

# Lambda Calculus

## Abstract Syntax

$X = \{x, y, z, \dots\}$  — variables

$C = \{X, Y, Z, \dots\}$  — constructors

$\Lambda =$	$X$	— variable
	$  \quad C$	— constructor
	$  \quad \lambda X. \Lambda$	— abstraction
	$  \quad \Lambda \Lambda$	— application

## Head Reductions (Big-Step)

Substitution:

$$x[z \leftarrow B] = \begin{cases} B & , \quad z = x \\ x & , \quad z \neq x \end{cases}$$

$$X[x \leftarrow B] = X$$

$$(M \ N)[x \leftarrow A] = (M[x \leftarrow A])(N[x \leftarrow A])$$

$$(\lambda z. B)[x \leftarrow A] = \begin{cases} \lambda z. B & , \quad z = x \\ \lambda z. (B[x \leftarrow A]) & , \quad z \neq x \end{cases}$$

Reduction rules:

$$x \rightarrow x, \ x \in X \cup C \qquad [\text{VAR}]$$

$$\frac{A \rightarrow A'}{\lambda x. A \rightarrow \lambda x. A'} \qquad [\text{ABS}]$$

$$\frac{M \rightarrow \lambda x. A, \ A[x \leftarrow N] \rightarrow K}{M \ N \rightarrow K} \qquad [\text{RED}]$$

$$\frac{M \rightarrow M'}{M\ N \rightarrow M'\ N},\ M' \neq \lambda x.A \qquad [\text{APP}]$$