# The Beauty and Joy of Computing

## Lecture #10
## Recursion II

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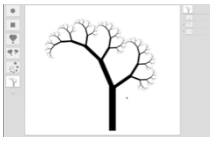
### RECURSIVE DRAWING

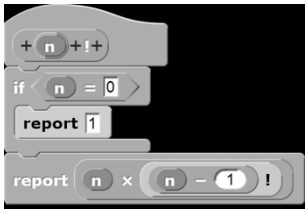
Toby Shachman created this amazing spatial programming language called "Recursive Drawing" that allows you to create drawings (even recursive ones) without typing a line of code. It's a great example of a next-generation interface…



**recursivedrawing.com**

# How the Computer Works … n!

- **Factorial(n) = n!**
  **Inductive definition:**
  - **n! = 1 , n = 0**
  - **n! = n * (n-1)!, n > 0**
- **Let's act it out…**
  - **"contractor" model**
  - **5!**




| n | n! |
|---|---|
| 0 | 1 |
| 1 | 1 |
| 2 | 2 |
| 3 | 6 |
| 4 | 24 |
| 5 | 120 |



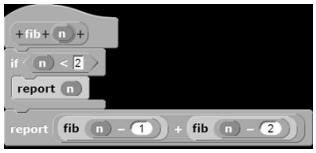
# How the Computer Works … fib(n)

en.wikipedia.org/wiki/Fibonacci_number
www.ics.uci.edu/~eppstein/161/960109.html

- **Inductive definition:**
  - **fib(n) = n , n < 2**
  - **fib(n) = fib(n-1)+fib(n-2), n > 1**

$$F(n) := \begin{cases} 0 & \text{if } n = 0; \\ 1. & \text{if } n = 1; \\ F(n-1) + F(n-2) & \text{if } n > 1. \end{cases}$$

- **Let's act it out…**
  - **"contractor" model**
  - **fib(5)**




| n | fib(n) |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 1 |
| 3 | 2 |
| 4 | 3 |
| 5 | 5 |

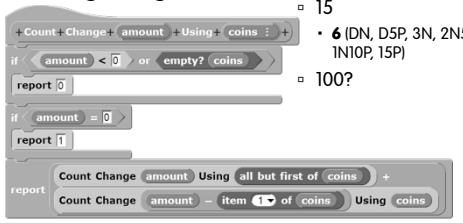
Leonardo de Pisa
aka, Fibonacci

Let's now: trace… (gif from Ybungalobill@wikimedia)



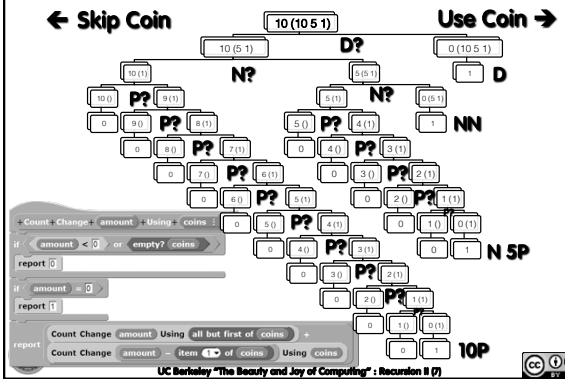
# Counting Change (thanks to BH)

- **Given coins {50, 25, 10, 5, 1} how many ways are there of making change?**
  - 5
    - **2** (N, 5P)
  - 10
    - **4** (D, 2N, N5P, 10P)
  - 15
    - **6** (DN, D5P, 3N, 2N5P, 1N10P, 15P)
  - 100?






# Call Tree for "Count Change 10 (10 5 1)"






# Summary

- **It's important to understand the machine model**
- **It's often the cleanest, simplest way to solve many problems**
  - Esp those recursive in nature!
- **Recursion is a very powerful idea, often separates good from great (you're great!)**

*Menger Cube* by Dan Garcia