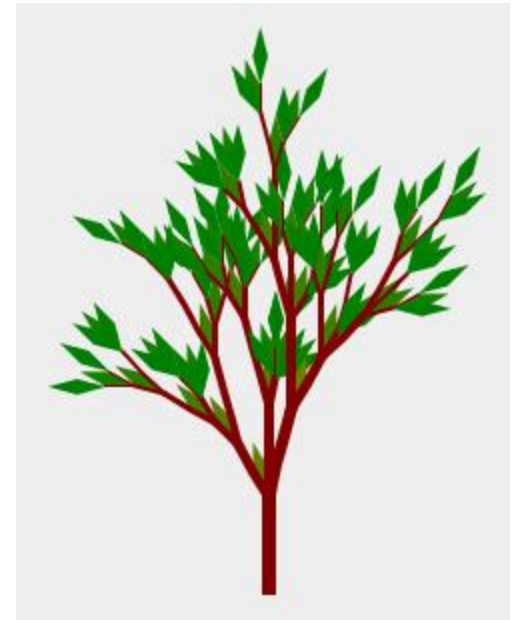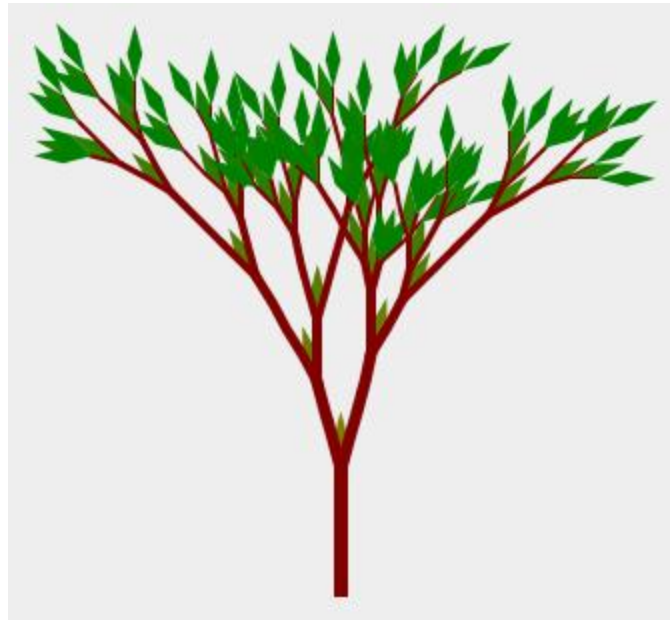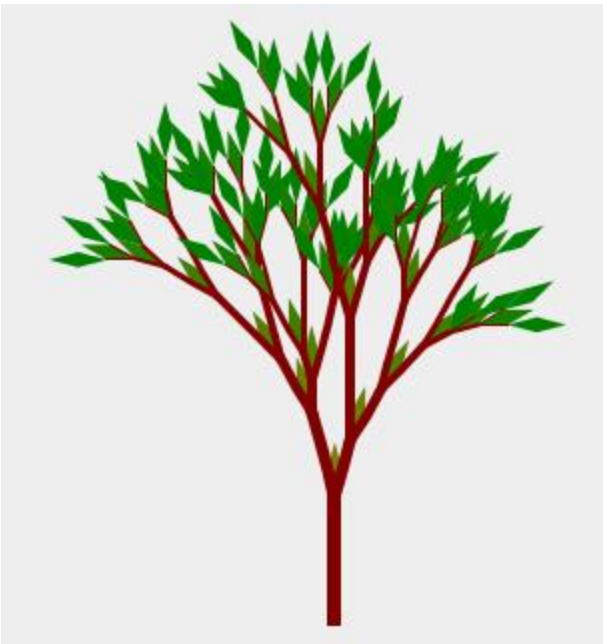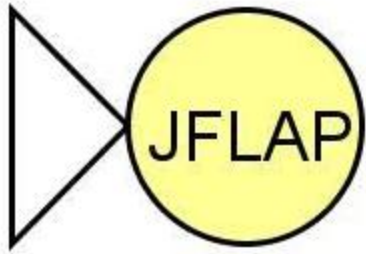# Stochastic Tree

