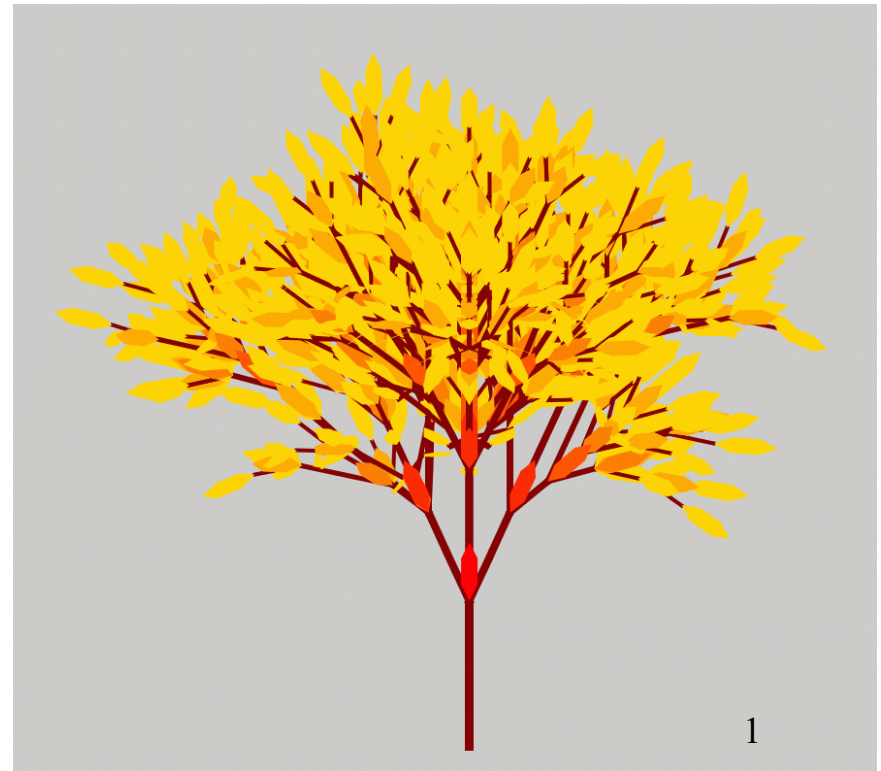
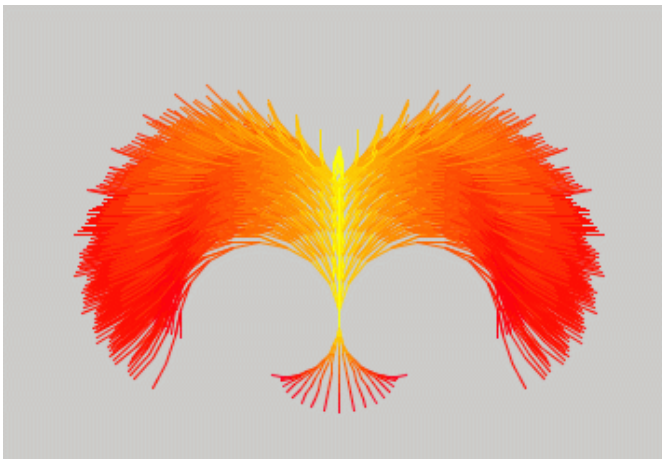


