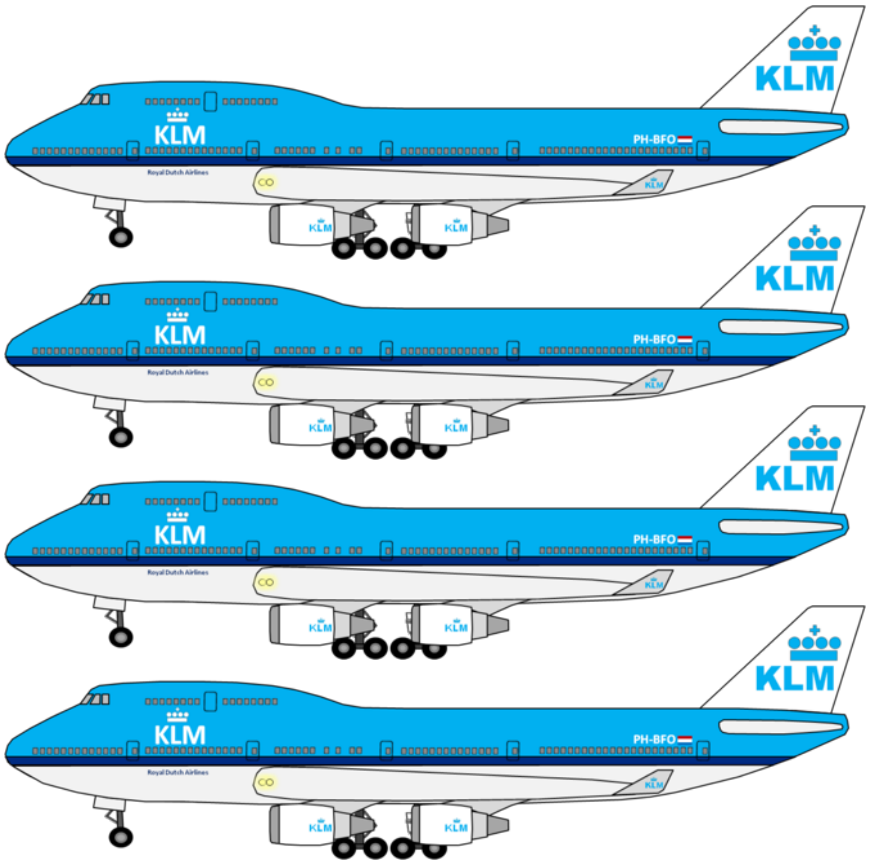
Fake Medicine is a Problem

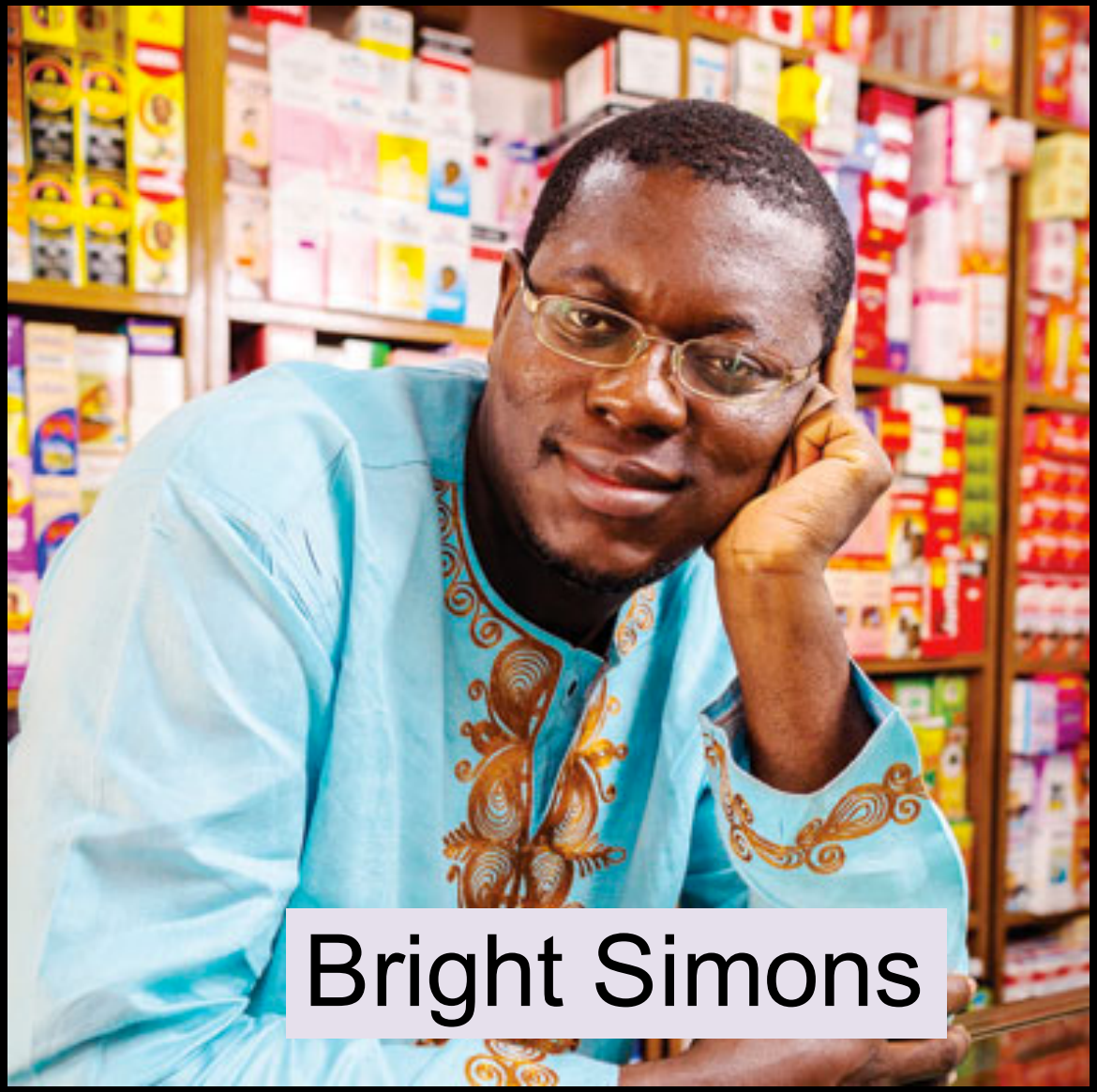
700,000 deaths a year from fake malaria and tuberculosis drugs [1]



Equivalent of this many crashes per day

[1] http://www.un.org/africarenewal/magazine/may-2013/counterfeit-drugs-raise-africa%E2%80%99s-temperature

Chris' Favorite Program



Underlying Puzzle

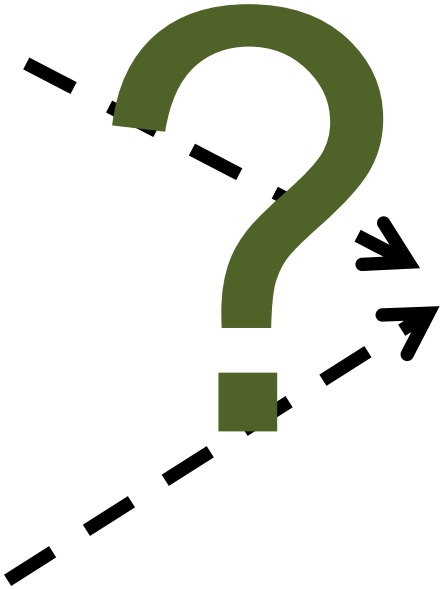
Counterfeiter

User

You (Distributor)

Underlying Puzzle

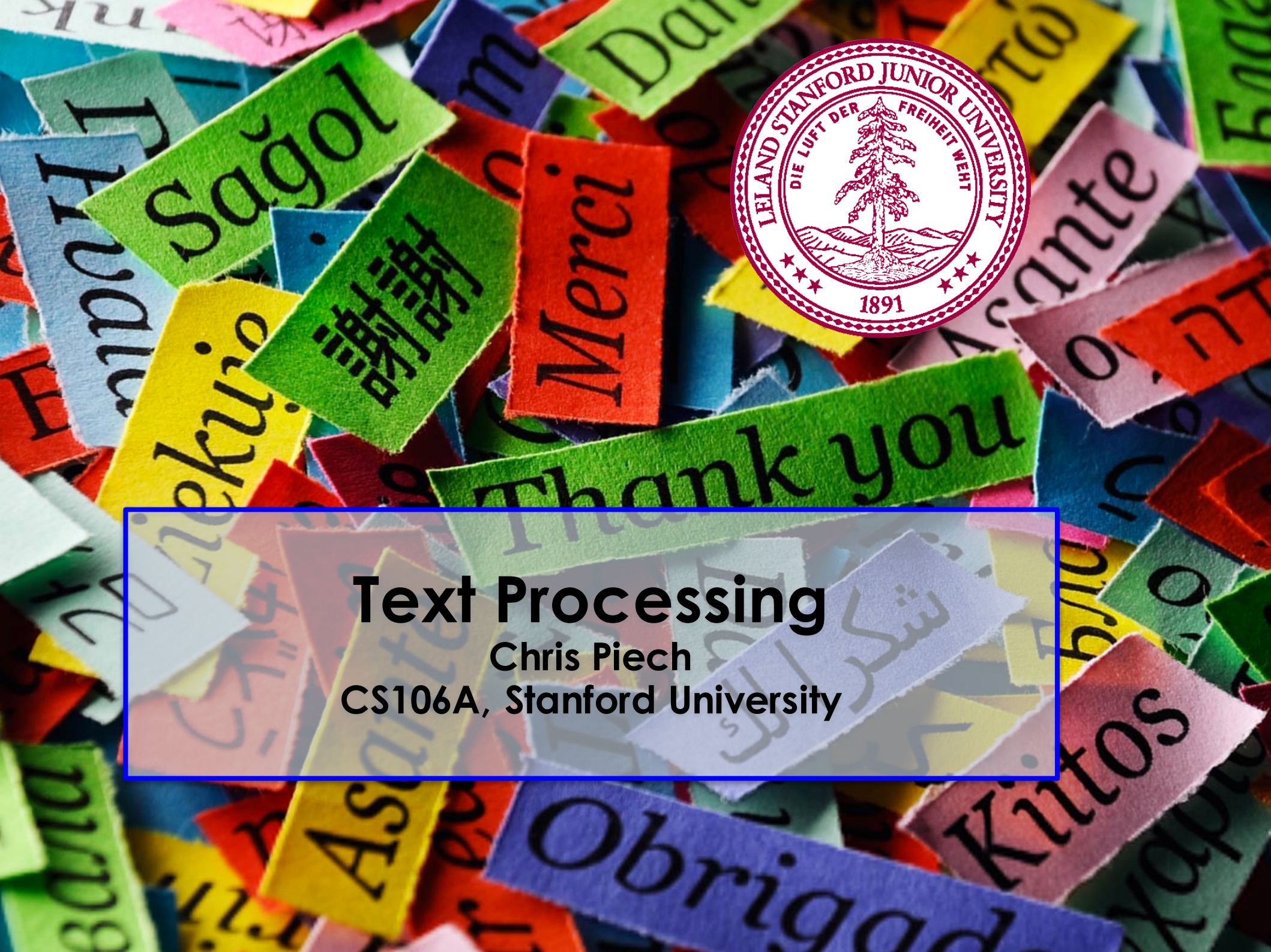
Counterfeiter



User

You (Distributor)

