Recursive Data 2

Mutually Recursive Data Definitions

(*HTDP* sec 15.1)

Previously: Family Trees

- Specifically, *ancestor family trees*

```
A family-tree-node is either
 - empty, or
 - (make-child fa mo da na ey)
   where na and ey are symbols
   and da is a number
   and fa and mo are family-tree-nodes
```

- A self-referential data type of our own invention

A function on ancestor family tree nodes

```
;; blue-eyed-ancestor? : ftn  ->  boolean

(define (blue-eyed-ancestor? a-ftree)
  (cond
  [(empty? a-ftree) false]
  [(symbol=? (child-eyes a-ftree) 'blue) true]
  [else (or
          (blue-eyed-ancestor? (child-father a-ftree))
          (blue-eyed-ancestor?
             (child-mother a-ftree))))]))
```

- The colored portions come directly from the template for ancestor family trees

A new data type: *descendant family trees*

- Like ancestor f.t.'s, with one key difference
  - each node now knows about its children, instead of its parents
- Ancestor trees were easy to represent
  - You can have at most two parents!
- Descendant trees will be harder
  - How do you encapsulate potentially many children in a structure?

Lists inside structures

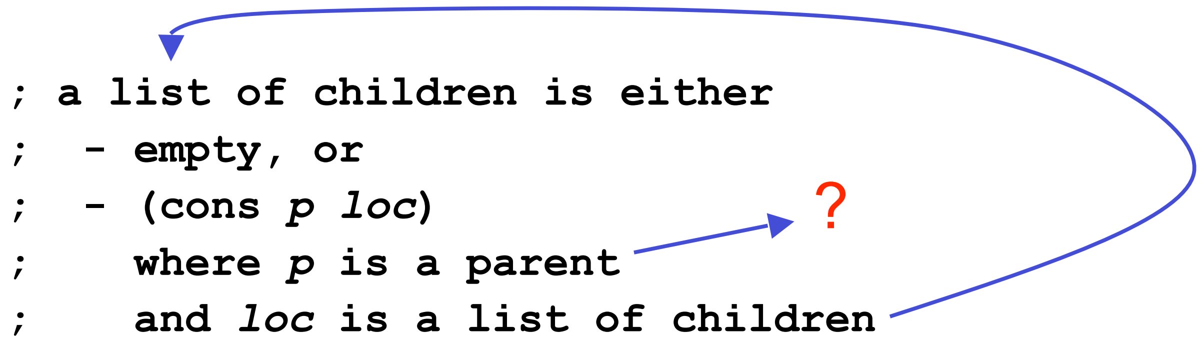
- Sure, why not? Let’s write the data definition for a node:
  - (we’ll call it “parent” since each node may have potentially many children)

```
; a parent is (make-parent loc n d e)
; where n, e are symbols
; and d is a number
; and loc is a list of children → ?
```

- Now we have a problem. What’s a “list of children”?

Lists inside structures (take 2)

- Let's try again, starting with the data definition for a *list of children*:

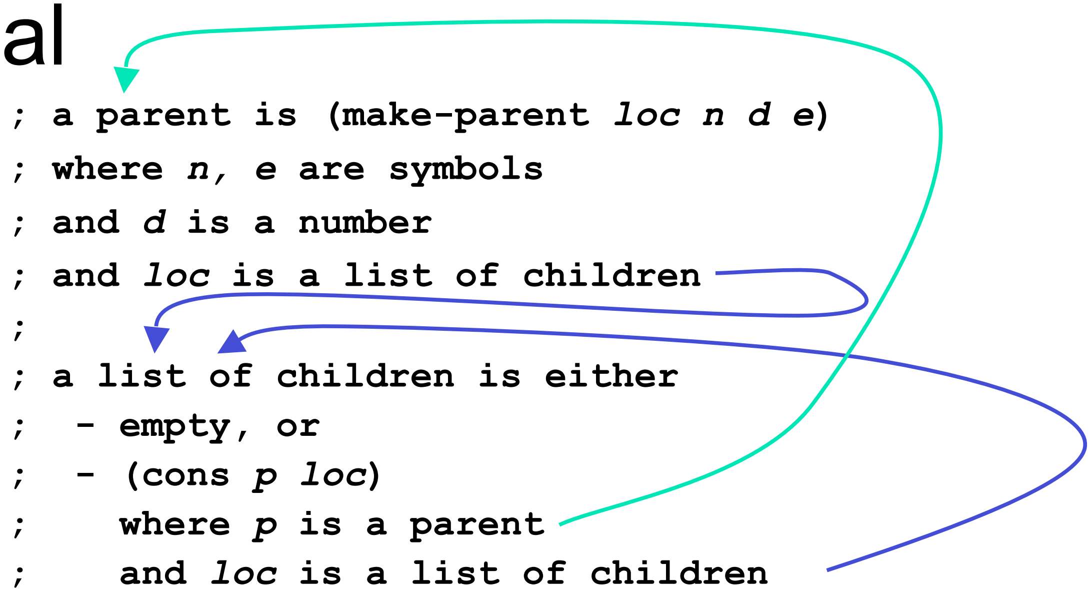


```
; a list of children is either
;  - empty, or
;  - (cons p loc)
;     where p is a parent
;     and loc is a list of children
```

- We're still stuck. Now we know what a list of children is, but "parent" is undefined.

Mutually Referential Data Definitions

- The point is, you need *both* parts of the data definition for it to be complete and legal



```
; a parent is (make-parent loc n d e)
; where n, e are symbols
; and d is a number
; and loc is a list of children
;
; a list of children is either
;  - empty, or
;  - (cons p loc)
;    where p is a parent
;    and loc is a list of children
```

Examples

```
(define-struct parent (children name date eyes))

(define Violet
  (make-parent empty 'VioletParr 1990 'brown))
(define Dash
  (make-parent empty 'DashiellParr 1995 'blue))
(define JackJack
  (make-parent empty 'JackParr 2002 'blue))

(define Elastigirl
  (make-parent
    (list Violet Dash JackJack) 'HelenParr 1962 'brown))
(define MrIncredible
  (make-parent
    (list Violet Dash JackJack) 'BobParr 1958 'blue))
```

Templates for M.R.D.D.

- The template should match the data definition
  - Because the d.d. has two parts, so must the template

```
; template for functions on descendant tree nodes
; dtn-func : parent -> ???
(define (dtn-func p)
  … (loc-func (parent-children p))
  … (parent-name p)
  … (parent-date p)
  … (parent-eyes p) … )

; template for functions on lists of children
; loc-func : list of children -> ???
(define (loc-func loc)
  (cond
   [(empty? loc) … ]
   [else … (dtn-func (first loc)) … (loc-func (rest loc)) … ]))
```

- (Does the second one look familiar? It should—it’s just the template for lists, with an extra recursive call.)

Example function: **blue-eyed-descendant?**

- Unlike **`blue-eyed-ancestor?`**, **`blue-eyed-descendant?`** must follow this *two-part* template.
  - (once again, colored portions come from the template)

```
;; blue-eyed-descendant? : parent  ->  boolean
;; to determine whether a-parent any of the descendants (children,
;; grandchildren, and so on) have 'blue in the eyes field
(define (blue-eyed-descendant? a-parent)
  (cond
      [(symbol=? (parent-eyes a-parent) 'blue) true]
      [else (blue-eyed-children? (parent-children a-parent))]))

;; blue-eyed-children? : list-of-children  ->  boolean
;; to determine whether any of the structures in aloc is blue-eyed
;; or has any blue-eyed descendant
(define (blue-eyed-children? aloc)
  (cond
      [(empty? aloc) false]
      [(blue-eyed-descendant? (first aloc)) true]
      [else (blue-eyed-children? (rest aloc))]))
```