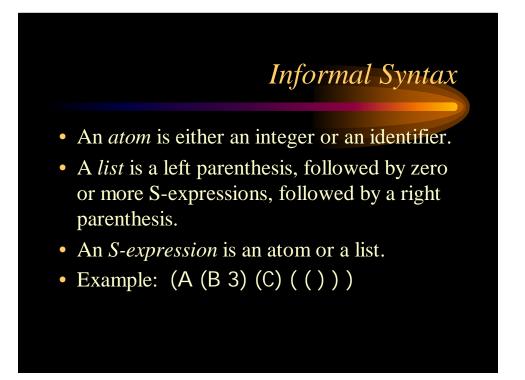


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Recursion

- Recursion is essential in Lisp
- A *recursive definition* is a definition in which
 - certain things are specified as belonging to the category being defined, and
 - a rule or rules are given for building new things in the category from other things already known to be in the category.



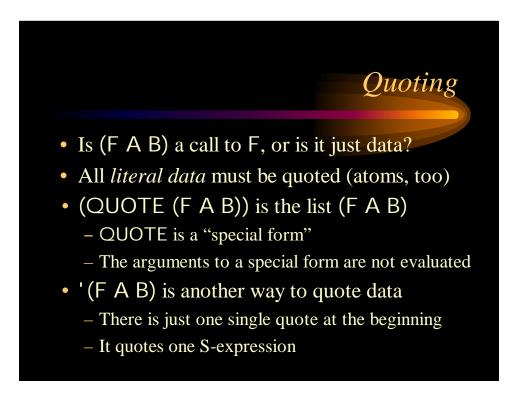
Formal Syntax (approximate)

- <S-expression> ::= <atom> | <list>
- <atom> ::= <number> | <identifier>
- <list> ::= (<S-expressions>)
- <S-expressions > ::= <empty> | <S-expressions > <S-expression>
- <number> ::= <digit> | <number> <digit>
- <identifier> ::= string of printable characters, not including parentheses



Function calls and data

- A function call is written as a list
 - the first element is the name of the function
 - remaining elements are the arguments
- Example: (F A B)
 - calls function ${\sf F}$ with arguments ${\sf A}$ and ${\sf B}$
- Data is written as atoms or lists
- Example: (F A B) is a list of three elements
 - Do you see a problem here?

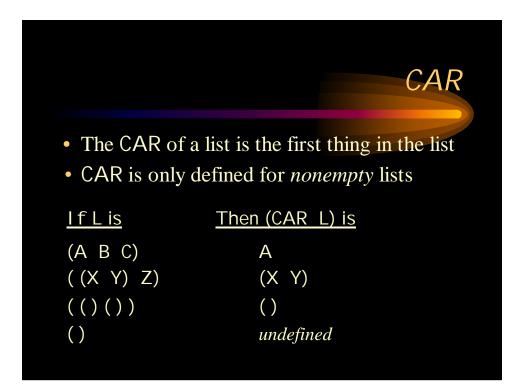


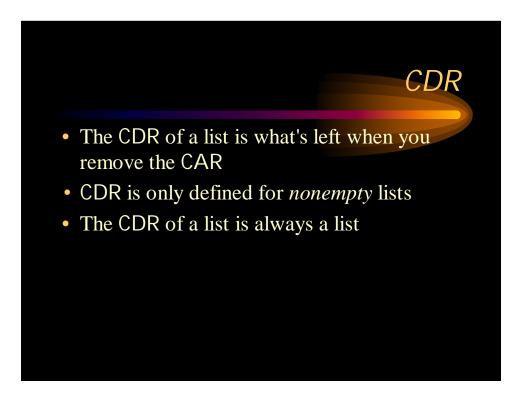
Basic Functions

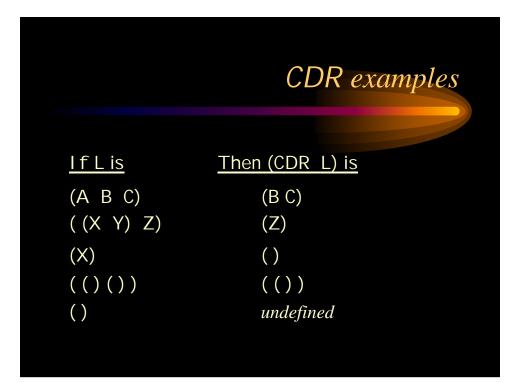
- CAR returns the head of a list
- CDR returns the tail of a list
- CONS inserts a new head into a list
- EQ compares two atoms for equality
- ATOM tests if its argument is an atom