Revisit this on Wednesday

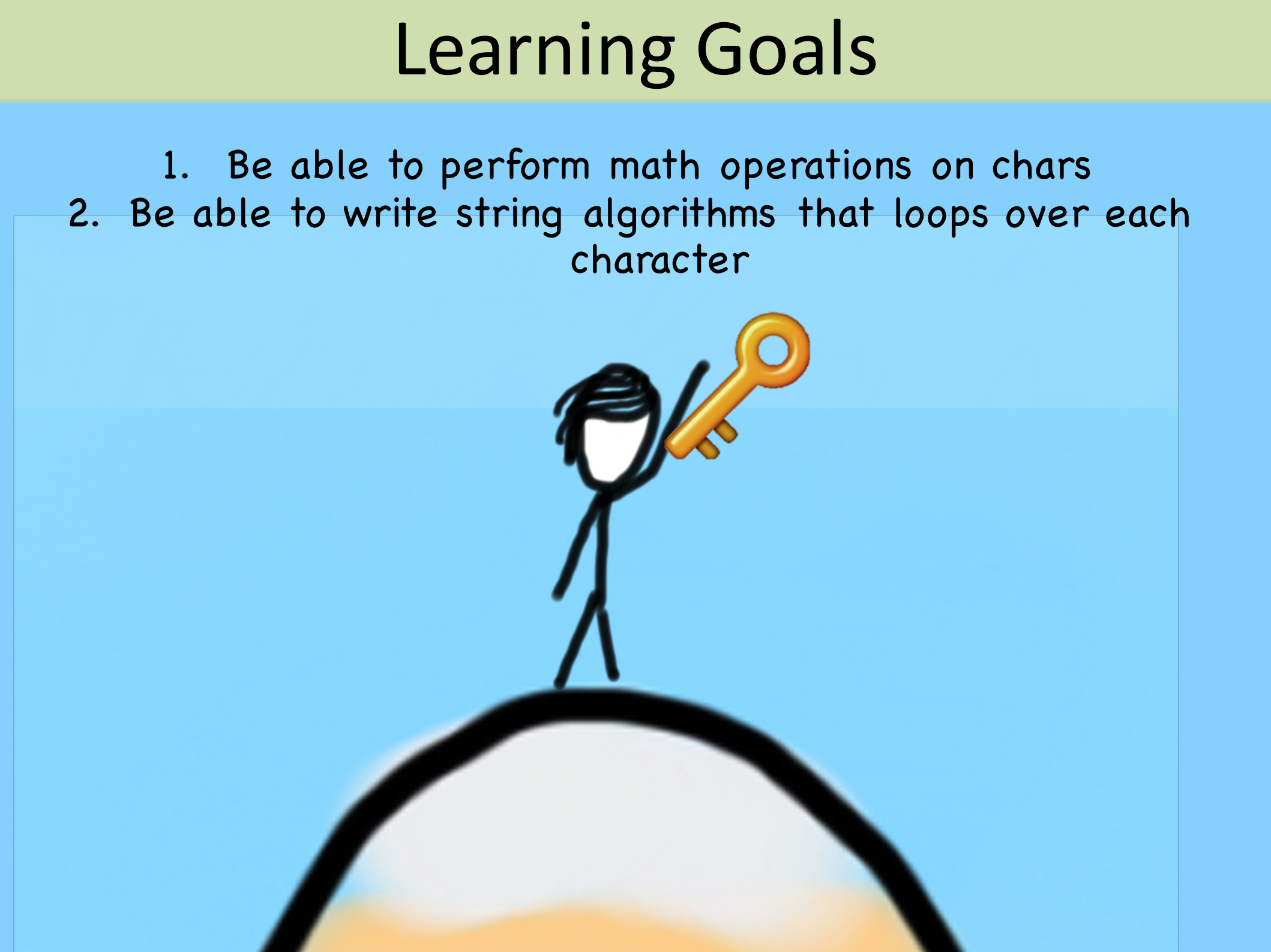


Text Processing

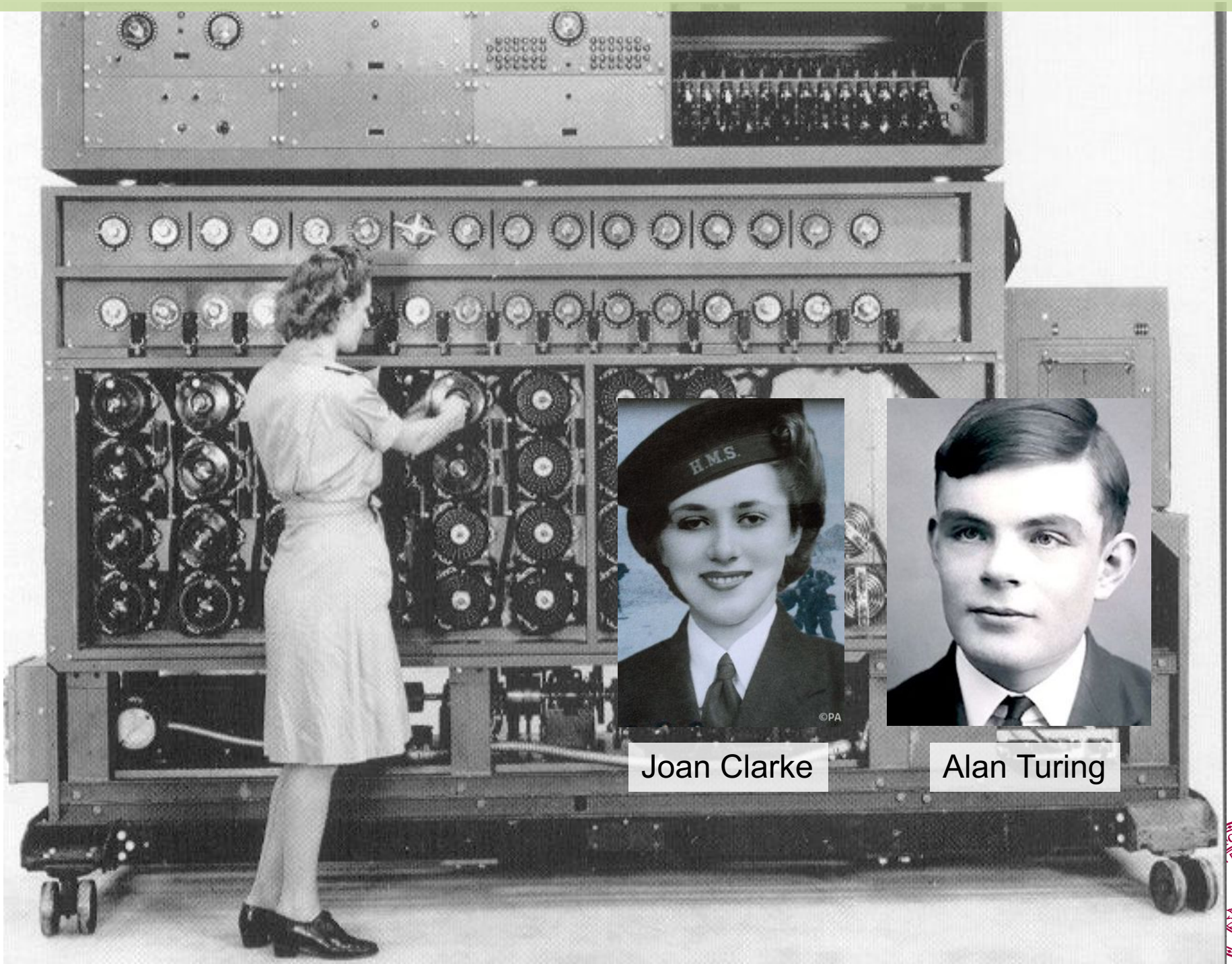
Chris Piech
CS106A, Stanford University

Learning Goals

1. Be able to perform math operations on chars
2. Be able to write string algorithms that loops over each character



Text Problem: Decryption



Text Problem: Translation

The spirit is willing but the flesh is weak.

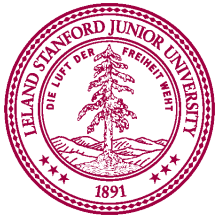
↓

(Russian)

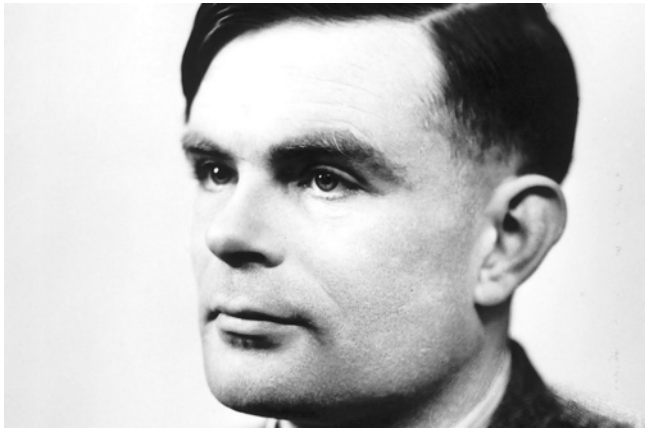
↓

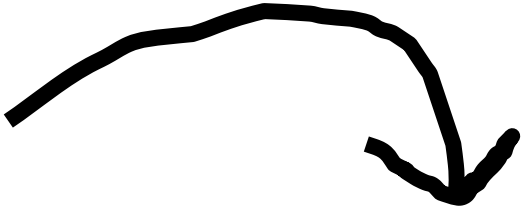
The vodka is good but the meat is rotten.

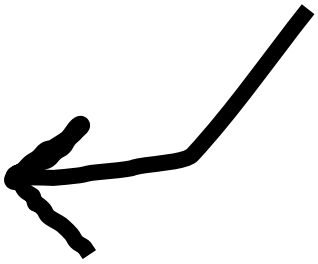
**This result cost billions of dollars (adjusted for inflation)*



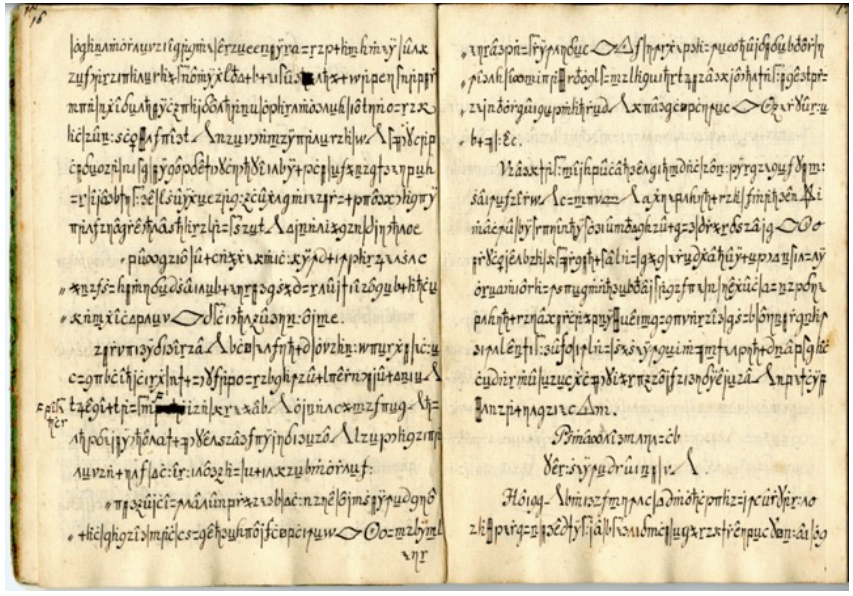
Translation and cryptography







Copiale Cipher from 1700s



http://www.nytimes.com/2011/10/25/science/25code.html

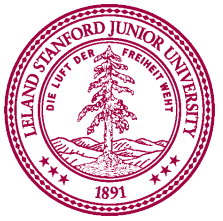
How is text
represented?

The variable type **`String`**

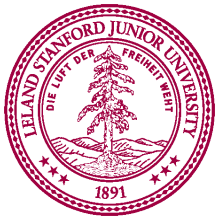
Text is stored using the variable type **`String`**.

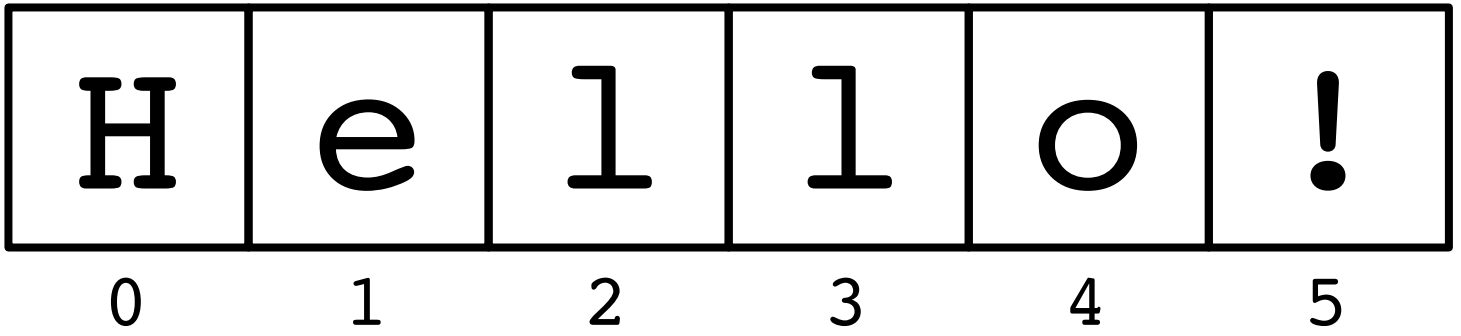
A **`String`** is a sequence of characters.

```
public void run() {
    String text = "hello!";
    println(text);
}
```

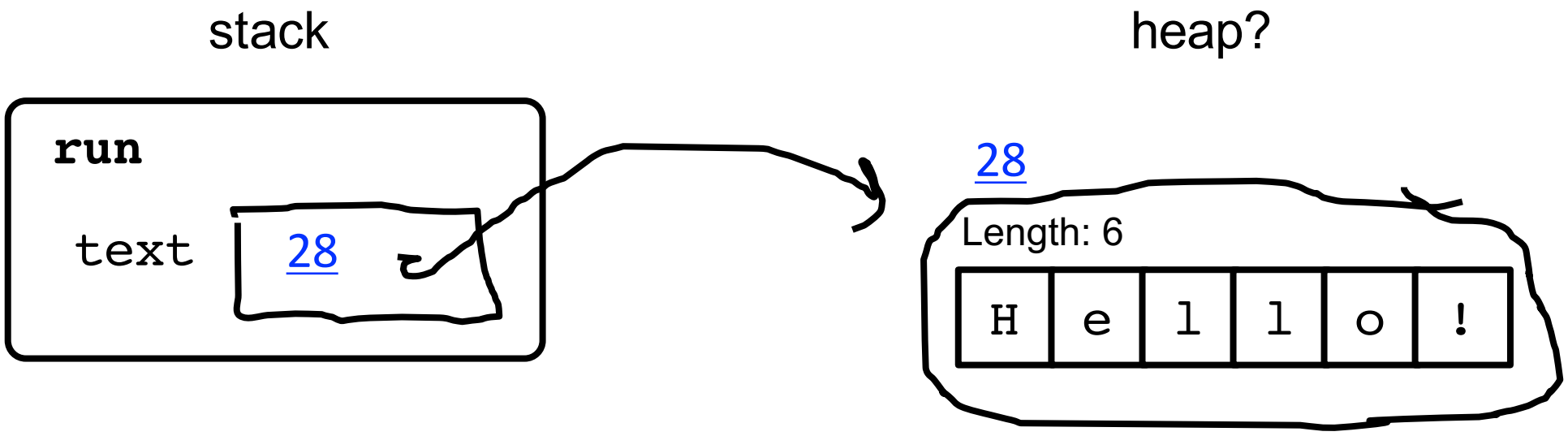
H e l l o !