Experimenting with Grammars to Generate L-Systems – in JFLAP

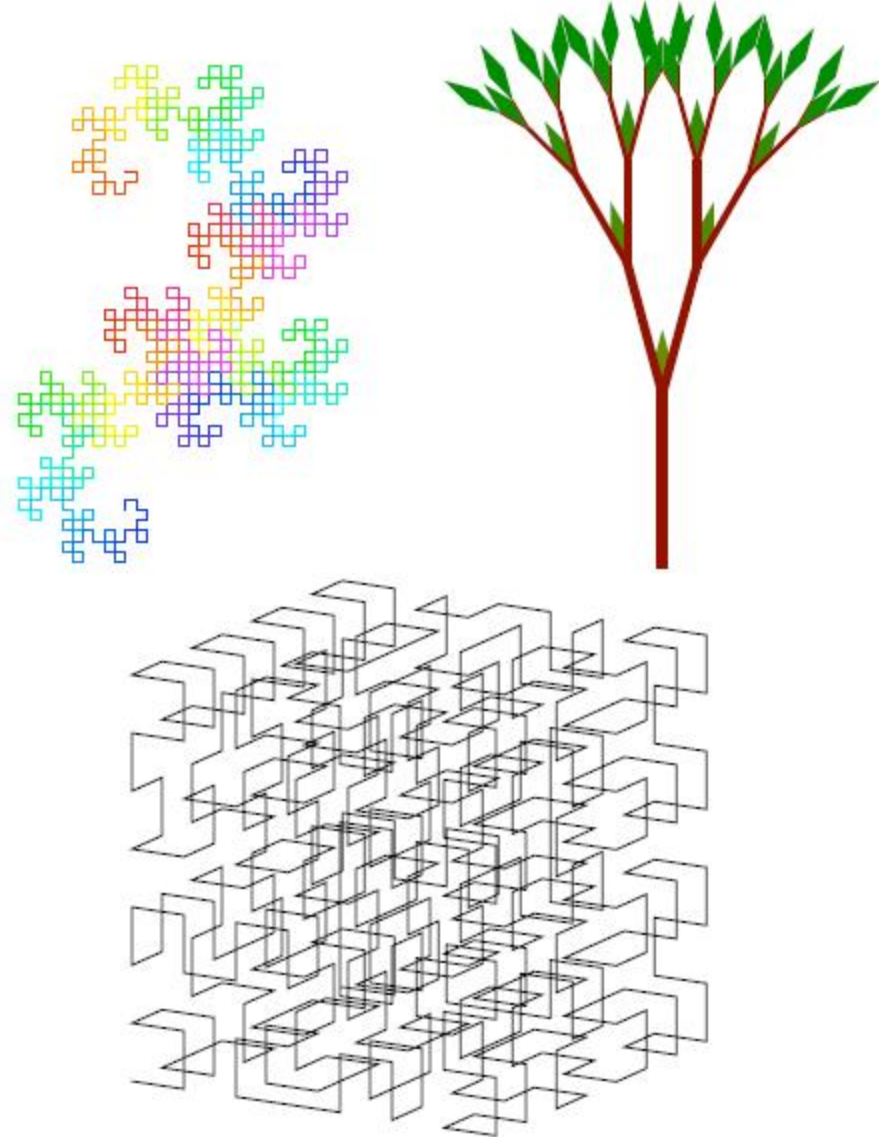
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L-Systems

- Grammatical systems introduced by Lindenmayer
- 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, $h:\Sigma \rightarrow \Sigma^*$.

$h(w)$

$h(w)$ 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

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

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

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

$X \rightarrow g f g X$

distance 15

lineWidth 5

color black

L =

What does this draw?

Geometric rules

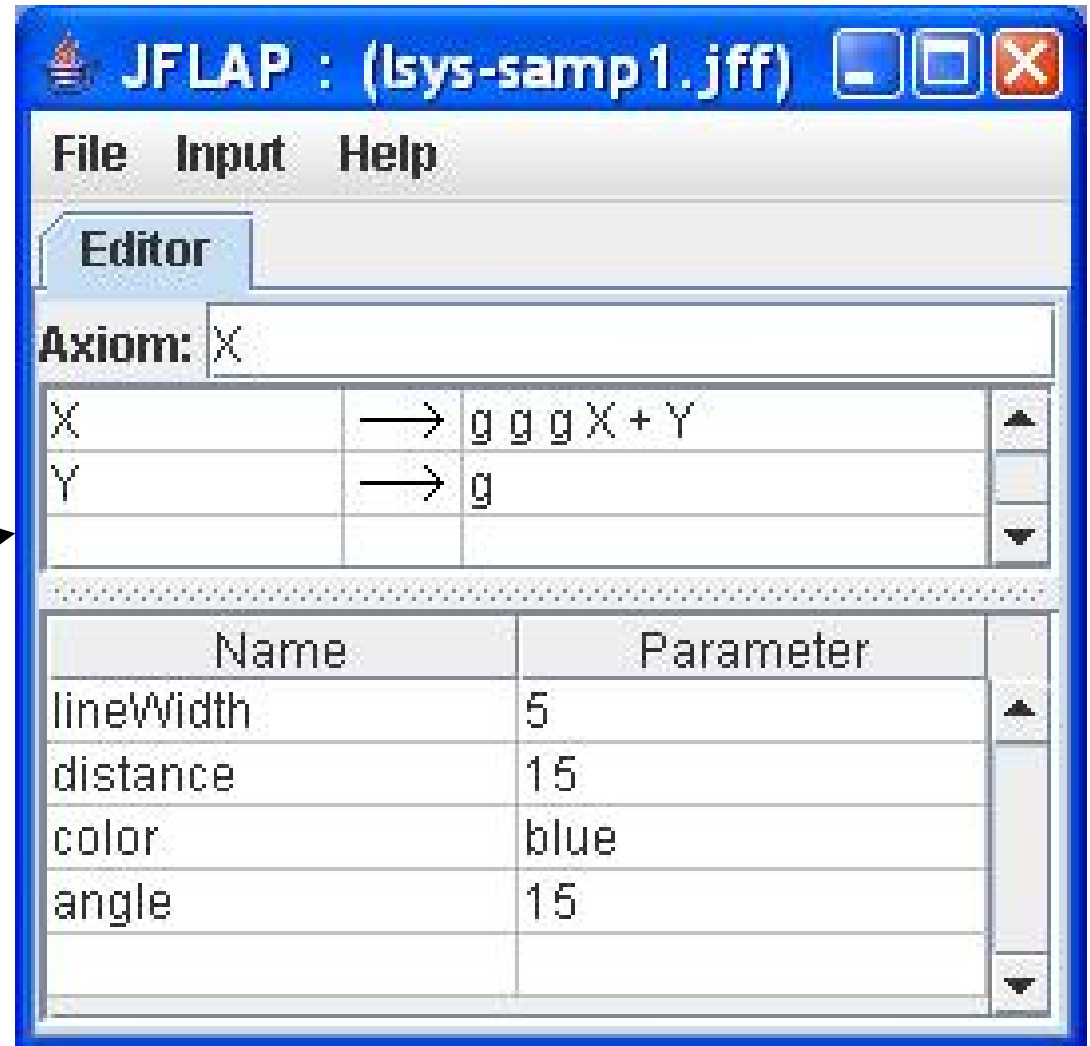
- + change direction to the right
- - change direction to the left
- % change direction 180 degrees
- ~ decrement the width of the next lines
- [save in stack current state info
-] recover from stack state info
- { start filled in polygon
- } end filled in polygon