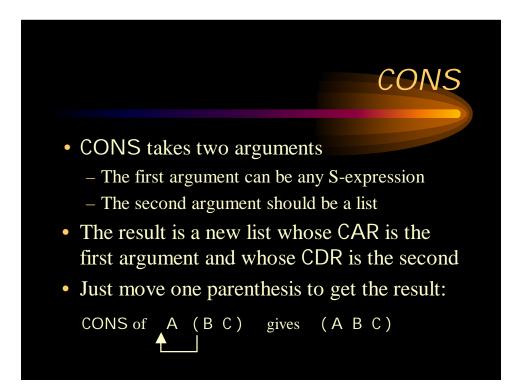
Other useful Functions

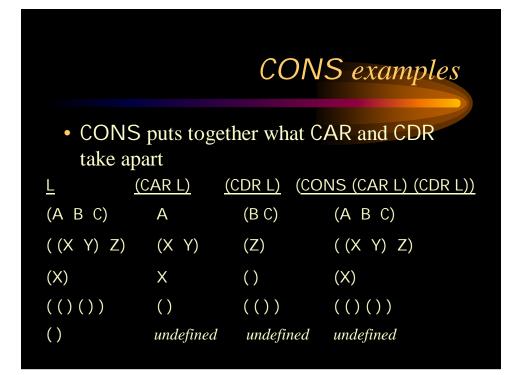
- (NULL S) tests if S is the empty list
- (LI STP S) tests if S is a list
- LI ST makes a list of its (evaluated) arguments
 (LI ST 'A '(B C) 'D) returns (A (B C) D)
 (LI ST (CDR '(A B)) 'C) returns ((B) C)
- APPEND concatenates two lists
 (APPEND '(A B) '((X) Y)) returns (A B (X) Y)



