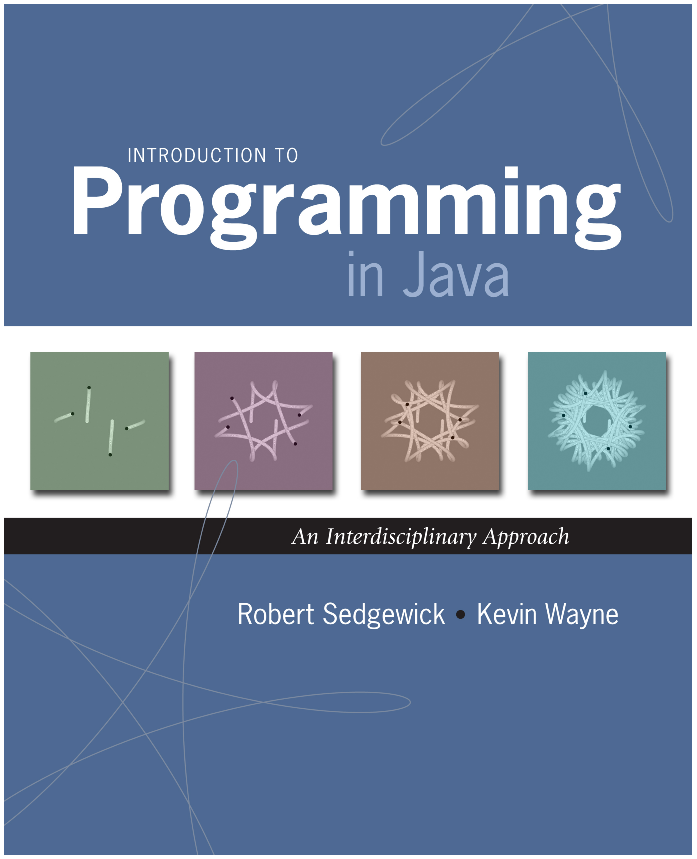
3.1 Using Data Types (II)



Text Processing

String Data Type

String data type. Basis for text processing.
Set of values. Sequence of Unicode characters.

API.

`public class String` *(Java string data type)*

	`String(String s)`	*create a string with the same value as* `s`
`int`	`length()`	*string length*
`char`	`charAt(int i)`	`i`*th character*
`String`	`substring(int i, int j)`	`i`*th through* (`j-1`)*st characters*
`boolean`	`contains(String sub)`	*does string contain* `sub` *as a substring?*
`boolean`	`startsWith(String pre)`	*does string start with* `pre`*?*
`boolean`	`endsWith(String post)`	*does string end with* `post`*?*
`int`	`indexOf(String p)`	*index of first occurrence of* `p`
`int`	`indexOf(String p, int i)`	*index of first occurrence of* `p` *after* `i`
`String`	`concat(String t)`	*this string with* `t` *appended*
`int`	`compareTo(String t)`	*string comparison*
`String`	`replaceAll(String a, String b)`	*result of changing* `a`*s to* `b`*s*
`String[]`	`split(String delim)`	*strings between occurrences of* `delim`
`boolean`	`equals(String t)`	*is this string's value the same as* `t`*'s?*

http://download.oracle.com/javase/6/docs/api/java/lang/String.html

Typical String Processing Code

is the string a palindrome?

```
public static boolean isPalindrome(String s)
{
   int N = s.length();
   for (int i = 0; i < N/2; i++)
      if (s.charAt(i) != s.charAt(N-1-i))
         return false;
   return true;
}
```

extract file name and extension from a command-line argument

```
String s = args[0];
int dot = s.indexOf(".");
String base      = s.substring(0, dot);
String extension = s.substring(dot + 1, s.length());
```

print all lines in standard input that contain a string specified on the command line

```
String query = args[0];
while (!StdIn.isEmpty())
{
   String s = StdIn.readLine();
   if (s.contains(query)) StdOut.println(s);
}
```

print all the hyperlinks (to educational institutions) in the text file on standard input

```
while (!StdIn.isEmpty())
{
   String s = StdIn.readString();
   if (s.startsWith("http://") && s.endsWith(".edu"))
      StdOut.println(s);
}
```