Example – lsys-samp1

- Axiom

- Replacement Rules

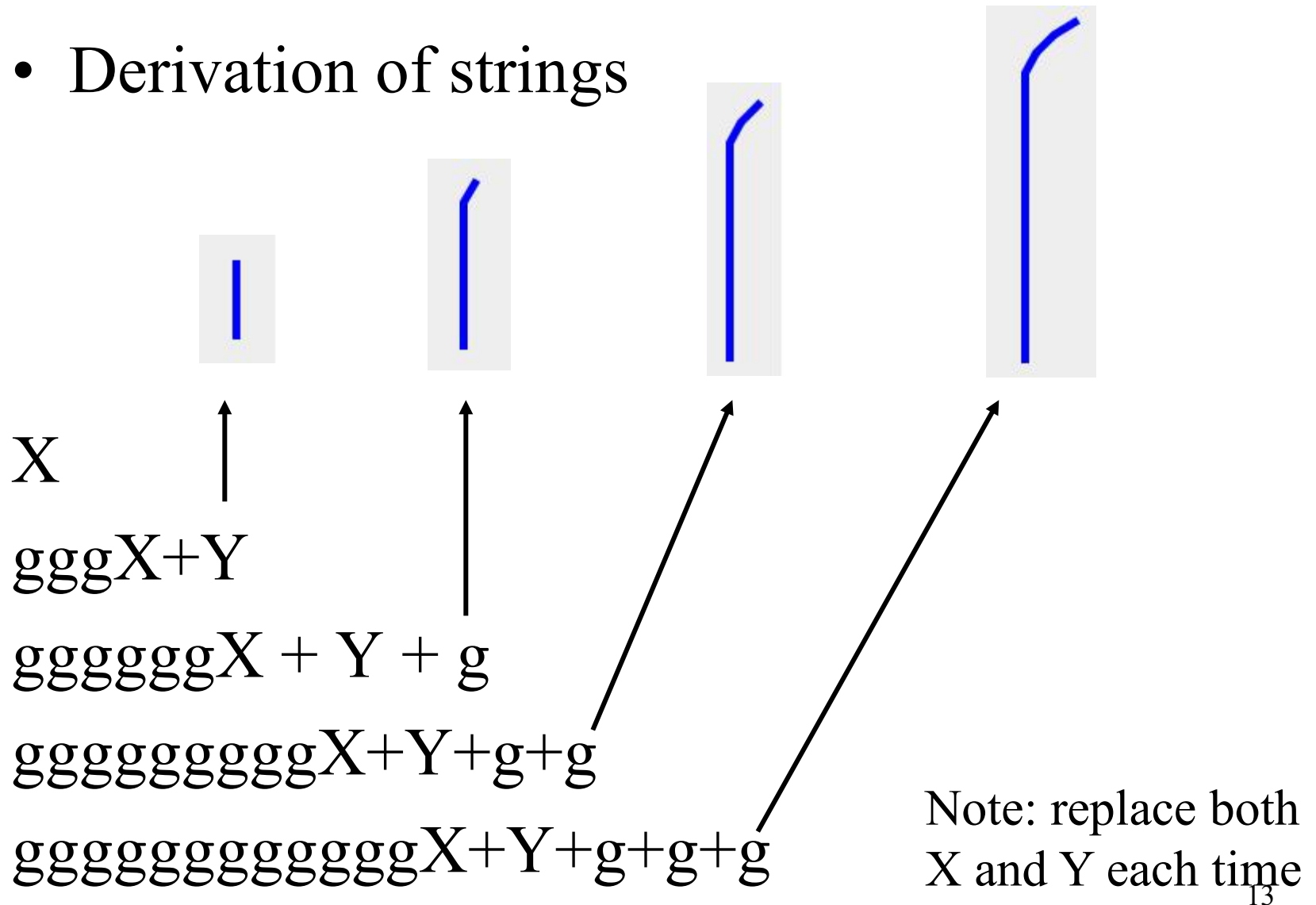
- Geometric Rules



NOTE: Must use spaces as separator between symbols

Example – lsys-samp1(cont)

- Derivation of strings



Example – lsys-samp2

The screenshot shows the JFLAP software window titled "JFLAP : (lsys-sam...". The menu bar includes "File", "Input", and "Help". The "Editor" tab is active, displaying the "Axiom:" section with the following grammar rules:

Variable	Rule
X	$\rightarrow g[\sim + Y g] g X$
Y	$\rightarrow + Y$

Below the grammar rules is a table of parameters:

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

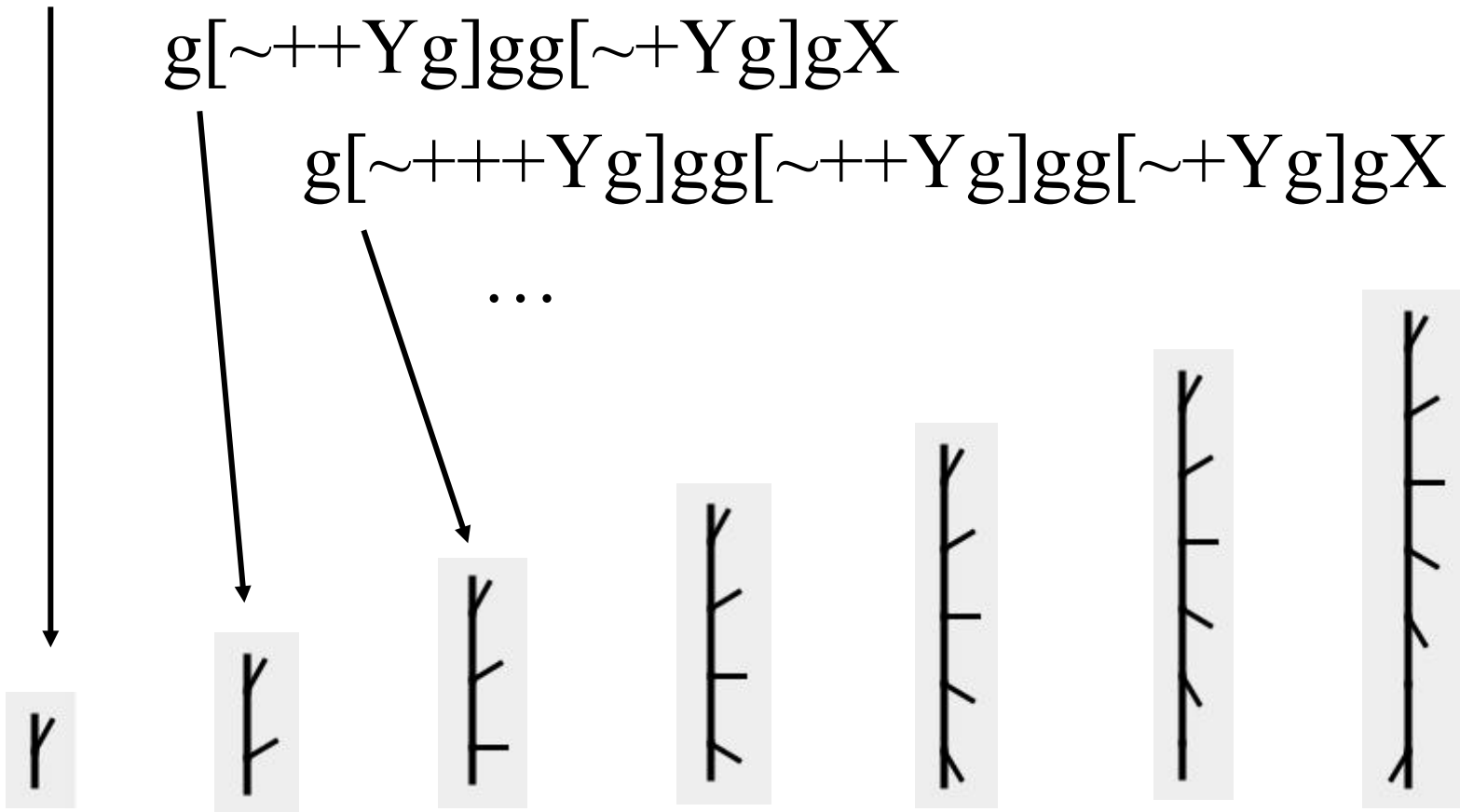
Example – lsys-samp2 (cont)