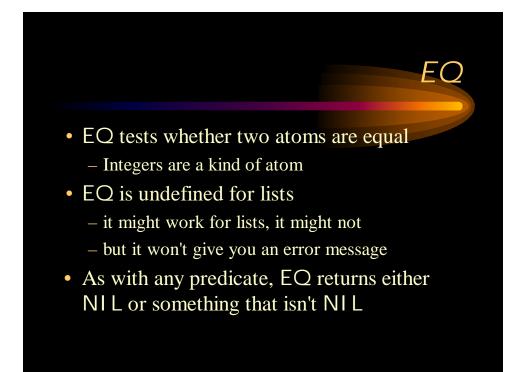


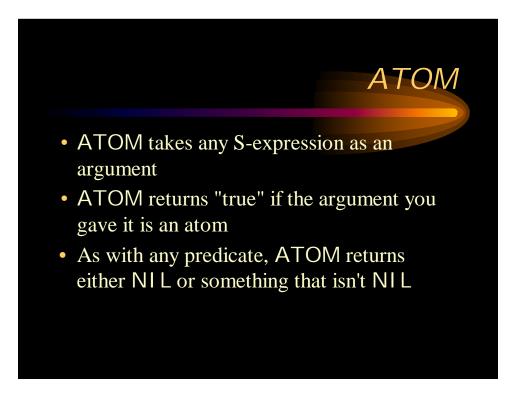


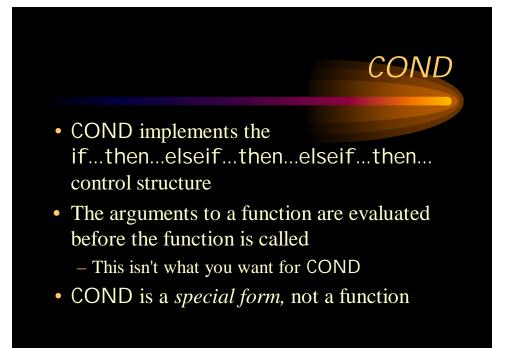


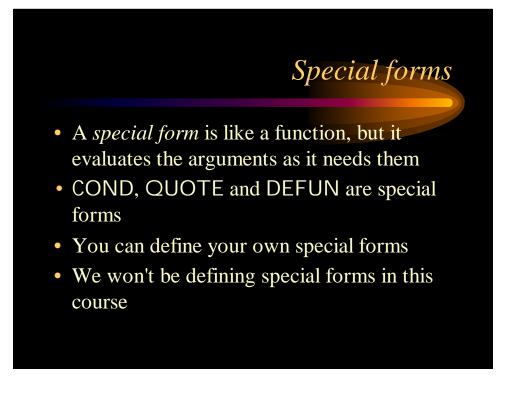


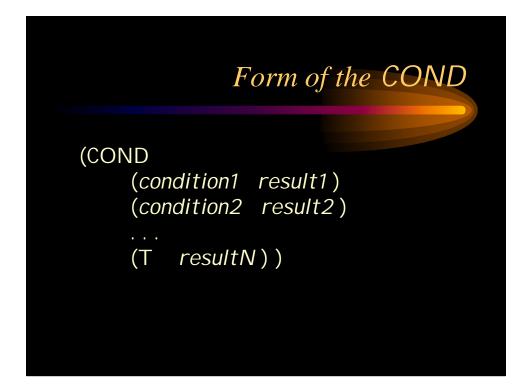


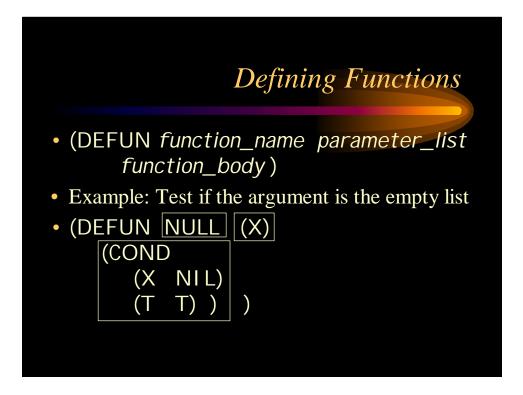


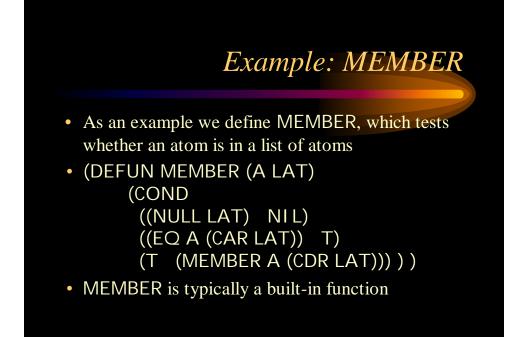


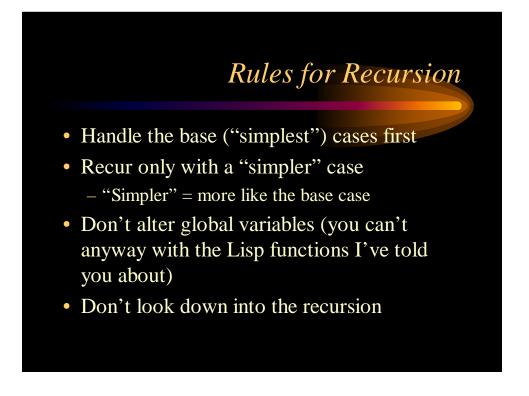






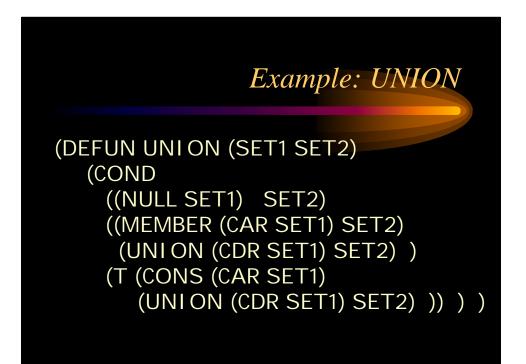






Guidelines for Lisp Functions

- Unless the function is trivial, start with COND.
- Handle the base case first.
- Avoid having more than one base case.
- The base case is usually testing for NULL.
- Do something with the CAR and recur with the CDR.



Still more useful Functions

- (LENGTH L) returns the length of list L
- (RANDOM N), where N is an integer, returns a random integer >= 0 and < N.