Gene Finding

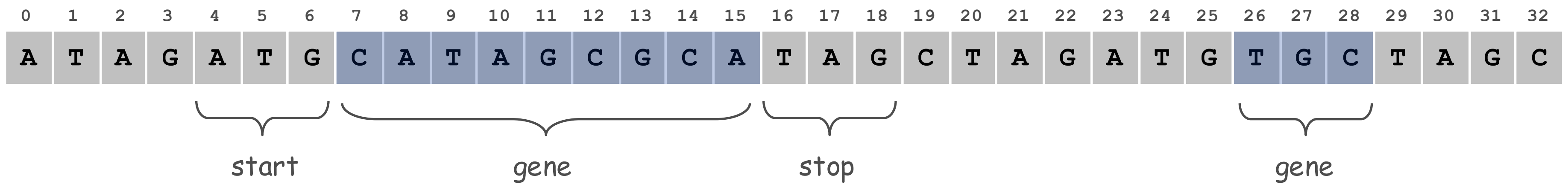
Pre-genomics era. Sequence a human genome.
Post-genomics era. Analyze the data and understand structure.

Genomics. Represent genome as a string over { A, C, T, G } alphabet.

Gene. A substring of genome that represents a functional unit.

- Preceded by **ATG**. [start codon]
- Multiple of 3 nucleotides. [codons other than start/stop]
- Succeeded by **TAG**, **TAA**, or **TGA**. [stop codons]

Goal. Find all genes.



Gene Finding: Algorithm

Algorithm. Scan left-to-right through genome.

- If start codon, then set **`beg`** to index **`i`**.
- If stop codon and substring is a multiple of 3
  - output gene
  - reset **`beg`** to -1

i	codon		beg	gene	*remaining portion of input string*
	start	*stop*			
0			-1		ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
1		TAG	-1		ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
4	ATG		4		ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
9		TAG	4		ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
16		TAG	4	$\overbrace{\text{CATAGCGCA}}^{\text{multiple of 3}}$	ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
20		TAG	-1		ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
23	ATG		23		ATAGATGCATAGCGCATAGCTAGATGTGCTAGC
29		TAG	23	TGC	ATAGATGCATAGCGCATAGCTAGATGTGCTAGC

Gene Finding: Implementation

```java
public class GeneFind {
   public static void main(String[] args) {
      String start  = args[0];
      String stop   = args[1];
      String genome = StdIn.readAll();

      int beg = -1;
      for (int i = 0; i < genome.length() - 2; i++) {
         String codon = genome.substring(i, i+3);
         if (codon.equals(start)) beg = i;
         if (codon.equals(stop) && beg != -1 && beg+3 < i) {
            String gene = genome.substring(beg+3, i);
            if (gene.length() % 3 == 0) {
               StdOut.println(gene);
               beg = -1;
            }
         }
      }
   }
}
```

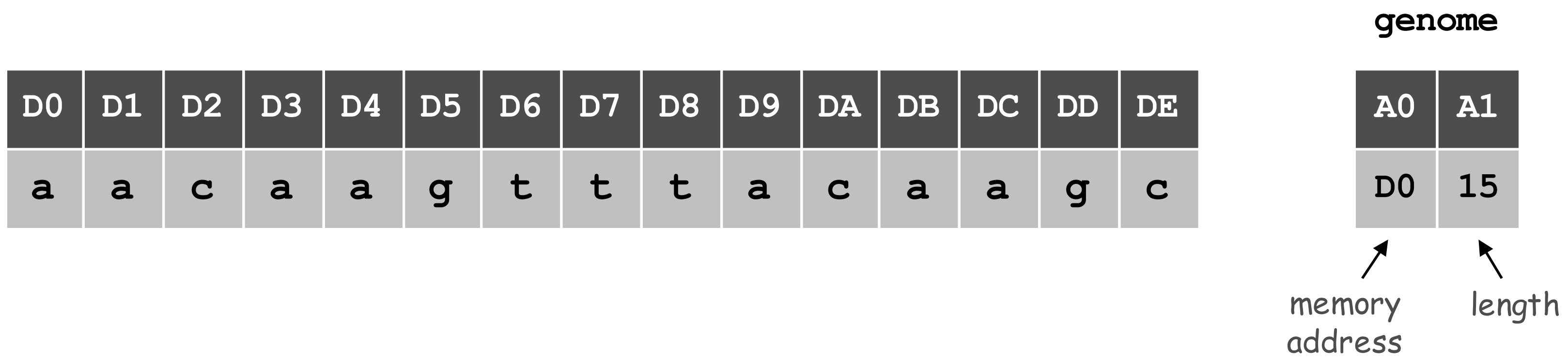
```
% more genomeTiny.txt
ATAGATGCATAGCGCATAGCTAGATGTGCTAGC

% java GeneFind ATG TAG < genomeTiny.txt
CATAGCGCA
TGC
```

OOP Context for Strings

Possible memory representation of a string.