$g[\sim+Yg]gX$

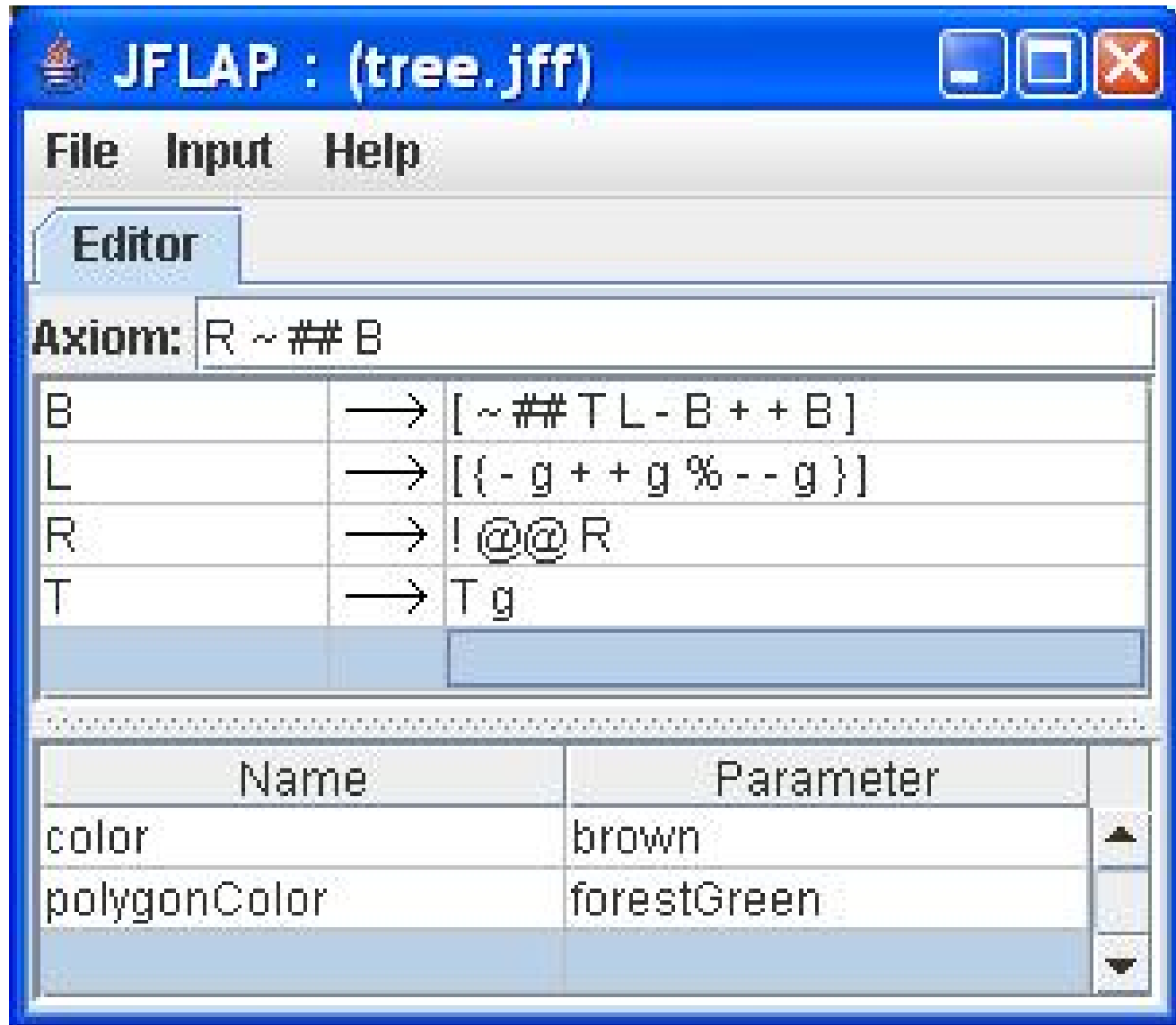
$g[\sim++Yg]gg[\sim+Yg]gX$

$g[\sim+++Yg]ggg[\sim++Yg]gg[\sim+Yg]gX$

...



Example - tree



The image shows a screenshot of the JFLAP (Java Finite Language Automata Package) window, titled "JFLAP : (tree.jff)". The window has a menu bar with "File", "Input", and "Help". Below the menu bar is a tabbed interface with the "Editor" tab selected. The Editor contains a text area with the following content:

Axiom: $R \sim \#\# B$

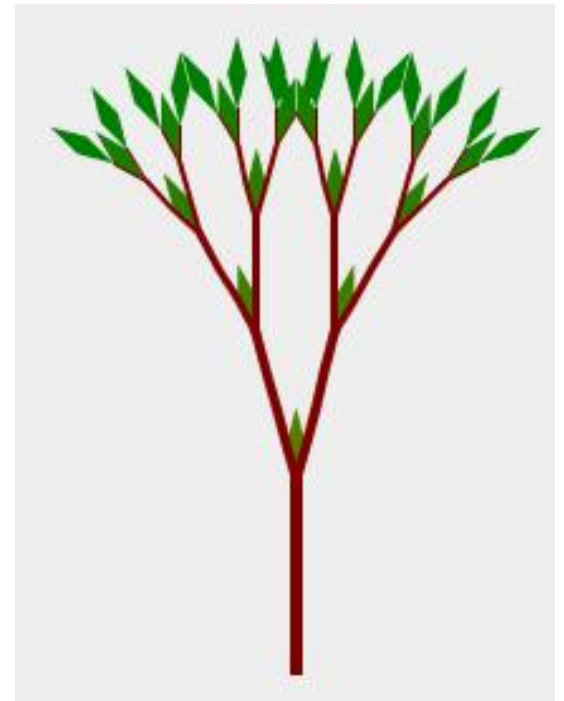
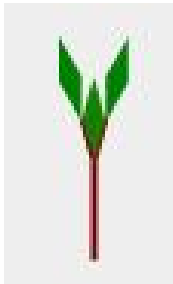
B	\longrightarrow	$[\sim \#\# T L - B + + B]$
L	\longrightarrow	$\{ - g + + g \% - - g \}$
R	\longrightarrow	$! @ @ R$
T	\longrightarrow	$T g$

Below the Editor is a table with two columns: "Name" and "Parameter".