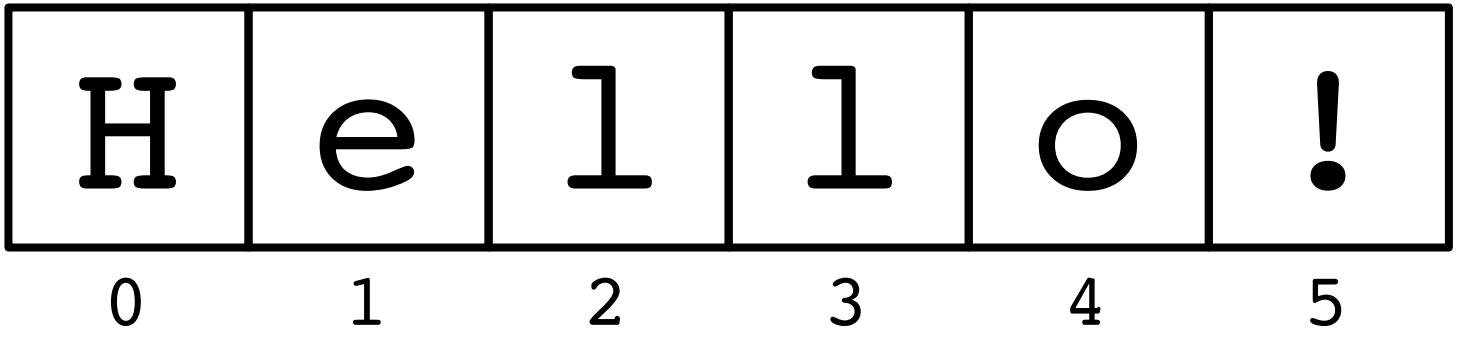

LELAND STANFORD JUNIOR UNIVERSITY
DIE LUFT DER FREIHEIT WEHT
1891


H e l l o !
0 1 2 3 4 5

How it is actually stored

```
public void run() {
    String text = "hello!";
}
```





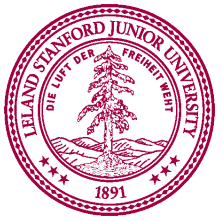
***text*.charAt(*index*)**

How are characters represented?

The variable type **`char`**

- The primitive type **`char`** represents a single character or glyph.
- Some examples:

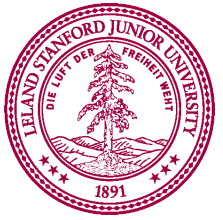
```
char letterA = 'A';
char plus    = '+'
char zero    = '0';
char space   = ' ';
char newLine = '\n'; // special
char first = text.charAt(0);
```


Takisha

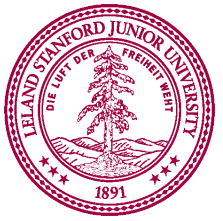
Enumeration

```
private static final int FROSH = 1;
private static final int SOPHOMORE = 2;
private static final int JUNIOR = 3;
private static final int SENIOR = 4;
private static final int OTHER = 5;


private int askForYear() {
  while (true) {
    int year = readInt("Enter class year: ");
    if (year >= FROSH && year <= OTHER) return year;
  }
}
```

Print Populations

```
private void printPopulation() {
    for(int year = FROSH; year <= SENIOR; year++) {
       println(countStudents(year));
    }
}
```



Chars are just a giant enumeration. You can use math operators on char!

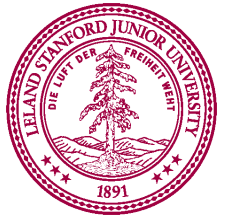
ASCII

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32	[space]	48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	'	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	[backspace]

* This is only the first half of the table

The letter A, for example, has the ASCII value 65_{10}

Using portions of slides by Eric Roberts

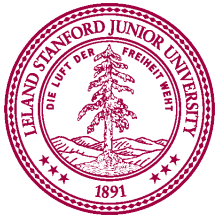


‘A’ -> ‘Z’ are sequential.
‘a’ -> ‘z’ are sequential.
‘0’ -> ‘9’ are sequential.

toUpperCase

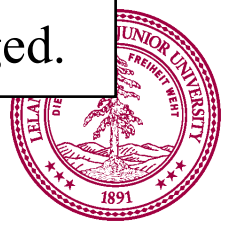
Useful Character methods

```
public void run() {
   String str = readLine("Line: ");

   char ch = str.charAt(0);
   println("Original first char: " + ch);

   ch = Character.toUpperCase(ch);
   println("Uppercase first char: " + ch);

   if(Character.isLetter(ch)) {
      println("It's a letter!");
   }
}
```

Useful Character methods

`static boolean isDigit(char ch)` Determines if the specified character is a digit.
`static boolean isLetter(char ch)` Determines if the specified character is a letter.
`static boolean isLetterOrDigit(char ch)` Determines if the specified character is a letter or a digit.
`static boolean isLowerCase(char ch)` Determines if the specified character is a lowercase letter.
`static boolean isUpperCase(char ch)` Determines if the specified character is an uppercase letter.
`static boolean isWhitespace(char ch)` Determines if the specified character is **whitespace** (spaces and tabs).
`static char toLowerCase(char ch)` Converts **`ch`** to its lowercase equivalent, if any. If not, **`ch`** is returned unchanged.
`static char toUpperCase(char ch)` Converts **`ch`** to its uppercase equivalent, if any. If not, **`ch`** is returned unchanged.

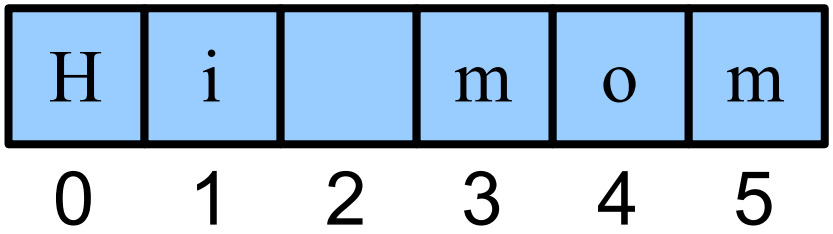


Looping with Strings

- Because each character in a string occupies a particular index, you can visit all the characters in a string one at a time using a loop.
- Canonical "loop over the characters in a string" loop:

```
for (int i = 0; i < string.length(); i++) {
   char ch = string.charAt(i);
   /* … process ch … */
}
```

- The `string.length()` method returns the number of characters in the string. This is one larger than the last valid index in the string.



(length 6)

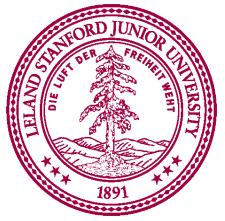
numUppercase

Strings have some unique properties

Strings are often made through concatenation

```
public void run() {
    String s1 = "CS106";
    String s2 = "A";
    String s3 = "I got an " + s2 + " in " + s1 + s2;

    println(s3);
}
```

```
I got an A in CS106A
```

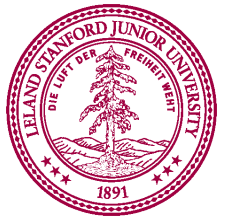




this
is
not
new

Strings are often made through concatenation

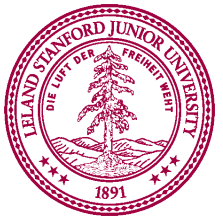
```
public void run() {
    String s1 = "CS106";
    String s2 = "A";
    String s3 = "I got an " + s2 + " in " + s1 + s2;

    println(s3);
}
```

```
I got an A in CS106A
```

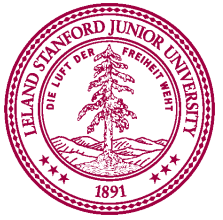



Strings are Immutable

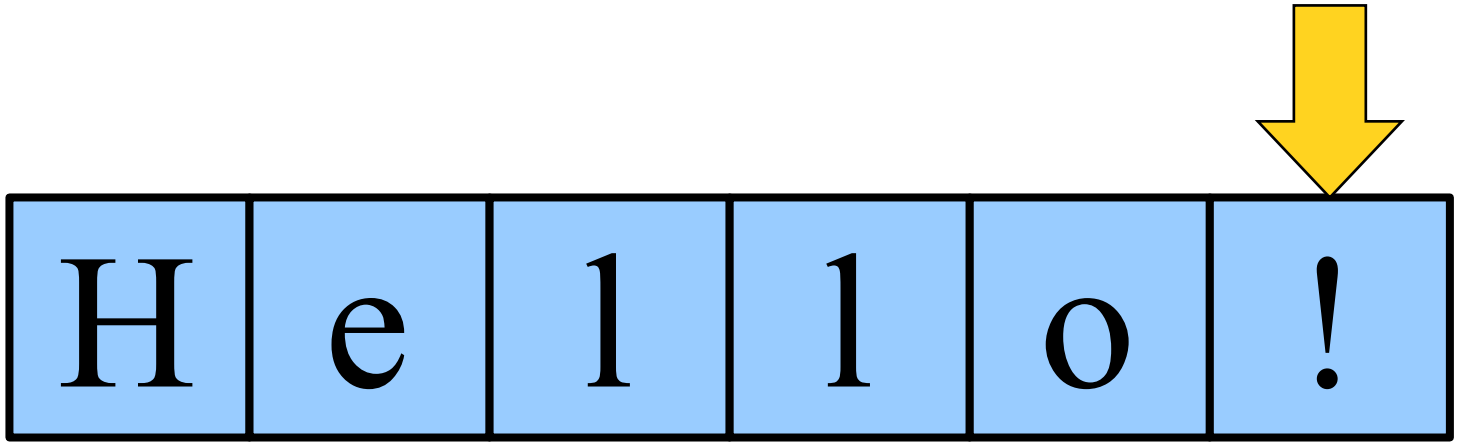
- Java strings are ***immutable***: once a string has been created, its contents cannot change.
- To change a string:
  - Create a new string holding the new value you want it to have.
  - Reassign the String variable to hold the new value.
- ***Important consequence:*** if you pass a String into a method, that method cannot modify that string.

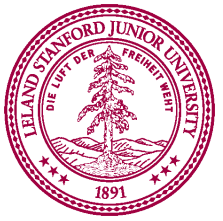


Many string algorithms use the “loop and construct” pattern.

