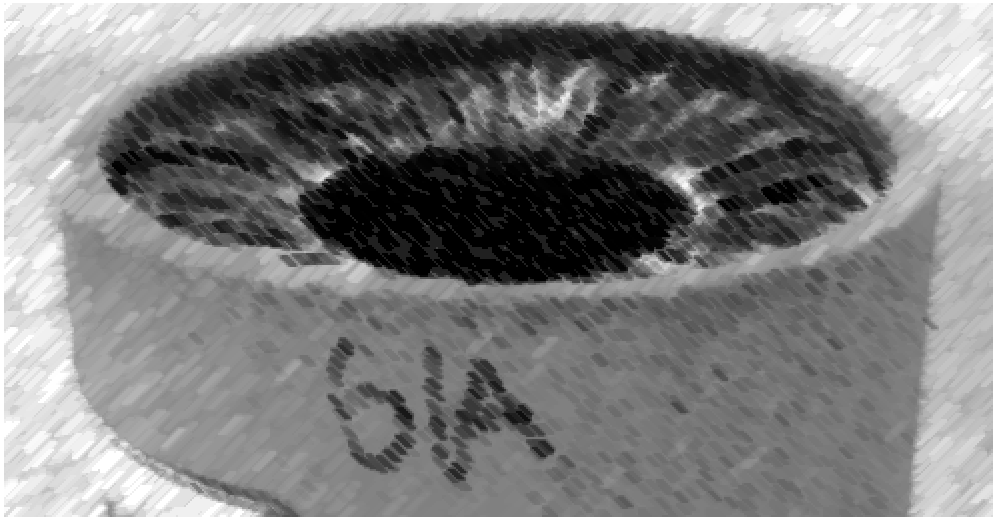

CS61A Lecture 15

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Announcements

- HW5 due on Wednesday
- Trends project out
  - Partners are required; find one in lab or on Piazza
  - Will not work in IDLE
  - New bug submission policy; see Piazza

The Sequence Abstraction

red, orange, yellow, green, blue, indigo, violet.

0 , 1 , 2 , 3 , 4 , 5 , 6 .

There isn't just one sequence type (in Python or in general)

This abstraction is a collection of behaviors:

Length. A sequence has a finite length.

Element selection. A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0 for the first element.

The sequence abstraction is shared among several types, including tuples.

Recursive Lists

Constructor:

```
def rlist(first, rest):
    """Return a recursive list from its first element and
    the rest."""
```

Selectors:

```
def first(s):
    """Return the first element of recursive list s."""

def rest(s):
    """Return the remaining elements of recursive list s."""
```