Name	Parameter
color	brown
polygonColor	forestGreen

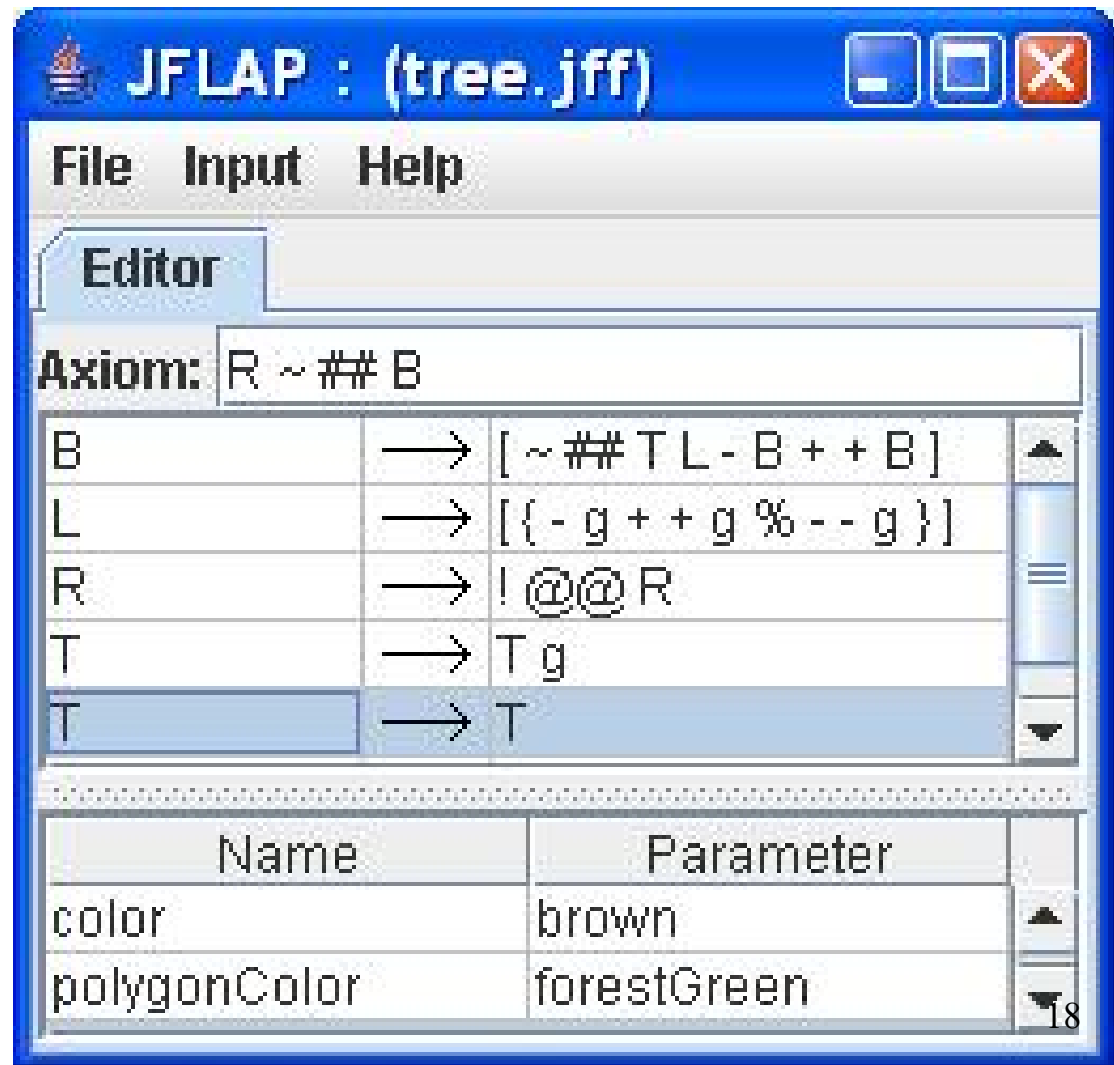
The window also features standard window controls (minimize, maximize, close) in the top right corner.