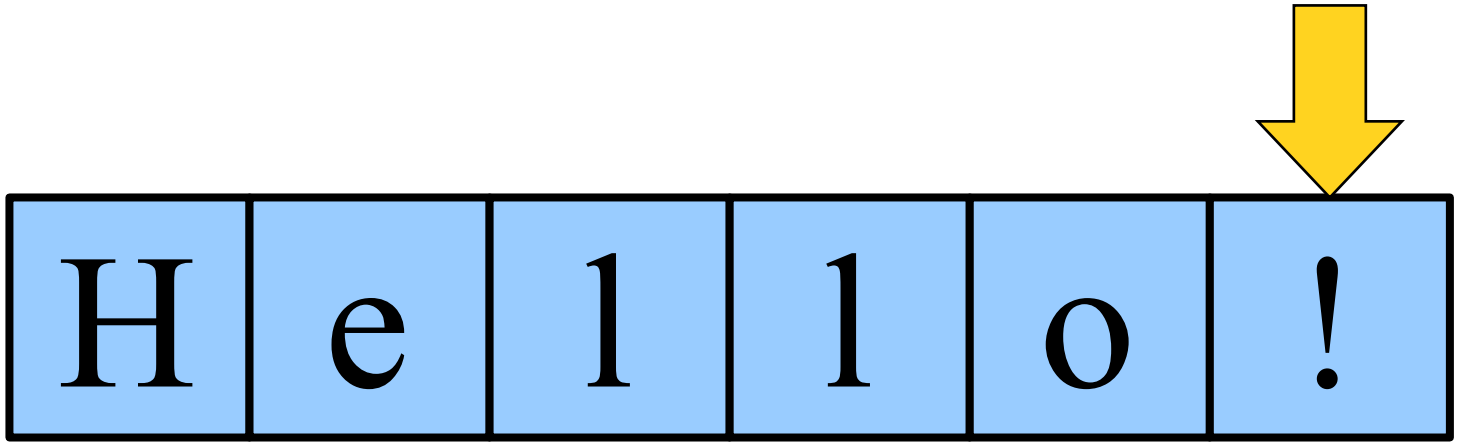


Reversing a String

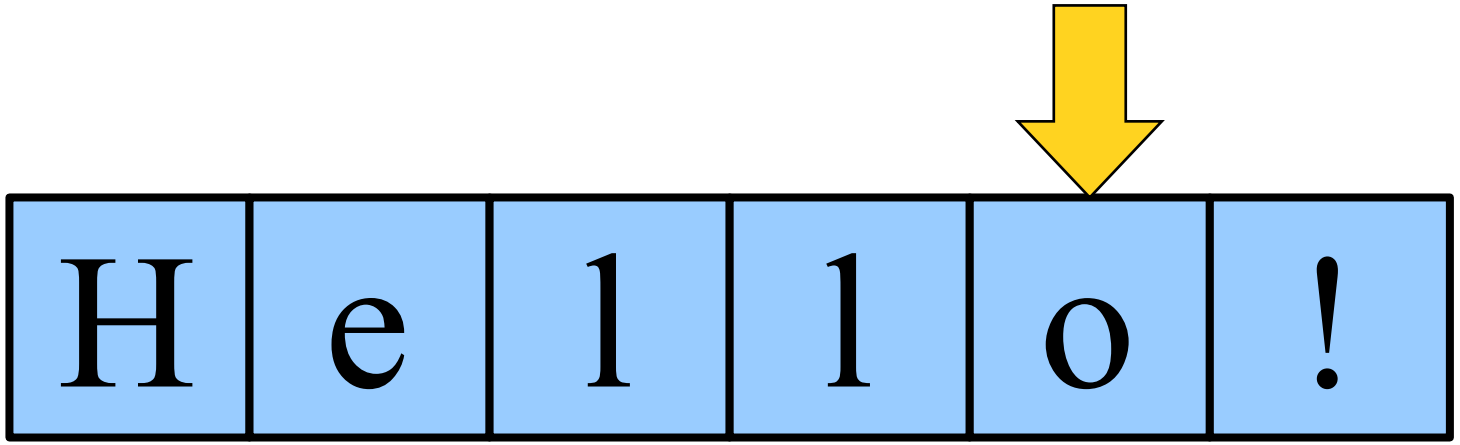




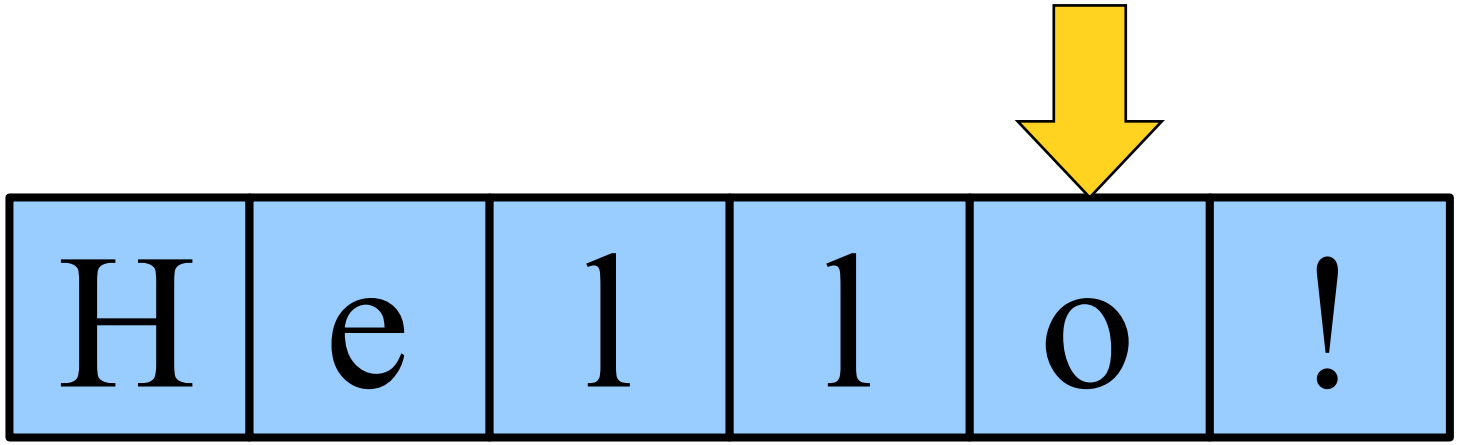
Reversing a String

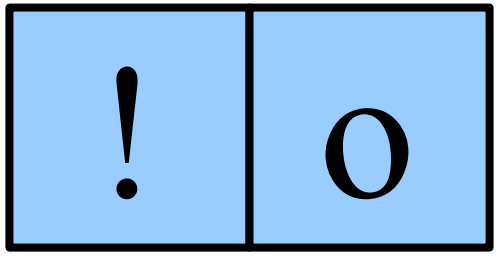


Reversing a String

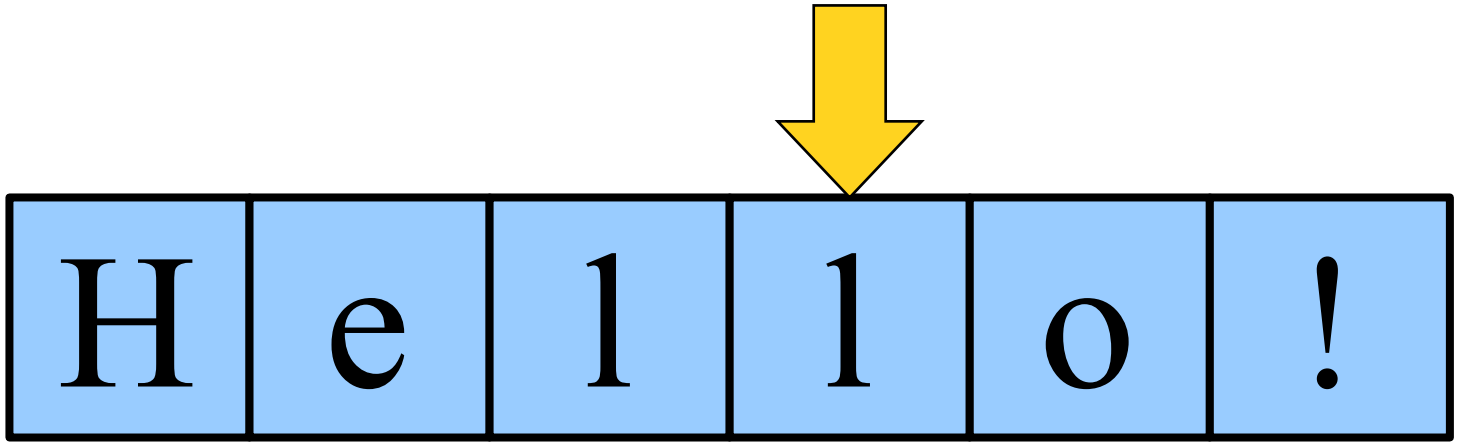


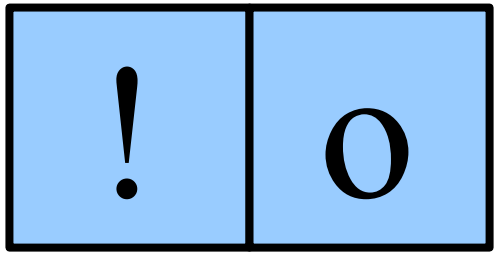
Reversing a String



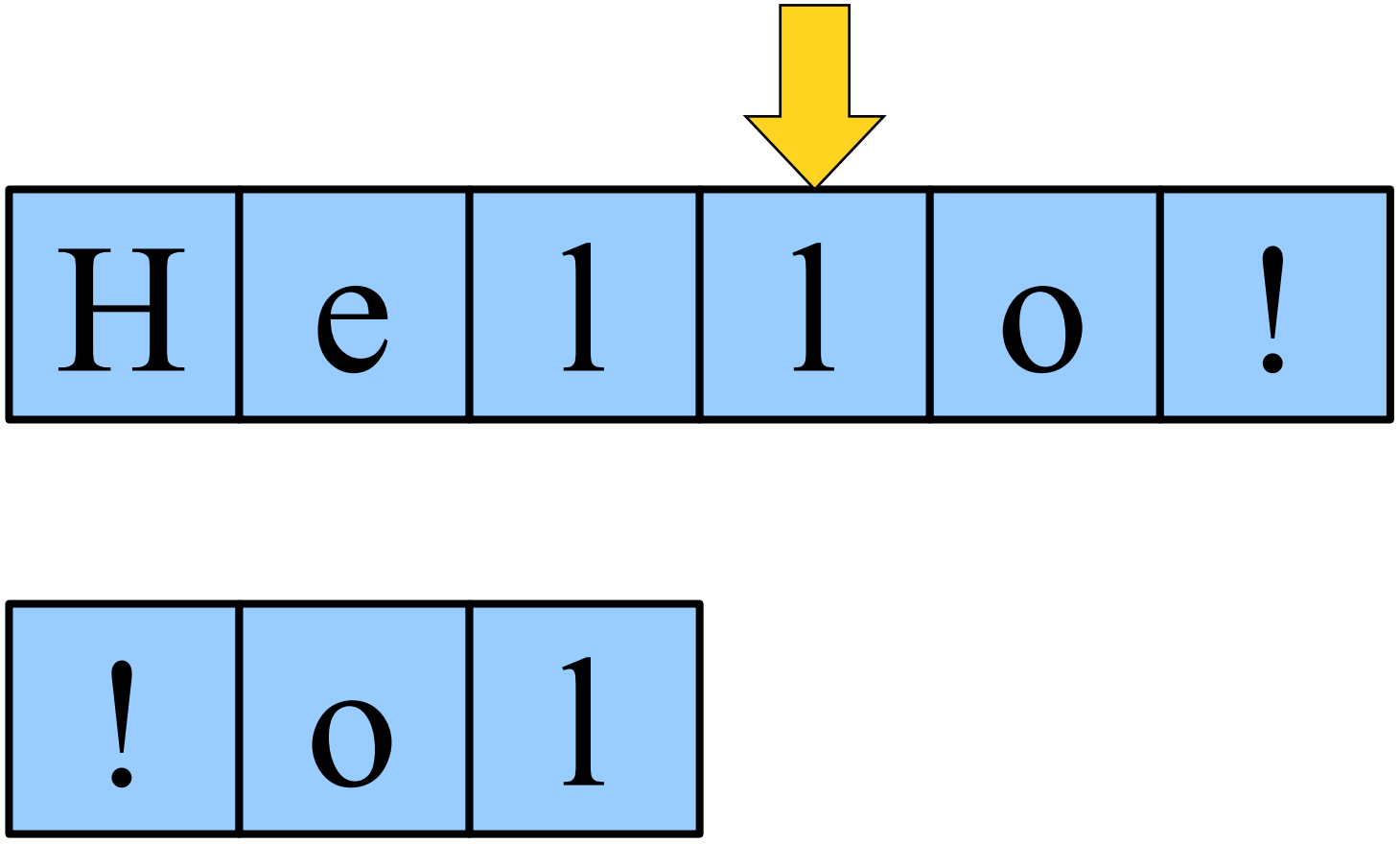


Reversing a String

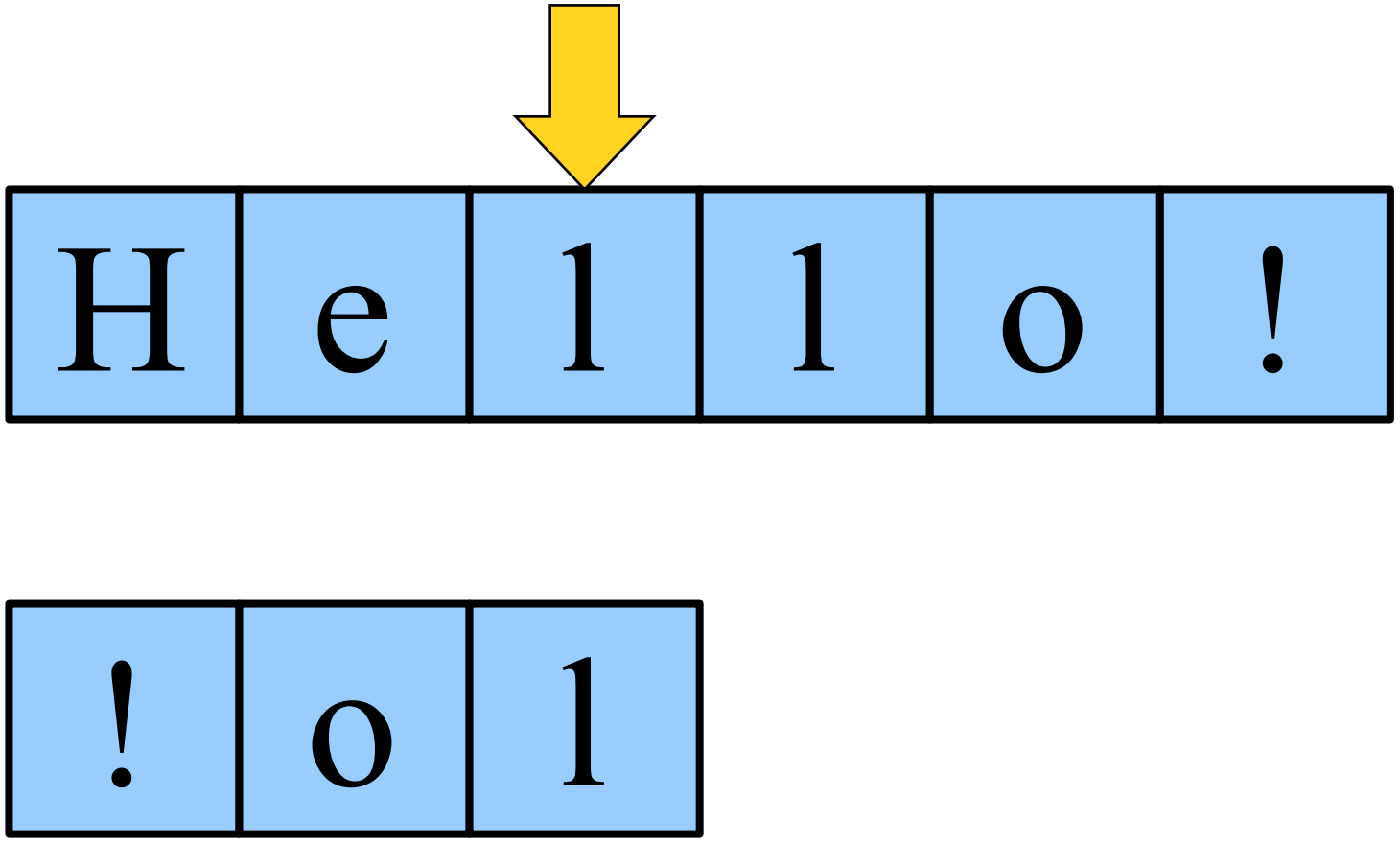




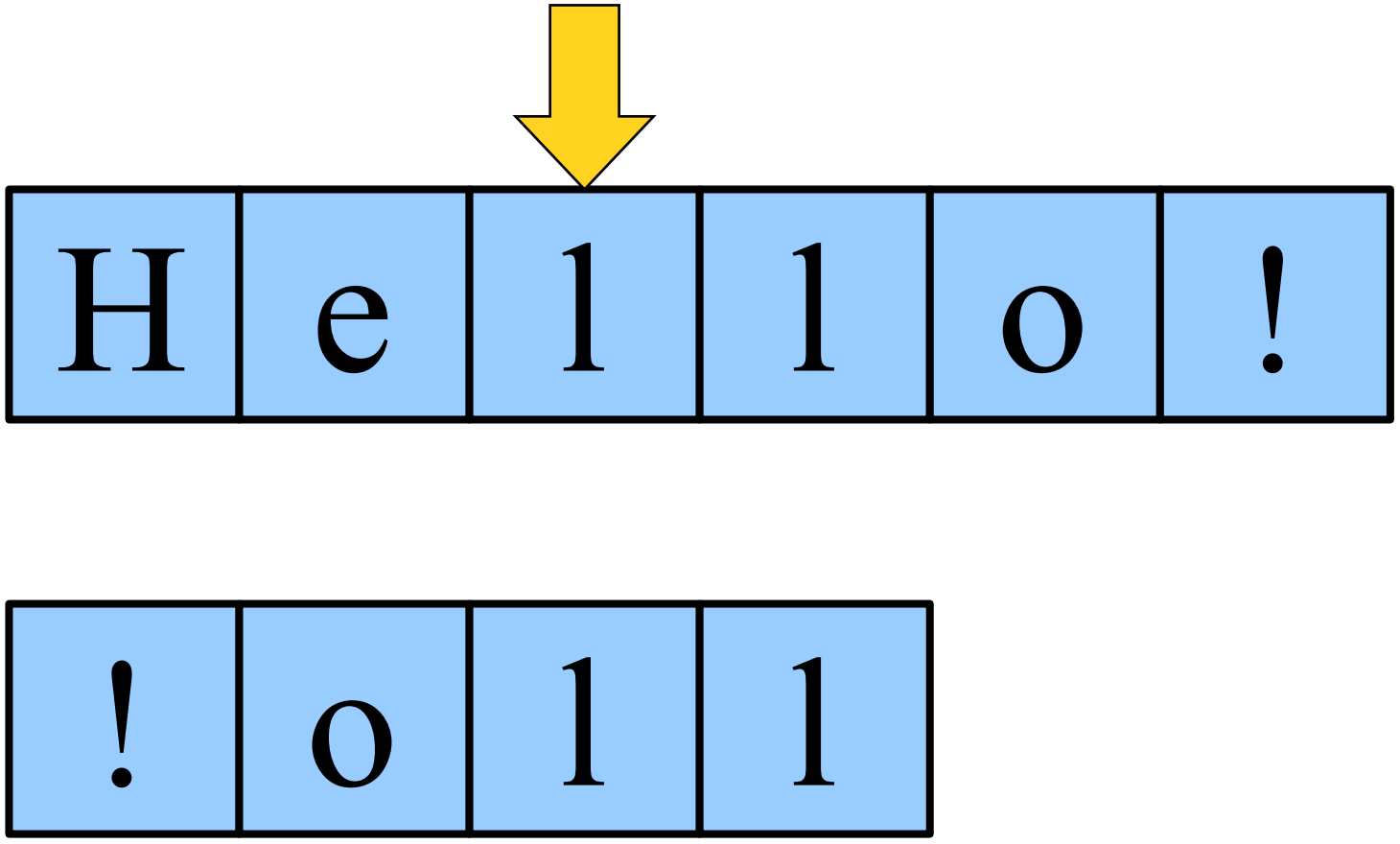
Reversing a String



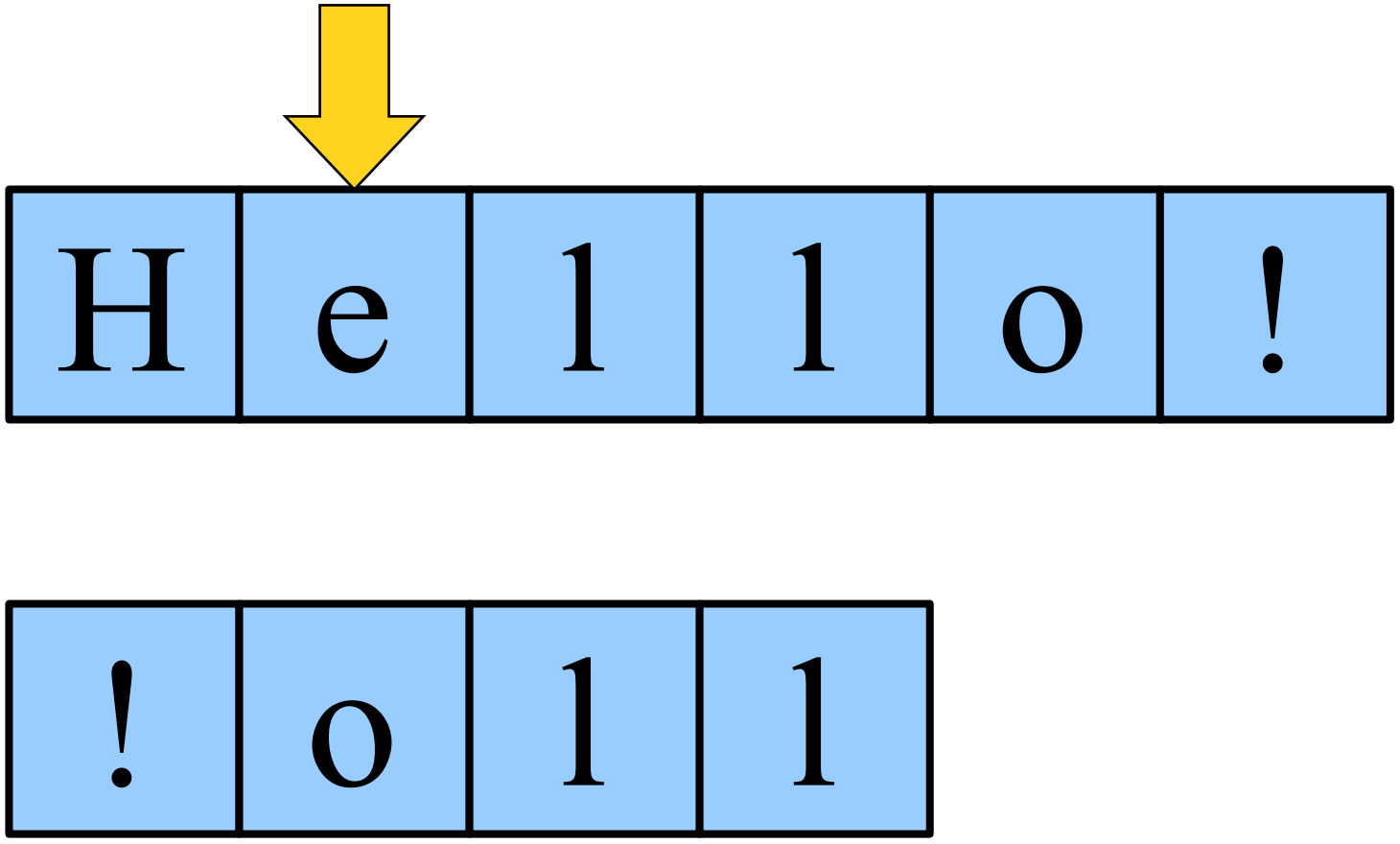
Reversing a String



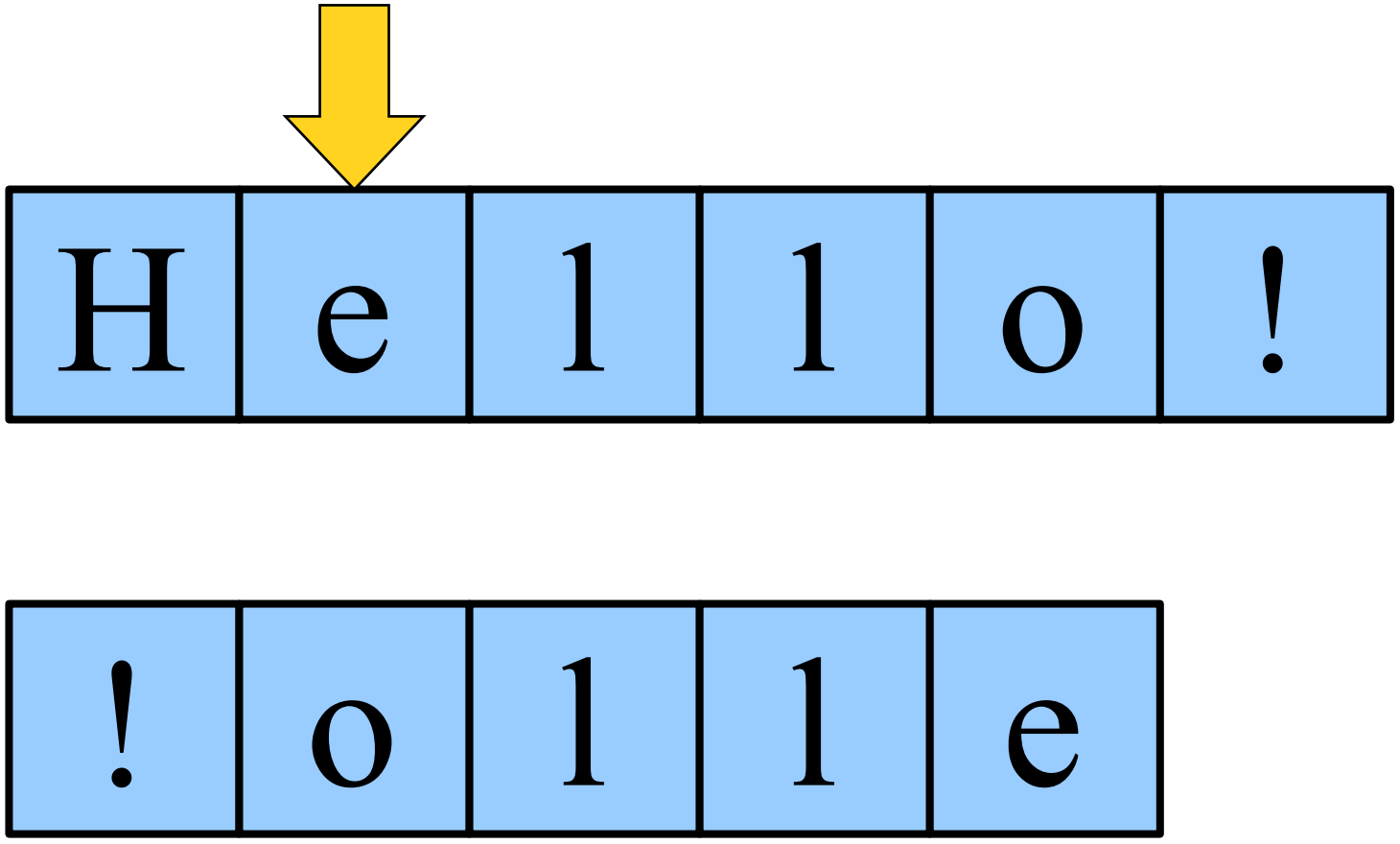
Reversing a String



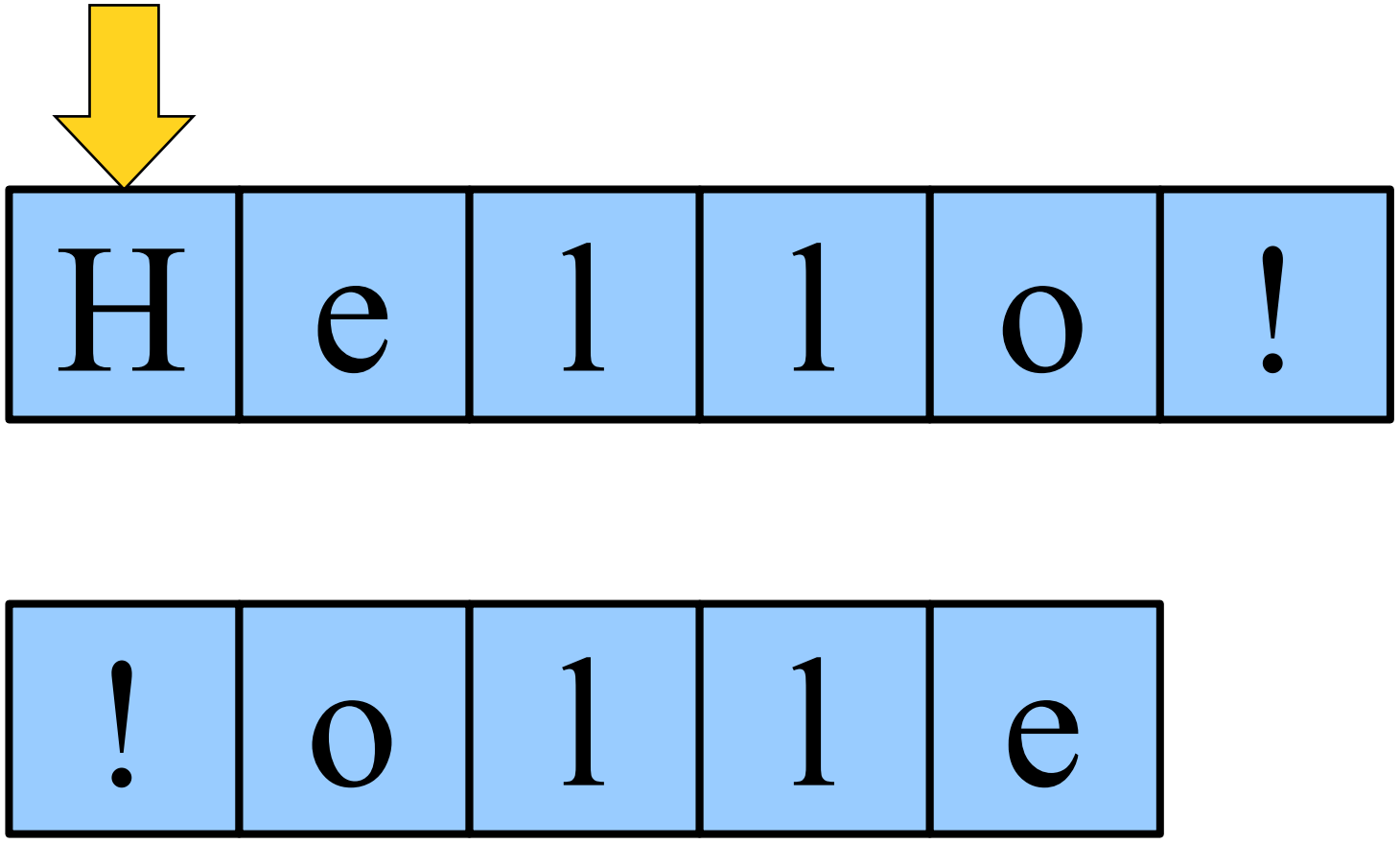
Reversing a String



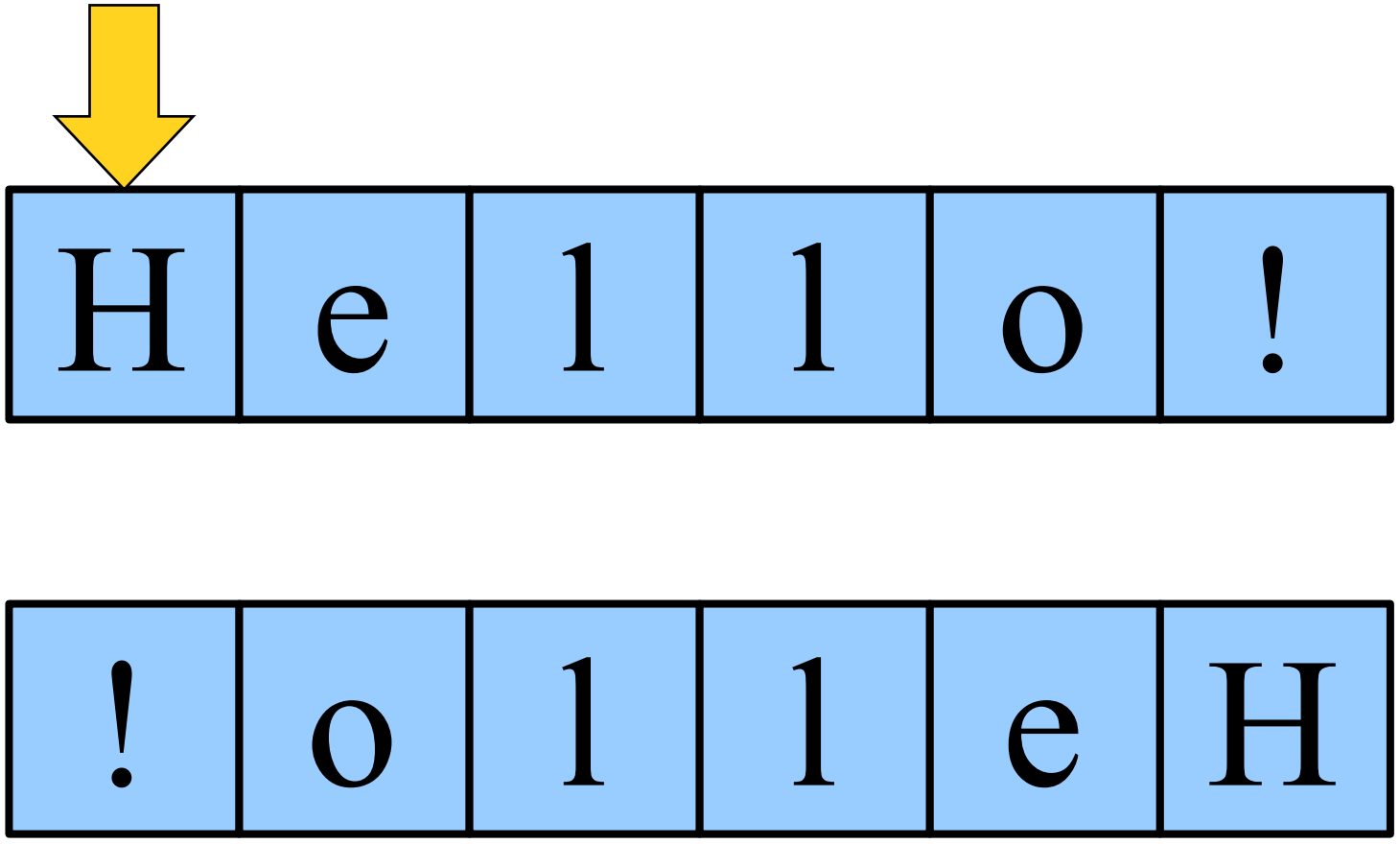
Reversing a String



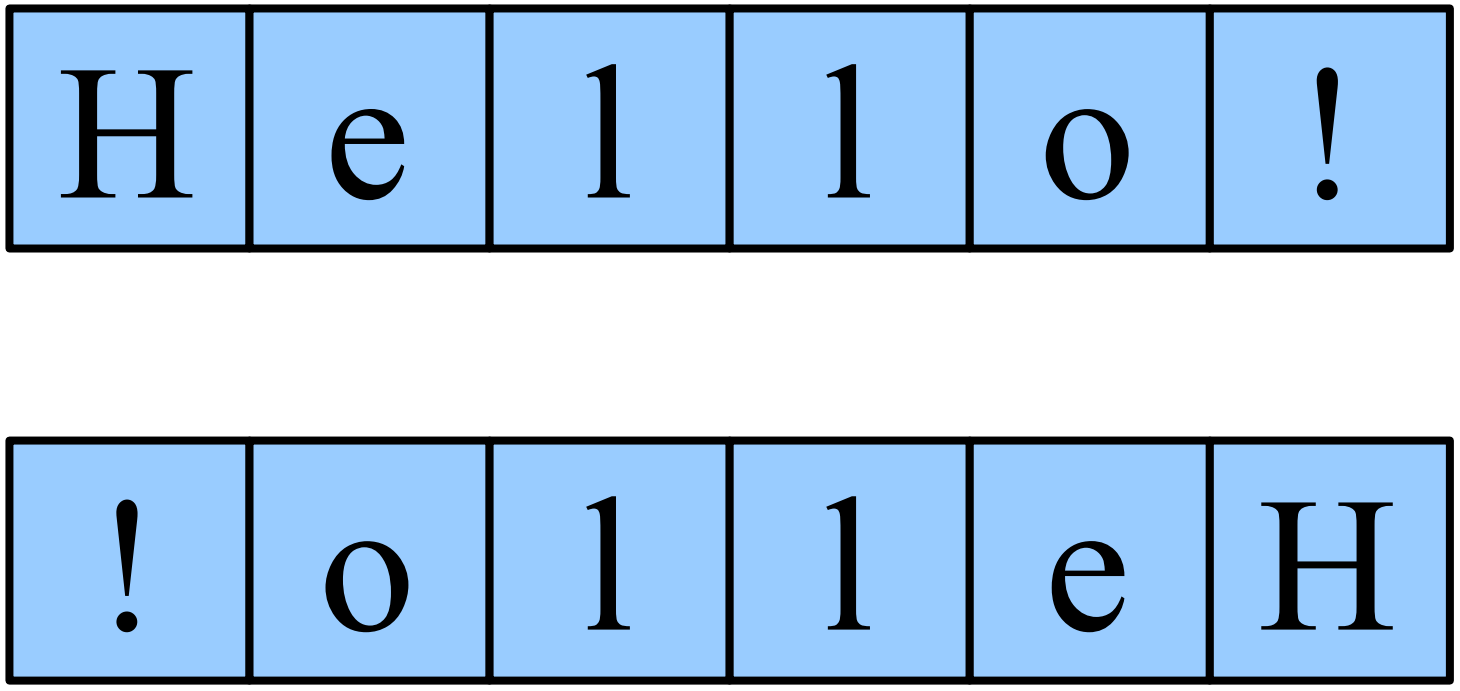
Reversing a String



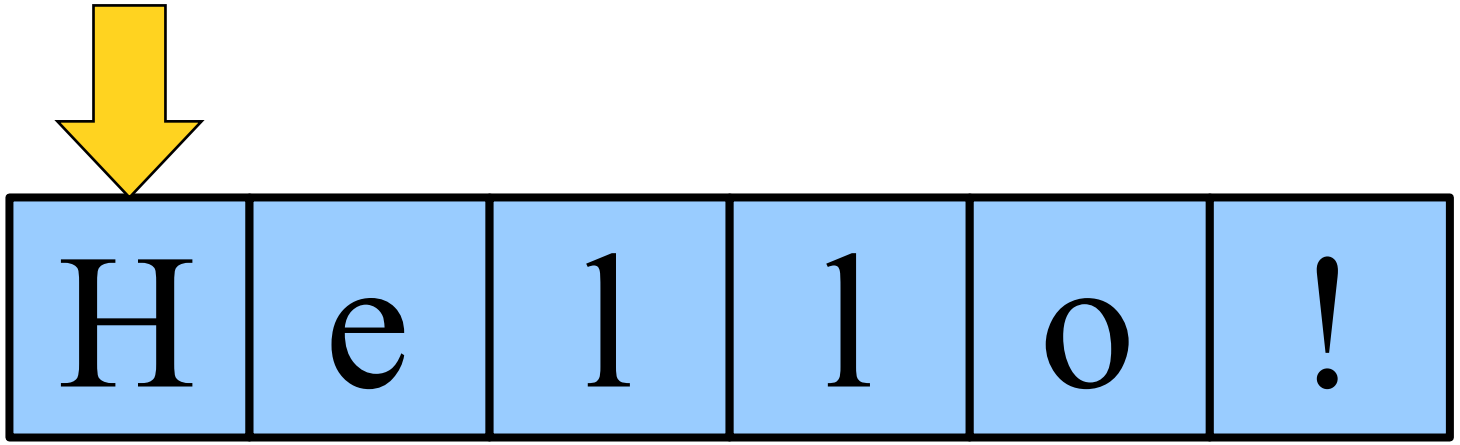
Reversing a String



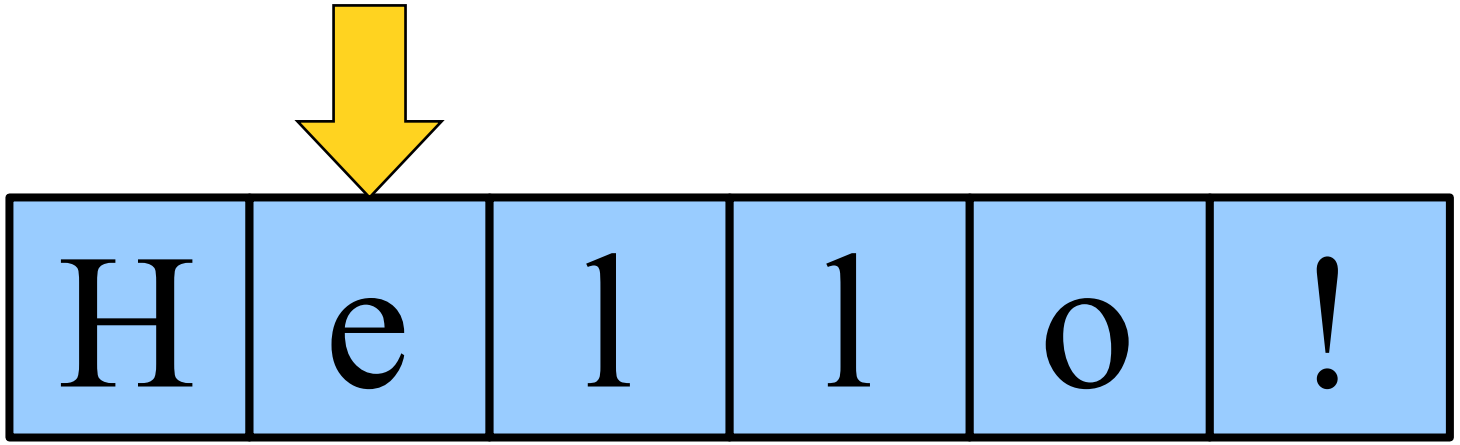
Reversing a String



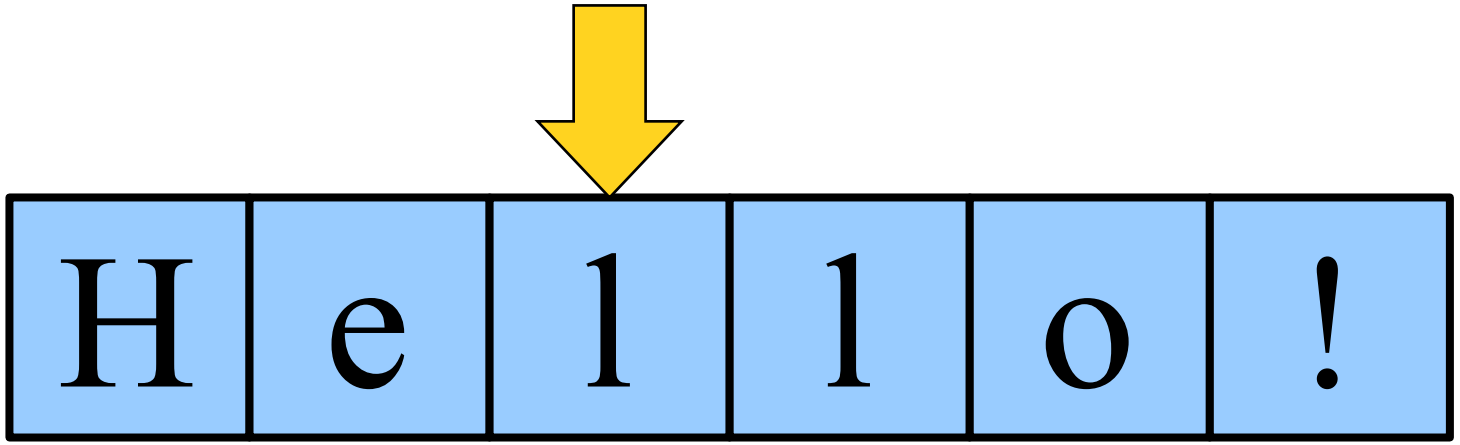
Reversing a String

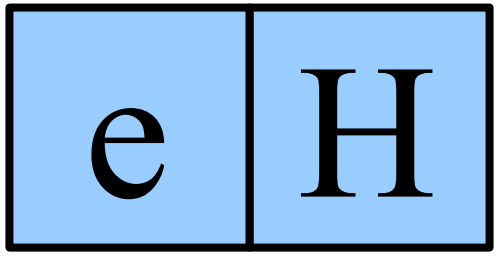


Reversing a String

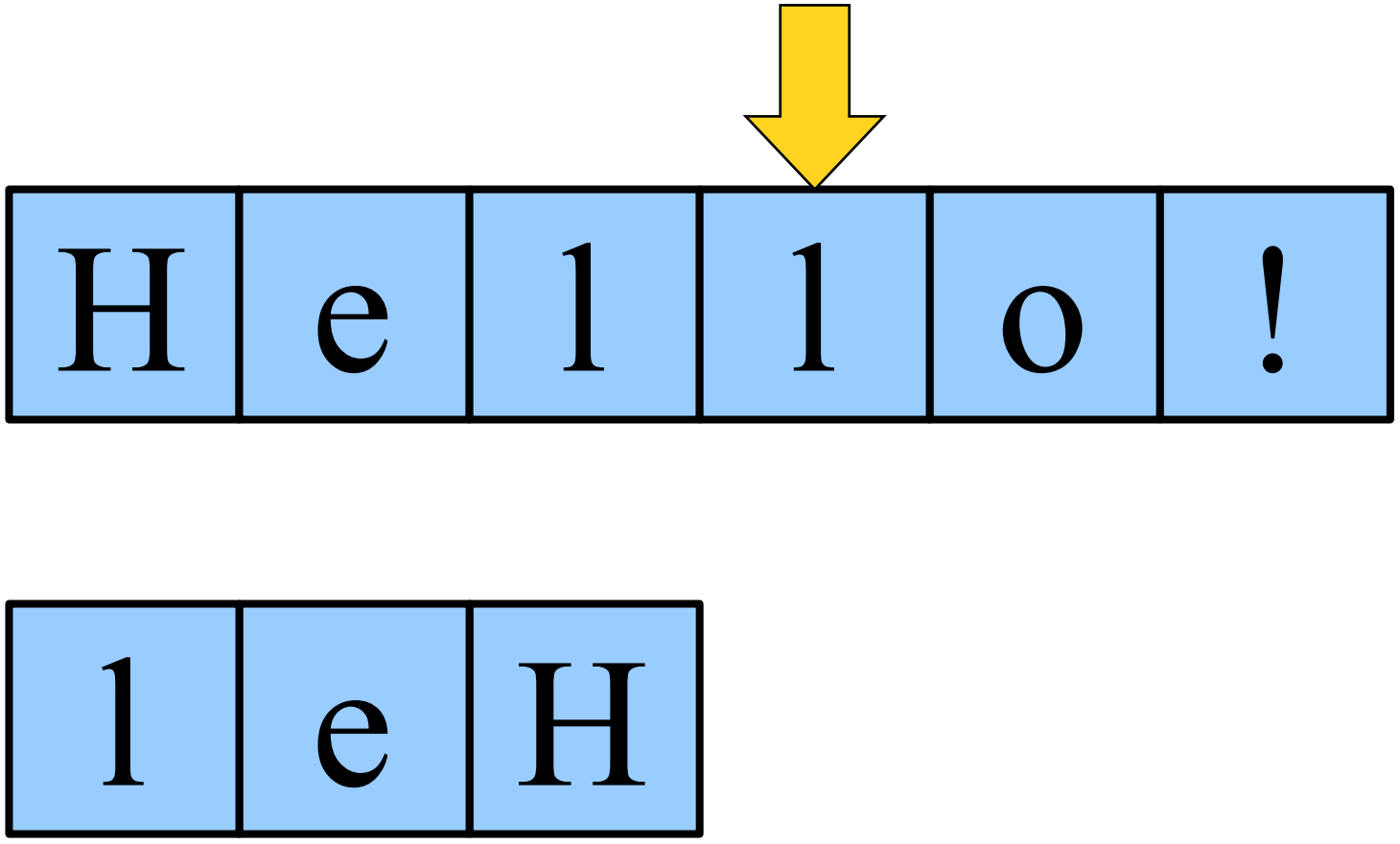


Reversing a String