- `genome = "aacaagtttacaagc";`



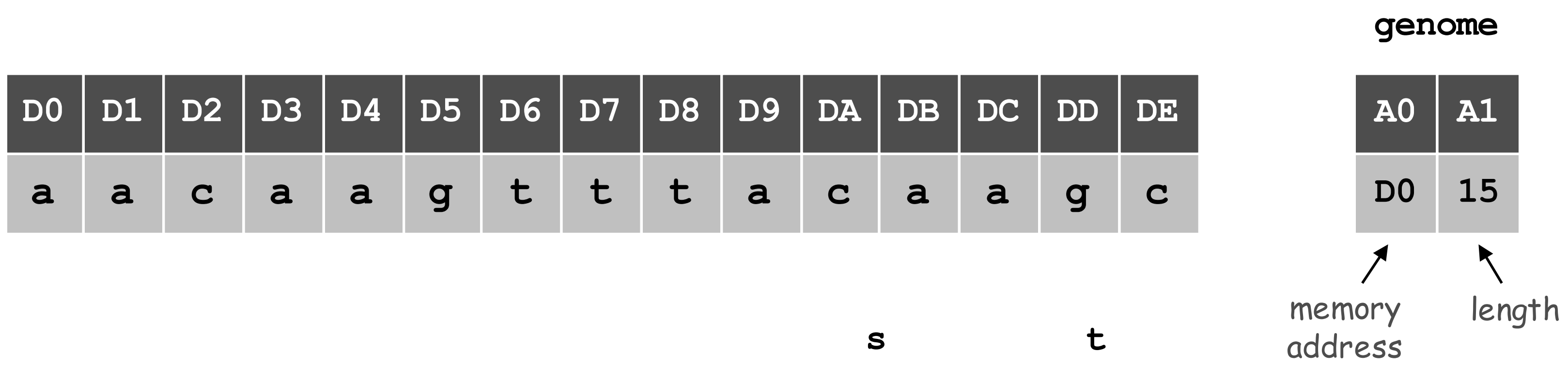
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE
a	a	c	a	a	g	t	t	t	a	c	a	a	g	c

A0	A1
D0	15

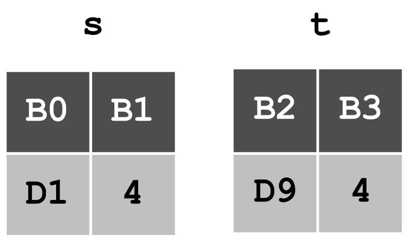
OOP Context for Strings

Possible memory representation of a string.

- `genome = "aacaagtttacaagc";`


genome
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE
a a c a a g t t t a c a a g c
A0 A1
D0 15
memory address
length

- `s = genome.substring(1, 5);`
- `t = genome.substring(9, 13);`



s and t refer to different strings that have the same value "acaa"