- Add a rule T -> T

- Now there is a choice for T, draw a line or don't
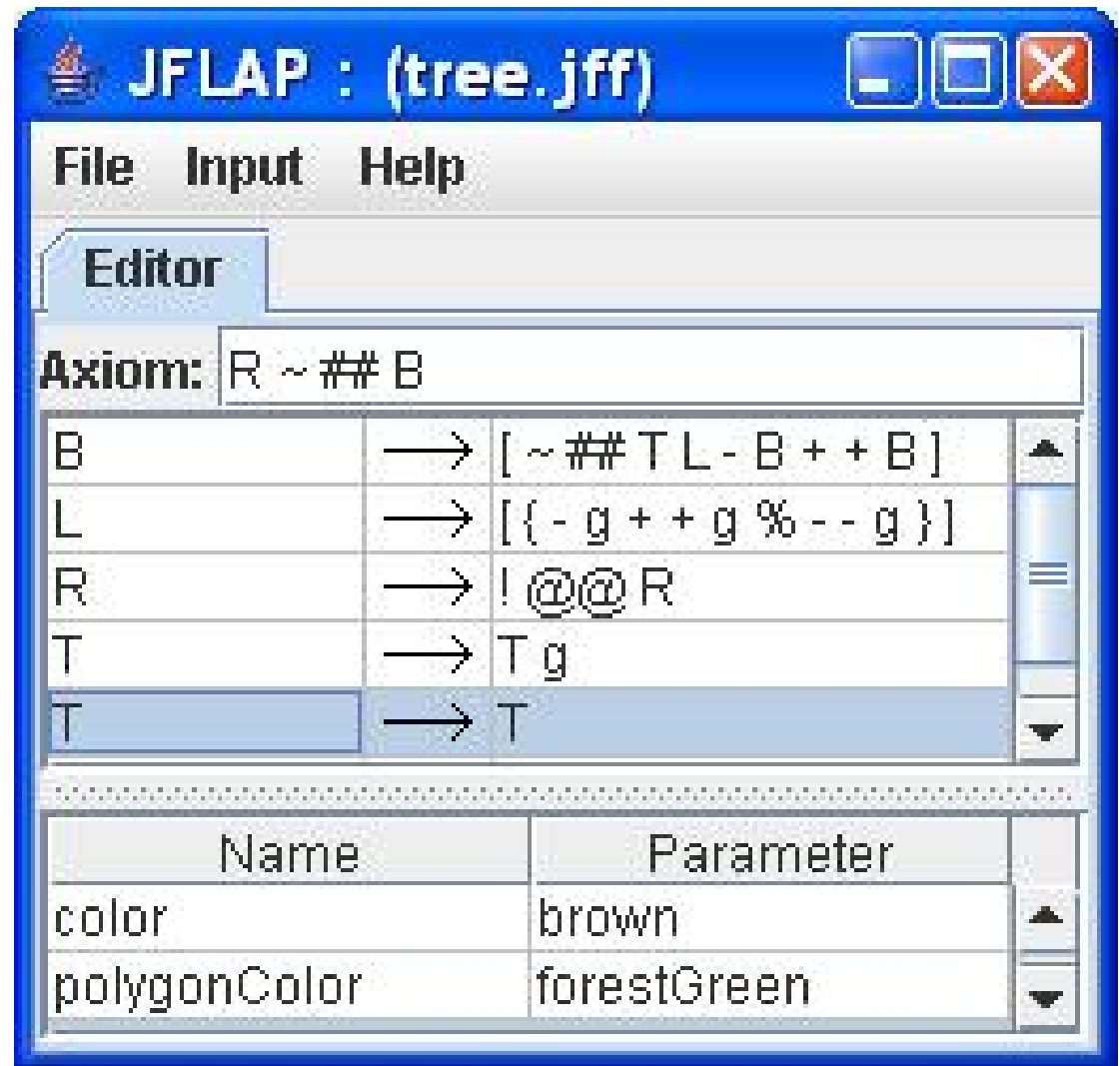
Same Stochastic L-System

- Rendered 3 times, each at 8th derivation

JFLAP

- JFLAP is available for free:

    www.jflap.org

- Duke School of Environment uses L-systems to model pine needles in Duke Forest

Classwork 5 - Exercise 1

- Write an L-system for the picture below.

- Symbols needed are: g, + and one variable

- Distance of the line is 100, rendering at 1 draws the first line, each additional render draws another line.
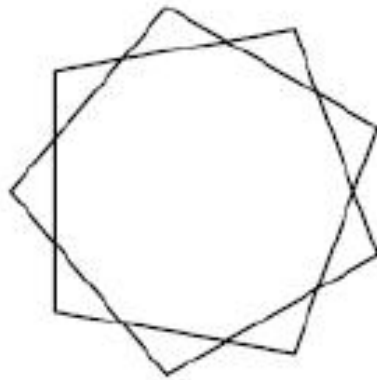
Exercise 2

- Write an L-system for the picture below.

- Symbols may need: g, %, +

- Distance set to 15, angle set to 45, side of square is length 30, first diagonal line is 60

- 1st, 2nd and 6th renderings shown
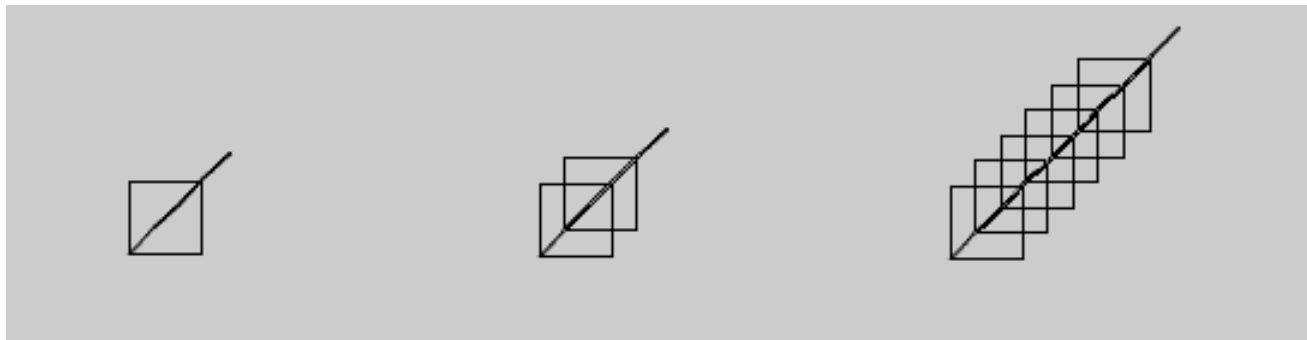
Exercise 3

- Write an L-system for the picture below.
- Symbols may need: g, +, -, [ ]
- Angle set to 90, distance set to 15
- Shows 1st, 2nd and 3rd renderings