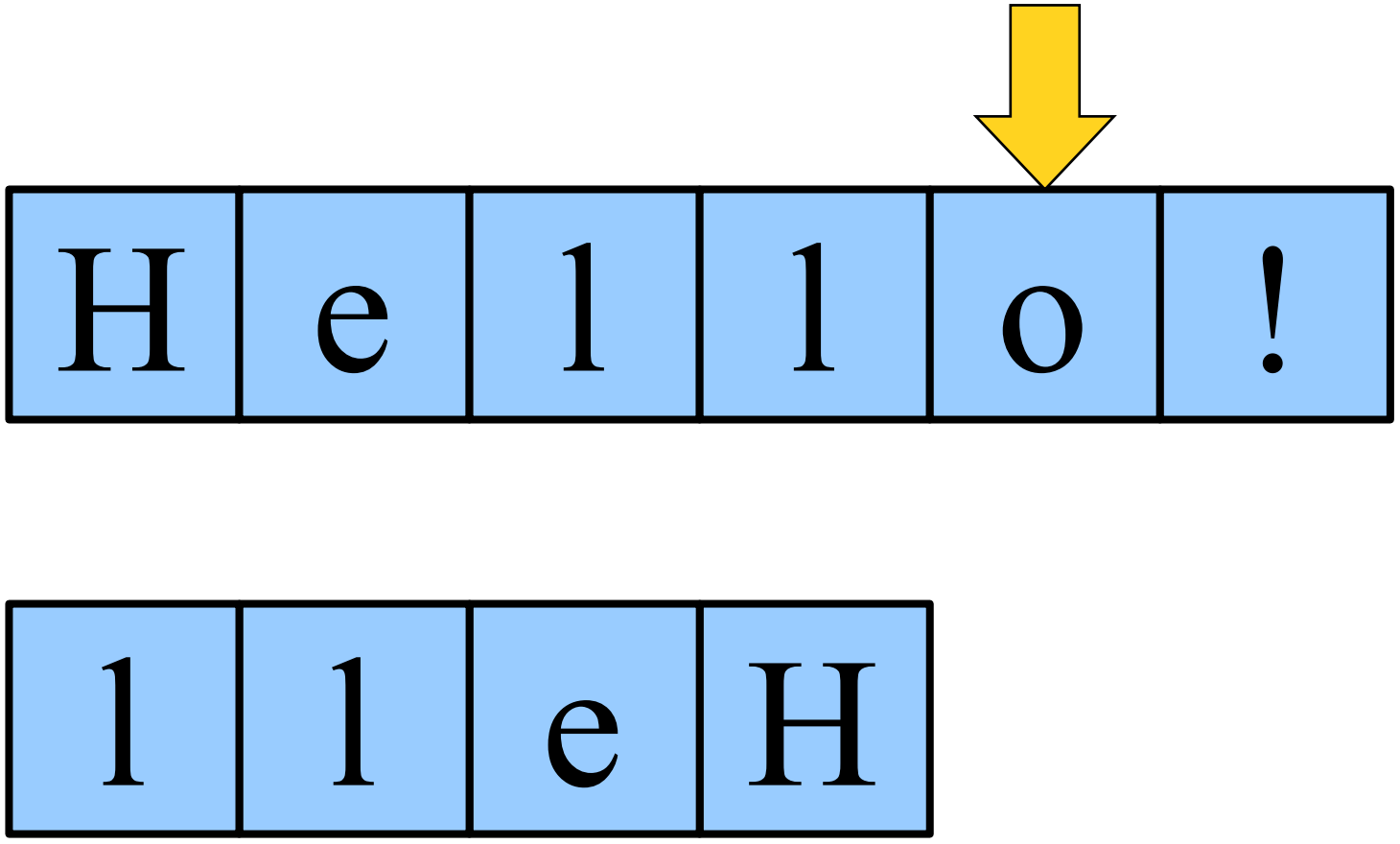




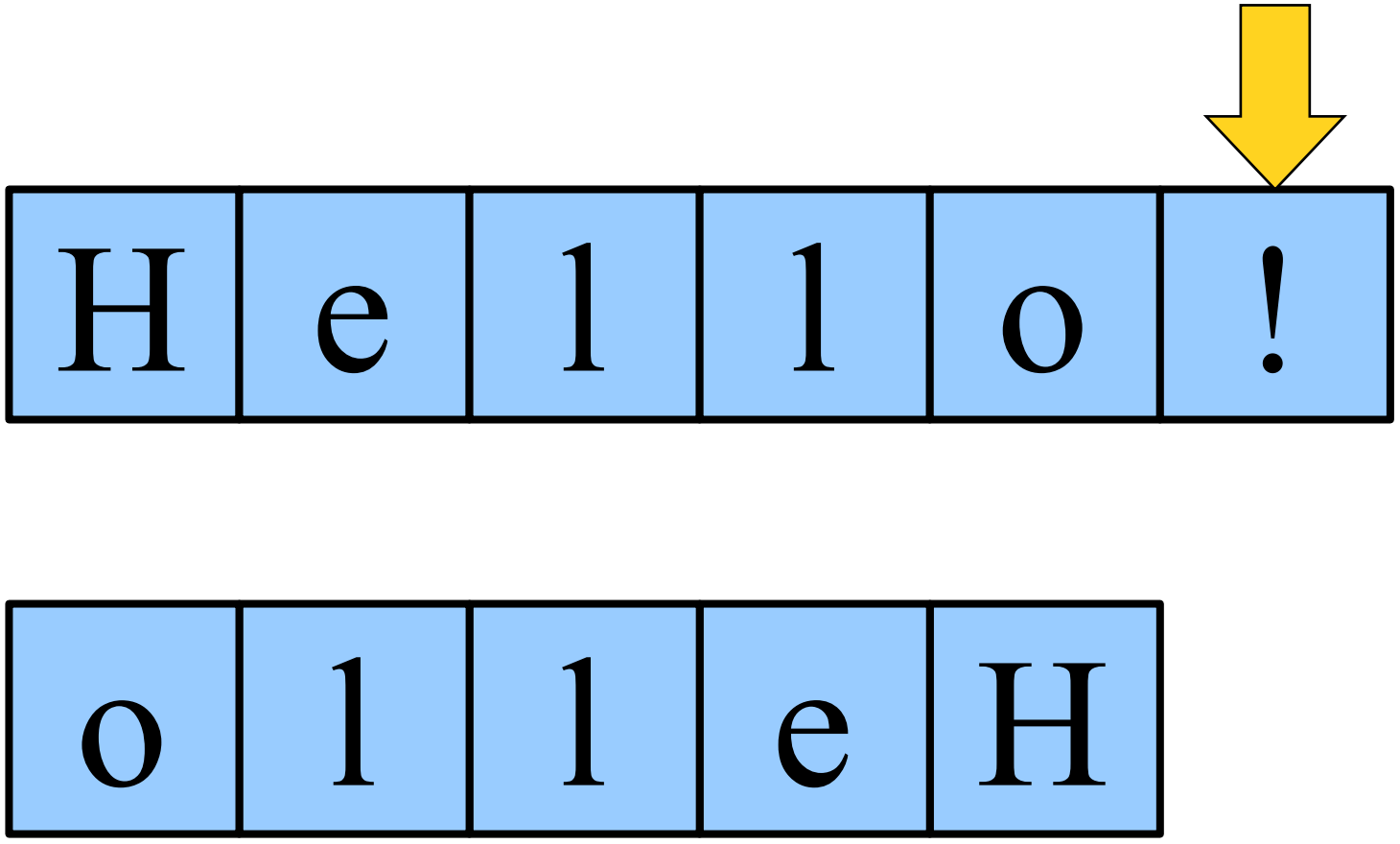
Reversing a String



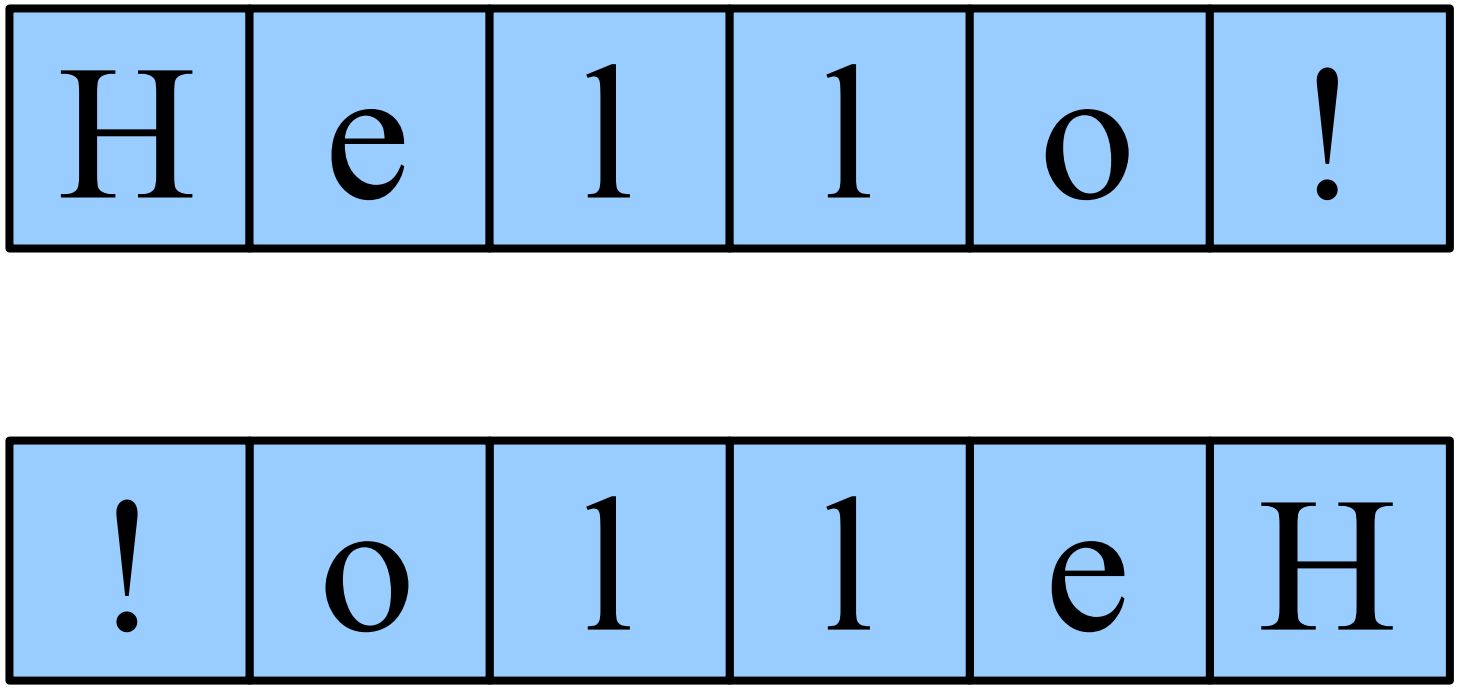
Reversing a String



Reversing a String



Reversing a String

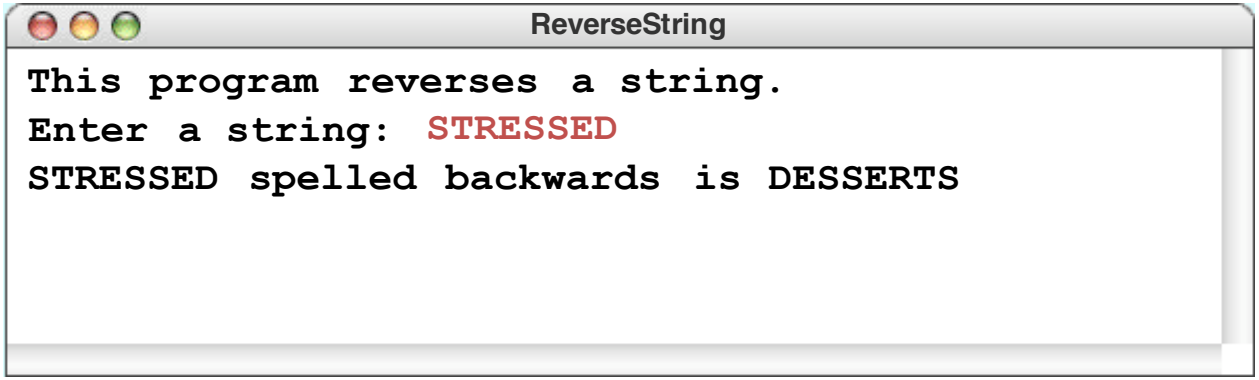


reverseString

```
public void run() {
```

```
private String reverseString(String str) {
   String result = "";
   for ( int i = 0; i < str.length(); i++ ) {
      result = str.charAt(i) + result;
   }
   return result;
}
```

result	str	i
DESSERTS	STRESSED	8



skip simulation

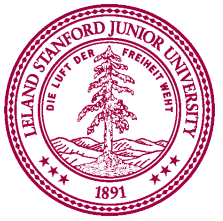
Useful String methods

`int length()` Returns the length of the string
`char charAt(int index)` Returns the character at the specified index. Note: Strings indexed starting at 0.
`String substring(int p1, int p2)` Returns the substring beginning at **`p1`** and extending up to but not including **`p2`**
`String substring(int p1)` Returns substring beginning at **`p1`** and extending through end of string.
`boolean equals(String s2)` Returns true if string **`s2`** is equal to the receiver string. This is case sensitive.
