

CS339: Abstractions and Paradigms for Programming

Bindings and Environment

Manas Thakur
CSE, IIT Bombay



Autumn 2024

Programming Languages

➤ Syntax

- Defined by a (context-free) grammar

Design

➤ Semantics

- Meaning of each construct that is enabled by the grammar

➤ Evaluator/Interpreter

- Execute the programs written using the syntax based on the defined semantics

Implementation



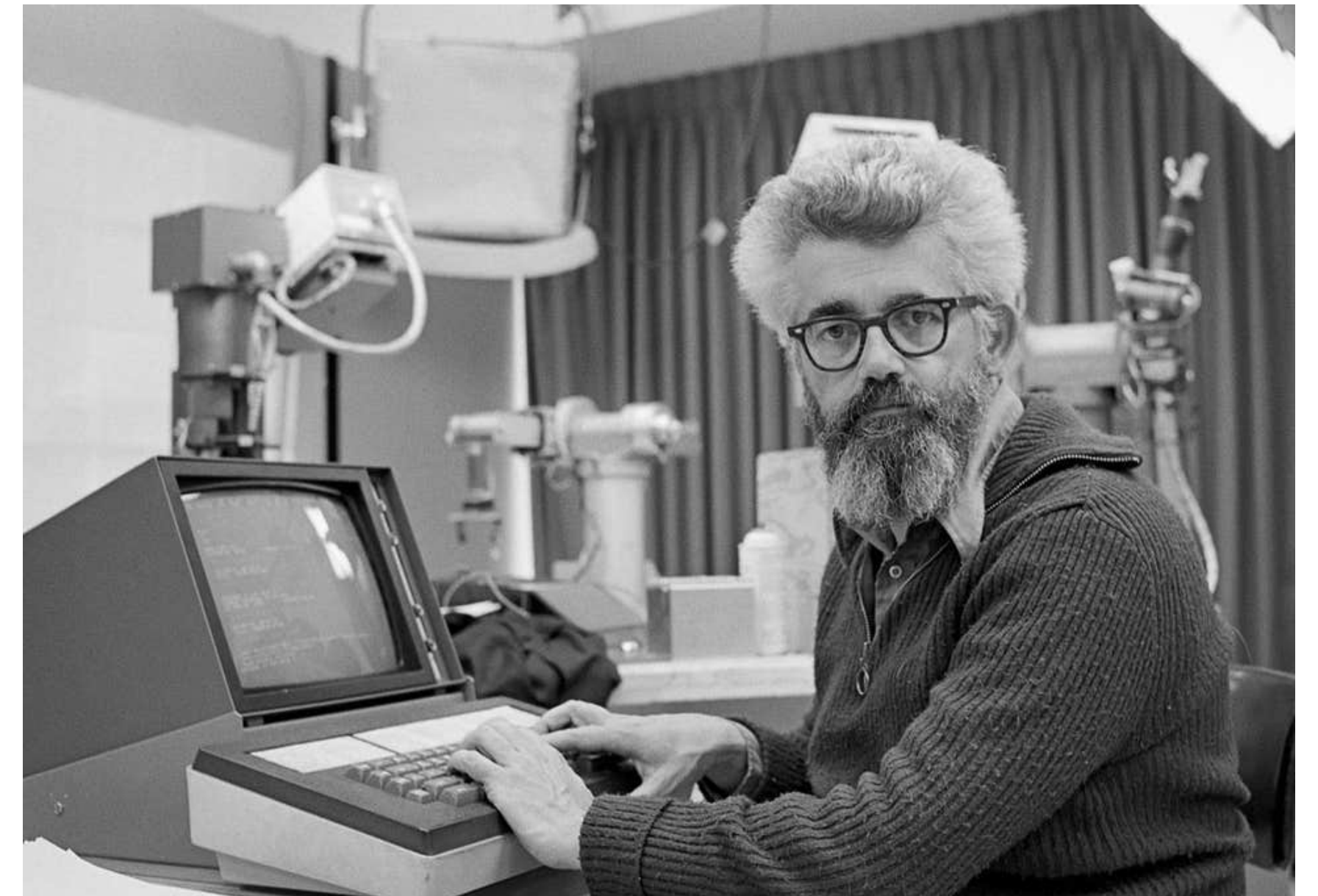
Our primary vehicle for APP: Scheme

- A dialect of **LISP** (for LISt Processing)
 - The second oldest PL that is still in use today
 - Which is the first one?
- Our evaluator: **DrRacket**
 - A popular cross-platform tool to learn and design Lisp-like language
 - Extremely popular in academia



Recalling another giant

- Coined the term *Artificial Intelligence*
- Designed several PLs
 - Invented **LISP**
 - Influenced the design of ALGOL
- Invented *garbage collection*
- Turing Award in 1971