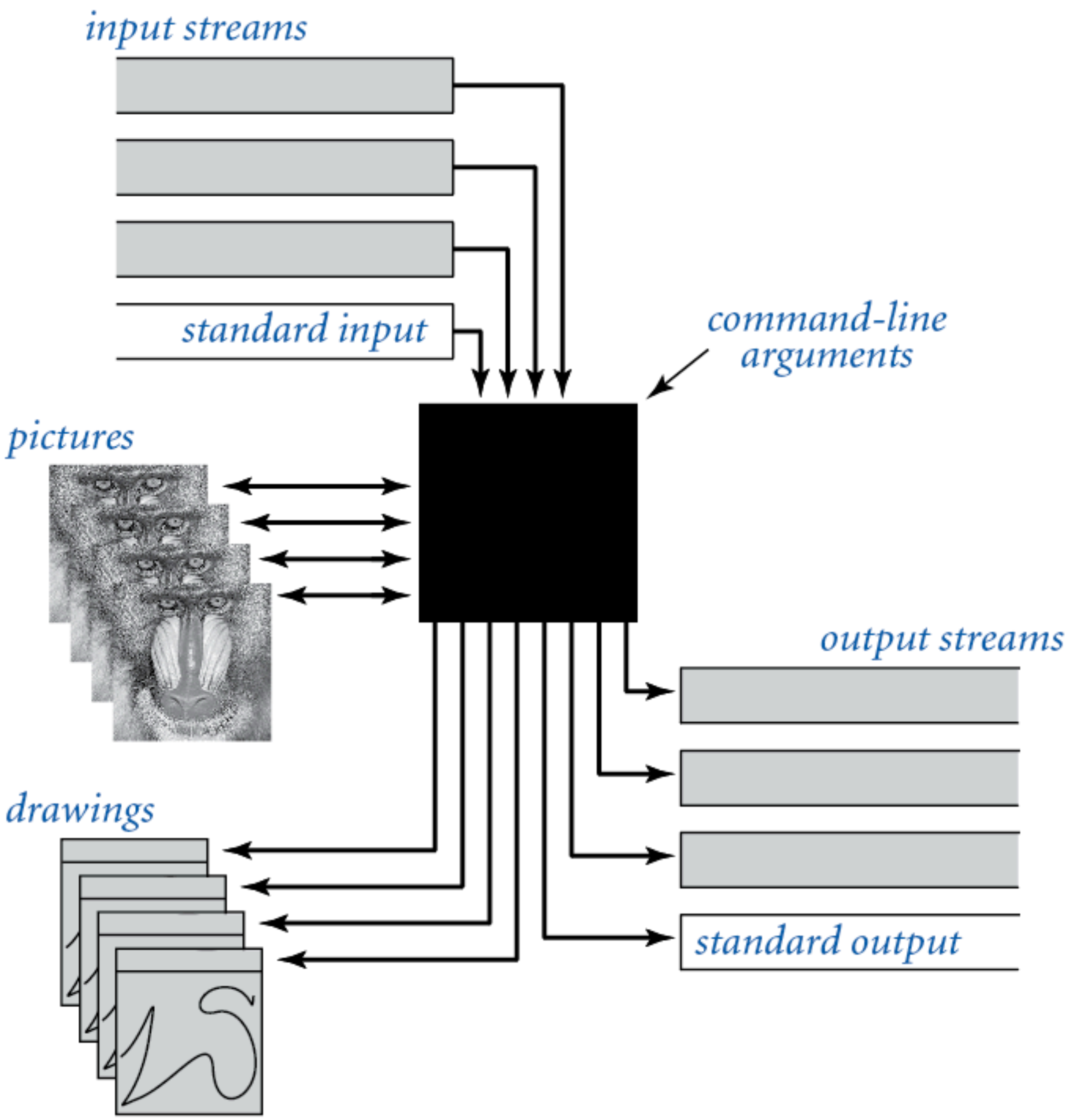
- `(s == t)` is `false`, but `(s.equals(t))` is `true`.

compares pointers

compares character sequences

In and Out

Bird's Eye View (Revisited)



Non-Standard Input

or use OS to redirect from one file

Standard input. Read from terminal window.

Goal. Read from several different input streams.

`In` data type. Read text from stdin, a file, a web site, or network.

Ex: Are two text files identical?

```
public class Diff {
   public static void main(String[] args) {
      In in0 = new In(args[0]);     ← read from one file
      In in1 = new In(args[1]);     ← read from another file
      String s = in0.readAll();
      String t = in1.readAll();
      StdOut.println(s.equals(t));
   }
}
```

Screen Scraping

Goal. Find current stock price of Google.

```
…
<tr>
<td class="yfnc_tablehead1" width="48%">
Last Trade:
</td>
<td class="yfnc_tabledata1">
<big>
<b>576.50</b>
</big>
</td>
</tr>
<tr>
<td class="yfnc_tablehead1" width="48%">
Trade Time:
</td>
<td class="yfnc_tabledata1">
11:45AM ET
</td>
</tr>
…
```

`http://finance.yahoo.com/q?s=goog`

NYSE symbol

Screen Scraping

Goal. Find current stock price of Google.

- `s.indexOf(t, i)`: index of first occurrence of pattern `t` in string `s`, starting at offset `i`.
- Read raw html from `http://finance.yahoo.com/q?s=goog`.
- Find first string delimited by `<b>` and `</b>` after `Last Trade`.

```java
public class StockQuote {
   public static void main(String[] args) {
      String name = "http://finance.yahoo.com/q?s=";
      In in = new In(name + args[0]);
      String input = in.readAll();
      int start    = input.indexOf("Last Trade:", 0);
      int from     = input.indexOf("<b>",  start);
      int to       = input.indexOf("</b>", from);
      String price = input.substring(from + 3, to);
      StdOut.println(price);
   }
}
```

```
% java StockQuote goog
576.50
```

Day Trader

Add bells and whistles.