`int compareTo(String s2)` Returns integer whose sign indicates how strings compare in lexicographic order
`int indexOf(char ch)` *or* **`int indexOf(String s)`** Returns index of first occurrence of the character or the string, or -1 if not found
`String toLowerCase()` *or* **`String toUpperCase()`** Returns a lowercase or uppercase version of the receiver string

Using portions of slides by Eric Roberts

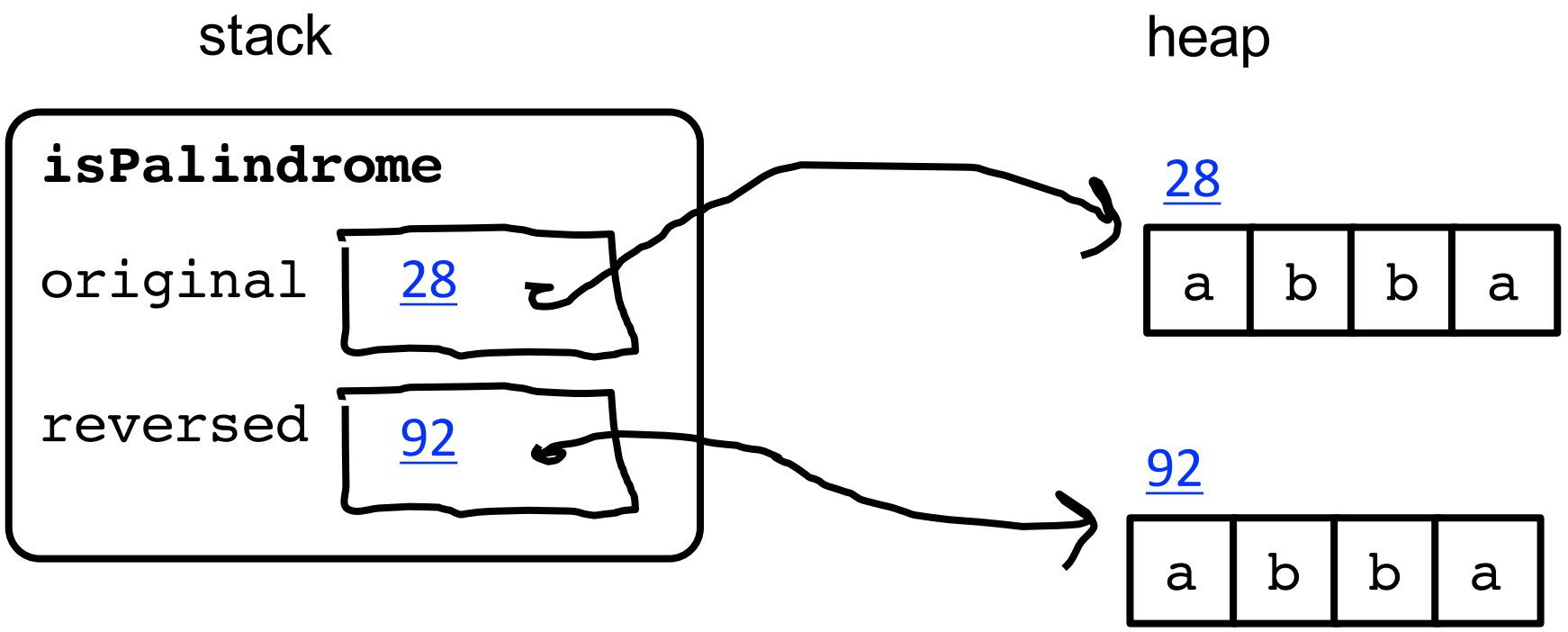
Palindrome

- A ***palindrome*** is a string that reads the same forwards and backwards.
- For example:
  - Abba
  - Racecar
  - Kayak
  - Mr. Owl ate my metal worm.
  - Go hang a salami! I'm a lasagna hog.
  - Elu par cette crapule

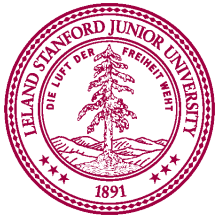


What went wrong?

```
private boolean isPalindrome(String original) {
    String reversed = reverse(original);
    return reversed == original;
}
```

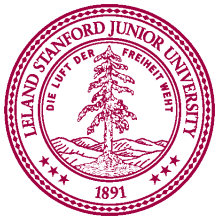


Use .equals to compare strings, not ==



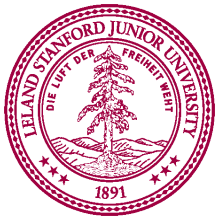
Some test cases

- Let's test our program on some examples:
  - Racecar
  - Kayak
  - Mr. Owl ate my metal worm.
  - Go hang a salami! I'm a lasagna hog.