John McCarthy (1927-2011)

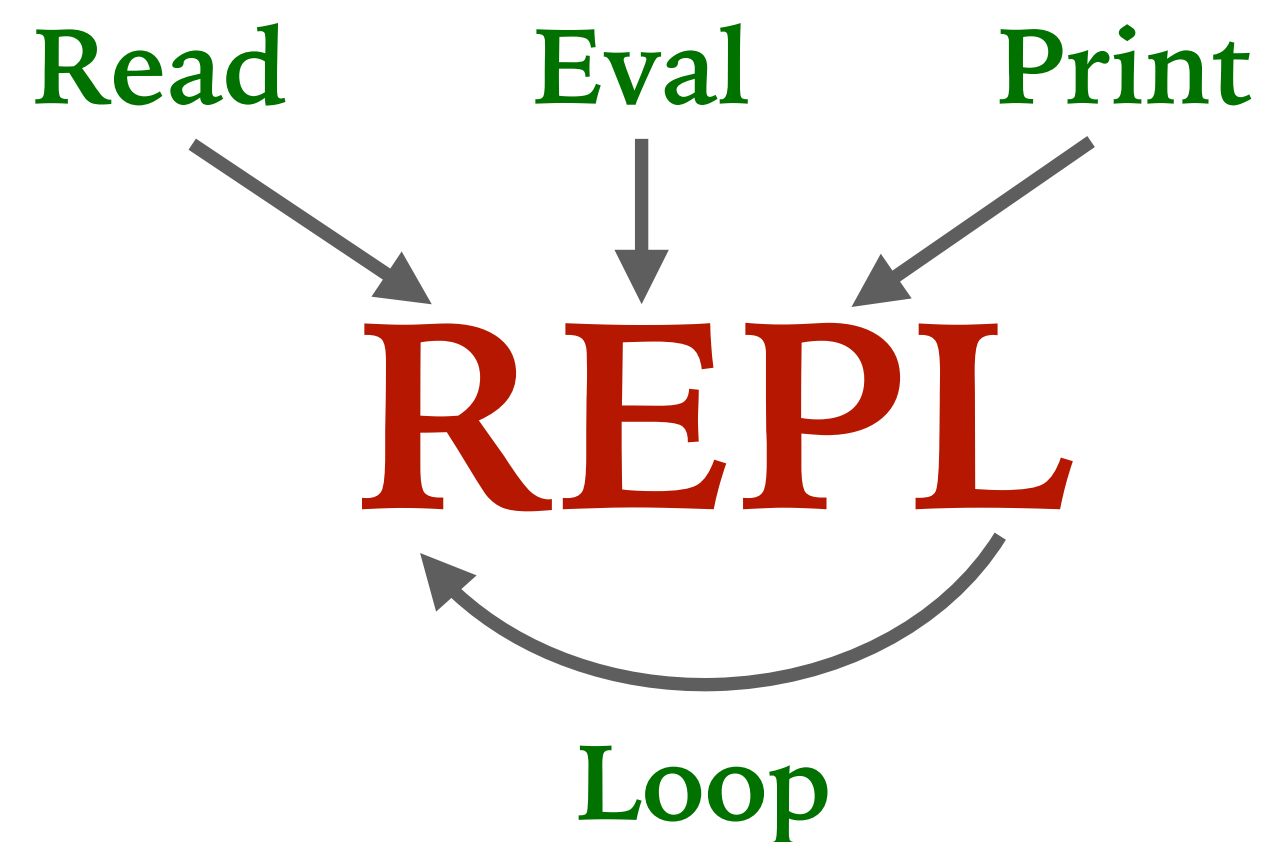
The Elements of a PL

- **Primitive** expressions
 - Things whose semantics are pre-defined in the language
- Means of **combination**
 - Building compound elements from primitive ones
- Means of **abstraction**
 - Ability to use compound elements as primitives themselves



Primitive expressions in Scheme

- An expression that cannot be evaluated further
- The language implementation (evaluator or interpreter) is “born” with these expressions
- How do interpreters work?



Combining Expressions

- Primitive **procedures** can be used to combine primitive expressions
 - Result is a compound expression
 - Syntax: (operator operand1 operand2 ...)
- Prefix notation
- Advantages of prefix notation?