Example – tree rendered



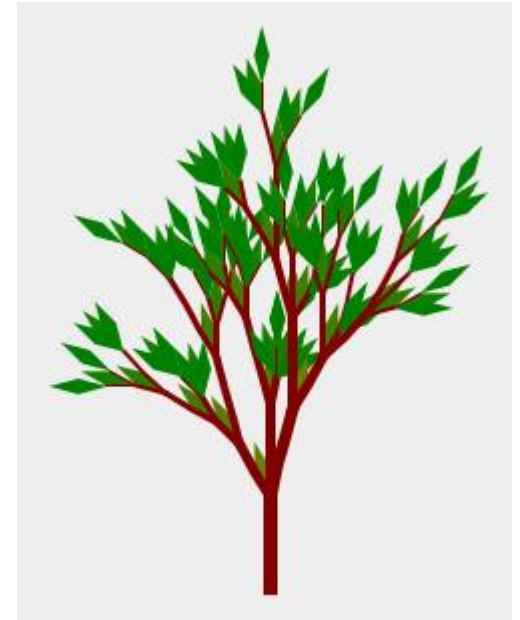
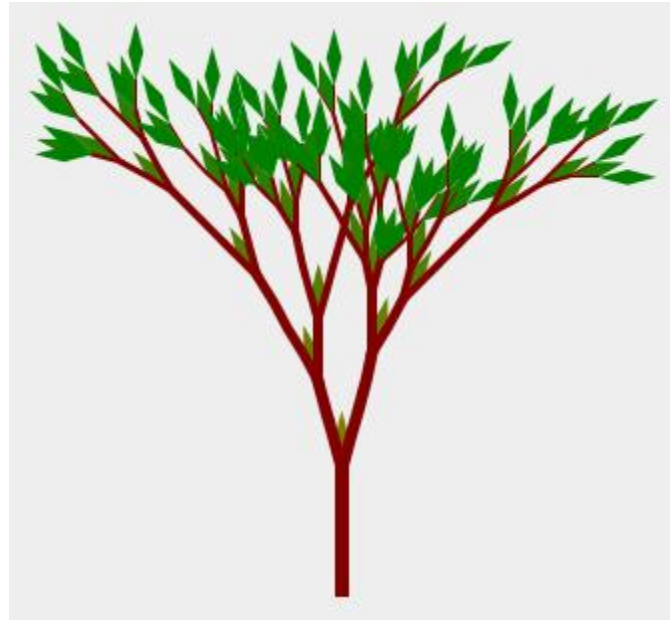
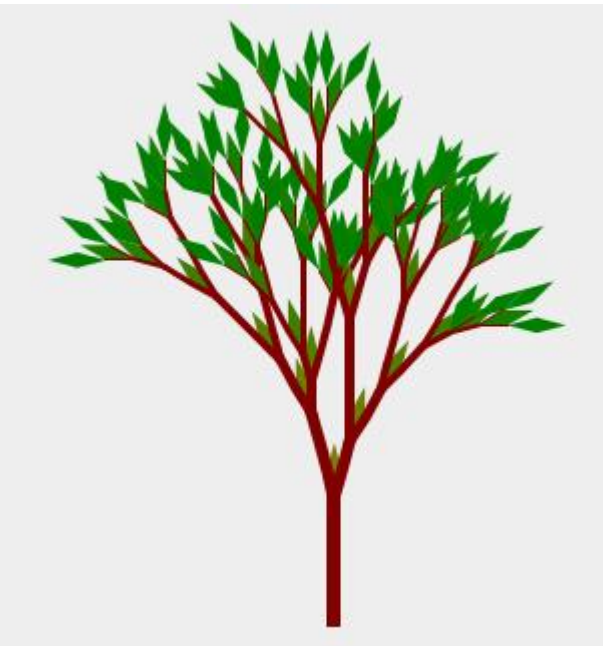
Stochastic Tree