- Will it work?



Stress Test

A man, a plan, a caret, a ban, a myriad, a sum, a lac, a liar, a hoop, a pint, a catalpa, a gas, an oil, a bird, a yell, a vat, a caw, a pax, a wag, a tax, a nay, a ram, a cap, a yam, a gay, a tsar, a wall, a car, a luger, a ward, a bin, a woman, a vassal, a wolf, a tuna, a nit, a pall, a fret, a watt, a bay, a daub, a tan, a cab, a datum, a gall, a hat, a tag, a zap, a say, a jaw, a lay, a wet, a gallop, a tug, a trot, a trap, a tram, a torr, a caper, a top, a tonk, a toll, a ball, a fair, a sax, a minim, a tenor, a bass, a passer, a capital, a rut, an amen, a ted, a cabal, a tang, a sun, an ass, a maw, a sag, a jam, a dam, a sub, a salt, an axon, a sail, an ad, a wadi, a radian, a room, a rood, a rip, a tad, a pariah, a revel, a reel, a reed, a pool, a plug, a pin, a peek, a parabola, a dog, a pat, a cud, a nu, a fan, a pal, a rum, a nod, an eta, a lag, an eel, a batik, a mug, a mot, a nap, a maxim, a mood, a leek, a grub, a gob, a gel, a drab, a citadel, a total, a cedar, a tap, a gag, a rat, a manor, a bar, a gal, a cola, a pap, a yaw, a tab, a raj, a gab, a nag, a pagan, a