- Plot price in real-time.
- Notify user if price dips below a certain price.
- Embed logic to determine when to buy and sell.
- Automatically send buy and sell orders to trading firm.

Warning. Please, please use at your own financial risk.

The New Yorker, September 6, 1999

OOP Summary

Object. Holds a data type value; variable name refers to object.

In Java, programs manipulate references to objects.

- Exception: primitive types, e.g., **`boolean`**, **`int`**, **`double`**.
- Reference types: **`String`**, **`Picture`**, **`Color`**, arrays, everything else.
- OOP purist: language should not have separate primitive types.

Bottom line. We wrote programs that manipulate colors, pictures, and strings.

Next time. We'll write programs that manipulate our own abstractions.

Extra Slides

Color Separation

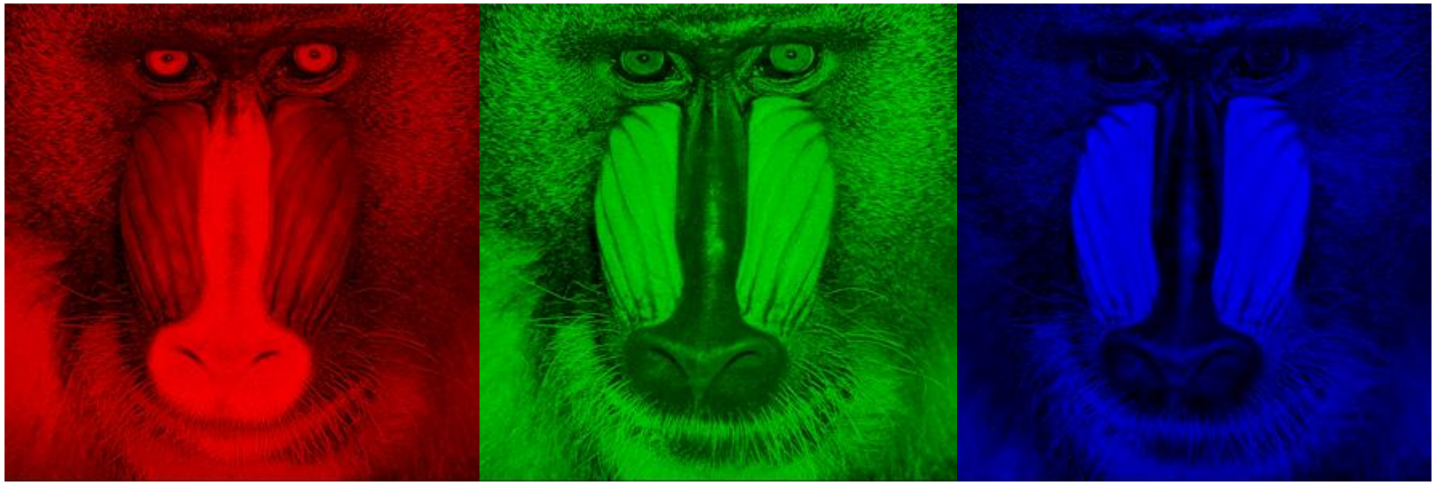
```
import java.awt.Color;
public class ColorSeparation {
    public static void main(String args[]) {
        Picture pic = new Picture(args[0]);
        int width  = pic.width();
        int height = pic.height();

        Picture R = new Picture(width, height);
        Picture G = new Picture(width, height);
        Picture B = new Picture(width, height);

        for (int x = 0; x < width; x++) {
            for (int y = 0; y < height; y++) {
                Color c = pic.get(x, y);
                int r = c.getRed();
                int g = c.getGreen();
                int b = c.getBlue();
                R.set(x, y, new Color(r, 0, 0));
                G.set(x, y, new Color(0, g, 0));
                B.set(x, y, new Color(0, 0, b));
            }
        }
        R.show();
        G.show();
        B.show();
    }
}
```

Color Separation

ColorSeparation.java. Creates three `Picture` objects and windows.



Memory Management

Value types.

- Allocate memory when variable is declared.
- Can reclaim memory when variable goes out of scope.

Reference types.

- Allocate memory when object is created with `new`.
- Can reclaim memory when last reference goes out of scope.
- Significantly more challenging if several references to same object.

Garbage collector. System automatically reclaims memory; programmer relieved of tedious and error-prone activity.