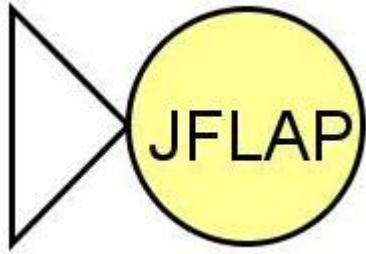
- Add a rule
 $T \rightarrow T$
- Now there is a choice for T, draw a line or don't



Same Stochastic L-System

- Rendered 3 times, each at 8th derivation



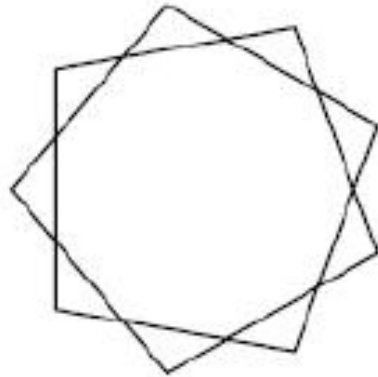


JFLAP

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

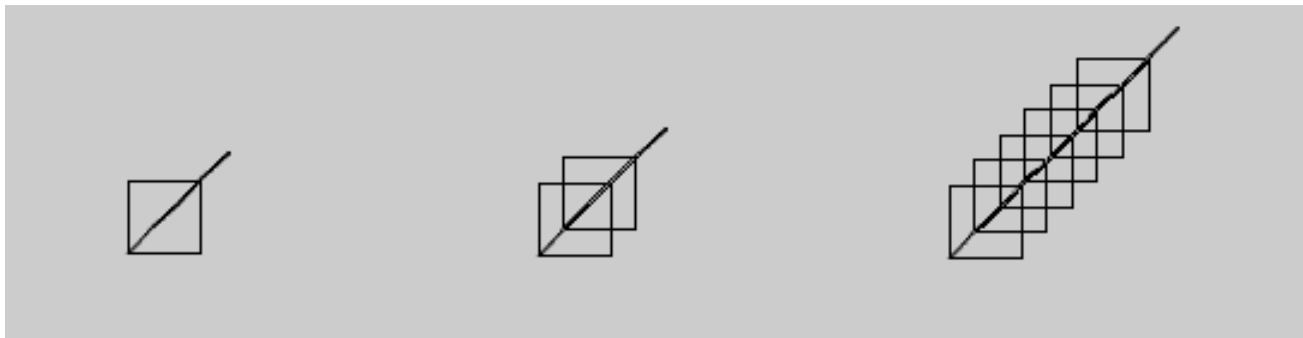
Classwork - Exercise 1

- 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