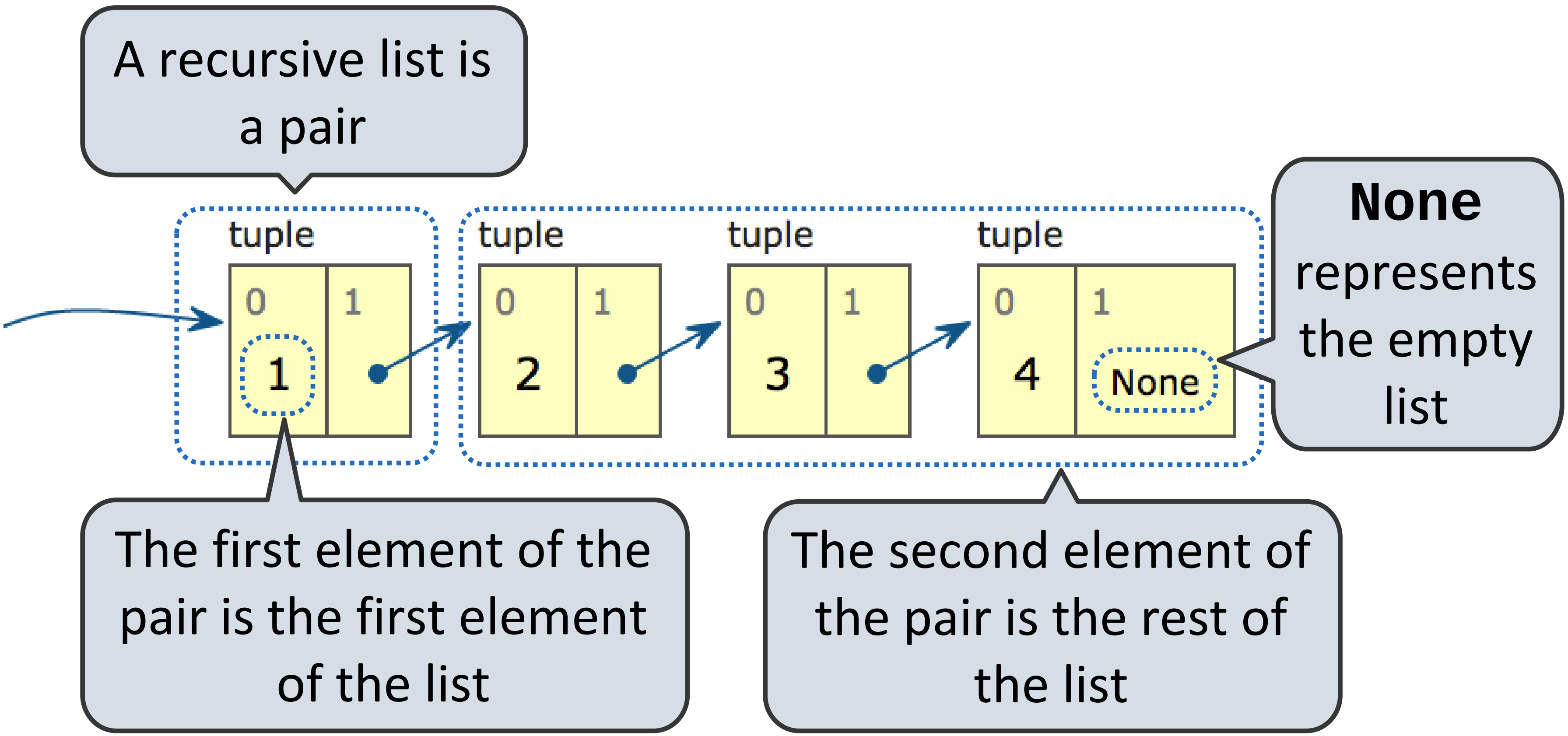
Behavior condition(s):

If a recursive list **s** is constructed from a first element **f** and a recursive list **r**, then

- **first(s)** returns **f**, and
- **rest(s)** returns **r**, which is a recursive list.

Implementing Recursive Lists Using Pairs

1 , 2 , 3 , 4



Example: http://goo.gl/fVhbF

Implementing the Sequence Abstraction

```
def len_rlist(s):
    """Return the length of recursive list s."""
    if s == empty_rlist:
        return 0
    return 1 + len_rlist(rest(s))

def getitem_rlist(s, i):
    """Return the element at index i of recursive list s."""
    if i == 0:
        return first(s)
    return getitem_rlist(rest(s), i - 1)
```

Length. A sequence has a finite length.

Element selection. A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0 for the first element.

Python Sequence Abstraction

Built-in sequence types provide the following behavior

Type-specific constructor	`>>> a = (1, 2, 3)` `>>> b = tuple([4, 5, 6, 7])`
Length	`>>> len(a), len(b)` `(3, 4)`
Element selection	`>>> a[1], b[-1]` `(2, 7)`
Slicing	`>>> a[1:3], b[1:1], a[:2], b[1:]` `((2, 3), (), (1, 2), (5, 6, 7))`
Membership	`>>> 2 in a, 4 in a, 4 not in b` `(True, False, False)`

A list; more on this later

Count from the end; -1 is last element

Sequence Iteration

Python has a special statement for iterating over the elements in a sequence

```
def count(s, value):
    total = 0
    for elem in s:
        if elem == value:
            total += 1
    return total
```

Name bound in the first frame of the current environment

For Statement Execution Procedure

```
for <name> in <expression>:
    <suite>
```

1. Evaluate the header `<expression>`, which must yield an iterable value.
2. For each element in that sequence, in order:
   A. Bind `<name>` to that element in the first frame of the current environment.
   B. Execute the `<suite>`.

Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```
>>> pairs = ((1, 2), (2, 2), (2, 3), (4, 4))

>>> same_count = 0
```

A name for each element in a fixed-length sequence

Each name is bound to a value, as in multiple assignment

```
>>> for x, y in pairs:
        if x == y:
            same_count = same_count + 1

>>> same_count
2
```

The Range Type

A range is a sequence of consecutive integers.*

```
..., -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ...
```

`range(-2, 3)`

Length: ending value - starting value

Element selection: starting value + index

```
>>> tuple(range(-2, 3))
(-2, -1, 0, 1, 2)
```

Tuple constructor

```
>>> tuple(range(4))
(0, 1, 2, 3)
```

With a 0 starting value

* Ranges can actually represent more general integer sequences.

String Literals

```
>>> 'I am string!'
'I am string!'
>>> "I've got an apostrophe"
"I've got an apostrophe"
>>> '您好'
'您好'
```

Single- and double-quoted strings are equivalent

```
>>> """The Zen of Python
claims, Readability counts.
Read more: import this."""
'The Zen of Python\nclaims, Readability counts.\nRead more: import this.'
```

A backslash "escapes" the following character

"Line feed" character represents a new line

Strings Are Sequences

```
>>> city = 'Berkeley'
>>> len(city)
8
>>> city[3]
'k'
```

An element of a string is itself a string!

The **`in`** and **`not in`** operators match substrings

```
>>> 'here' in "Where's Waldo?"
True
```

Why? Working with strings, we care about words, not characters

Sequence Arithmetic

Some Python sequences support arithmetic operations

```
>>> city = 'Berkeley'
>>> city + ', CA'
'Berkeley, CA'
```

Concatenate

```
>>> "Don't repeat yourself! " * 2
"Don't repeat yourself! Don’t repeat yourself! "
```

Repeat twice

```
>>> (1, 2, 3) * 3
(1, 2, 3, 1, 2, 3, 1, 2, 3)

>>> (1, 2, 3) + (4, 5, 6, 7)
(1, 2, 3, 4, 5, 6, 7)
```

Sequences as Conventional Interfaces

We can apply a function to every element in a sequence

This is called *mapping* the function over the sequence

```
>>> fibs = tuple(map(fib, range(8)))
>>> fibs
(0, 1, 1, 2, 3, 5, 8, 13)
```

We can extract elements that satisfy a given condition

```
>>> even_fibs = tuple(filter(is_even, fibs))
>>> even_fibs
(0, 2, 8)
```

We can compute the sum of all elements

```
>>> sum(even_fibs)
10
```

Both **`map`** and **`filter`** produce an iterable, not a sequence

Iterables

Iterables provide access to some elements in order but do not provide length or element selection

Python-specific construct; more general than a sequence

Many built-in functions take iterables as argument

`tuple`	Construct a tuple containing the elements
`map`	Construct a map that results from applying the given function to each element
`filter`	Construct a filter with elements that satisfy the given condition
`sum`	Return the sum of the elements
`min`	Return the minimum of the elements
`max`	Return the maximum of the elements

For statements also operate on iterable values.

Generator Expressions

One large expression that combines mapping and filtering to produce an iterable

```
(<map exp> for <name> in <iter exp> if <filter exp>)
```

- Evaluates to an iterable.
- <iter exp> is evaluated when the generator expression is evaluated.
- Remaining expressions are evaluated when elements are accessed.

No-filter version: `(<map exp> for <name> in <iter exp>)`

Precise evaluation rule introduced in Chapter 4.

Reducing a Sequence

Reduce is a higher-order generalization of max, min, and sum.

```
>>> from operator import mul
>>> from functools import reduce
>>> reduce(mul, (1, 2, 3, 4, 5), 1)
120
```

First argument: A two-argument function

Second argument: an iterable object

Optional initial value as third argument

Like accumulate from Homework 2, but with iterables

```
def accumulate(combiner, start, n, term):
    return reduce(combiner,
                  map(term, range(1, n + 1)),
                  start)
```

More Functions on Iterables (Bonus)

Create an iterable of fixed-length sequences

```
>>> a, b = (1, 2, 3), (4, 5, 6, 7)
>>> for x, y in zip(a, b):
...     print(x + y)
...
5
7
9
```

Produces tuples with one element from each argument, up to length of smallest argument

The **`itertools`** module contains many useful functions for working with iterables

```
>>> from itertools import product, combinations
>>> tuple(product(a, b[:2]))
((1, 4), (1, 5), (2, 4), (2, 5), (3, 4), (3, 5))
>>> tuple(combinations(a, 2))
((1, 2), (1, 3), (2, 3))
```