Defining Abstractions

- Associate names with values

> (**define** x 2)

Evaluate:

> x

- Associate names with expressions

> (**define** y (+ x 1))

Evaluate:

> y

- Associate names with procedures

> (**define** (add x y)
 (+ x y))

Evaluate:

> (add op1 op2)



Procedures as Entities

- What did we associate the name `add` with here?

```
> (define (add x y)
    (+ x y))
```

- Can be equivalently written as:

```
> (define add
    (lambda (x y)
      (+ x y)))
```

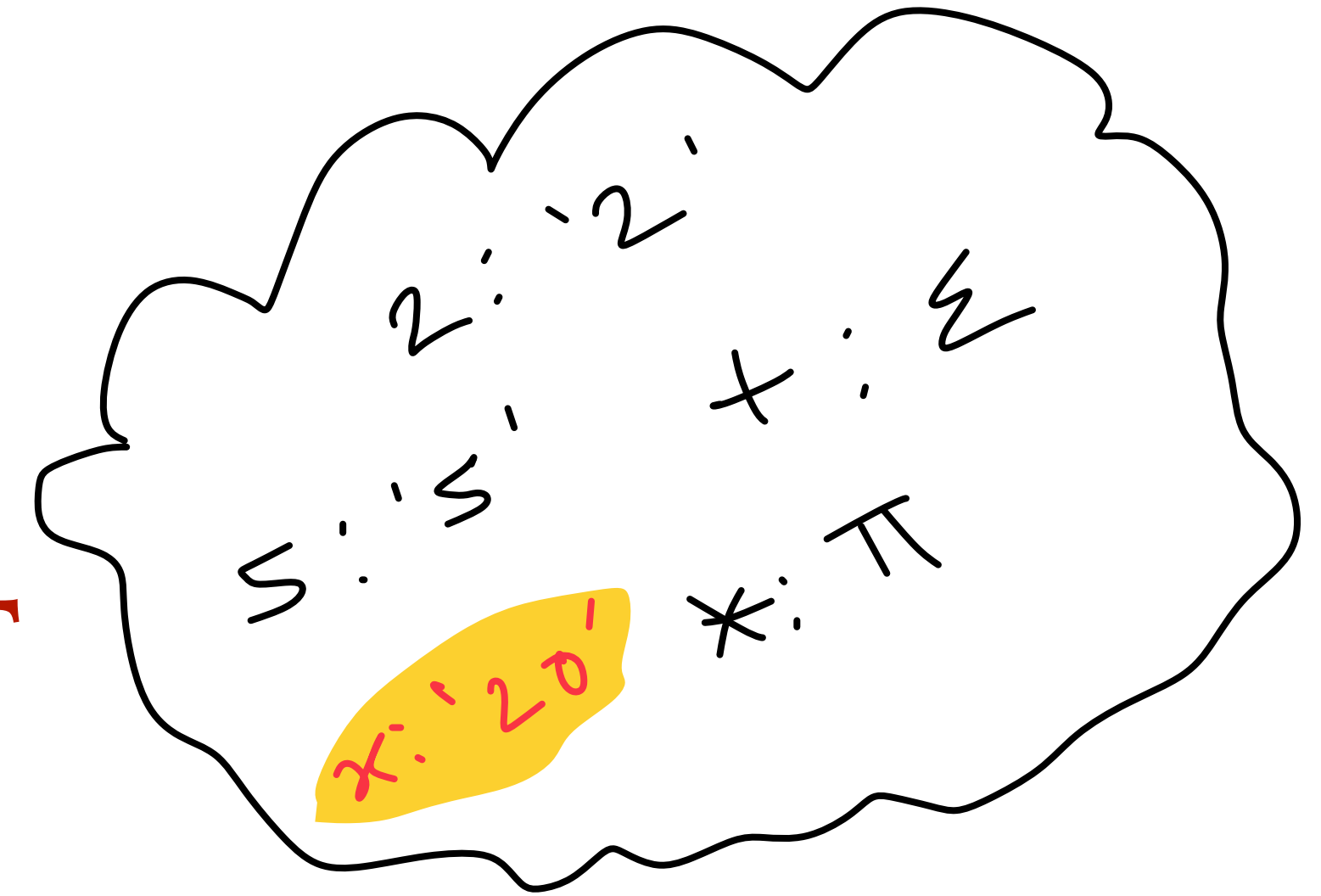
add belongs as much to
the vocabulary now as + did!

- We had named a procedure (a lambda).
- Procedures/functions/lambdaes are *first-class* entities even without names, in the exact same way as numbers — they *exist*!



Bindings and Environment

- `(define x 20)` creates a binding from `x` to `20`
- Where is it created/remembered?
 - The **ENVIRONMENT**
 - Default: The **GLOBAL ENVIRONMENT**



- Lookup involves searching in the current environment
 - We shall see how do we work with multiple environments in future.

Applying Procedures

- Substitute actual arguments in place of formal parameters (at once) in the body of the procedure, and then evaluate the body of the procedure.

> (define (add x y)
 (+ x y))

> (add 4 (+ 7 5))

```
(+ 4 (+ 7 5))  
(+ 4 12)  
> 16
```

Next class:
Orders of Evaluation

Called the **Substitution Model** of Evaluation