bag, a jar, a bat, a way, a papa, a local, a gar, a baron, a mat, a rag, a gap, a tar, a decal, a tot, a led, a tic, a bard, a leg, a bog, a burg, a keel, a doom, a mix, a map, an atom, a gum, a kit, a baleen, a gala, a ten, a don, a mural, a pan, a faun, a ducat, a pagoda, a lob, a rap, a keep, a nip, a gulp, a loop, a deer, a leer, a lever, a hair, a pad, a tapir, a door, a moor, an aid, a raid, a wad, an alias, an ox, an atlas, a bus, a madam, a jag, a saw, a mass, an anus, a gnat, a lab, a cadet, an em, a natural, a tip, a caress, a pass, a baronet, a minimax, a sari, a fall, a ballot, a knot, a pot, a rep, a carrot, a mart, a part, a tort, a gut, a poll, a gateway, a law, a jay, a sap, a zag, a tat, a hall, a gamut, a dab, a can, a tabu, a day, a batt, a waterfall, a patina, a nut, a flow, a lass, a van, a mow, a nib, a draw, a regular, a call, a war, a stay, a gam, a yap, a cam, a ray, an ax, a tag, a wax, a paw, a cat, a valley, a drib, a lion, a saga, a plat, a catnip, a pooh, a rail, a calamus, a dairyman, a bater, a canal – Panama!



Remember!

Counterfeiter

You (Distributor)

User

Can you solve it?