Chapter 7: String

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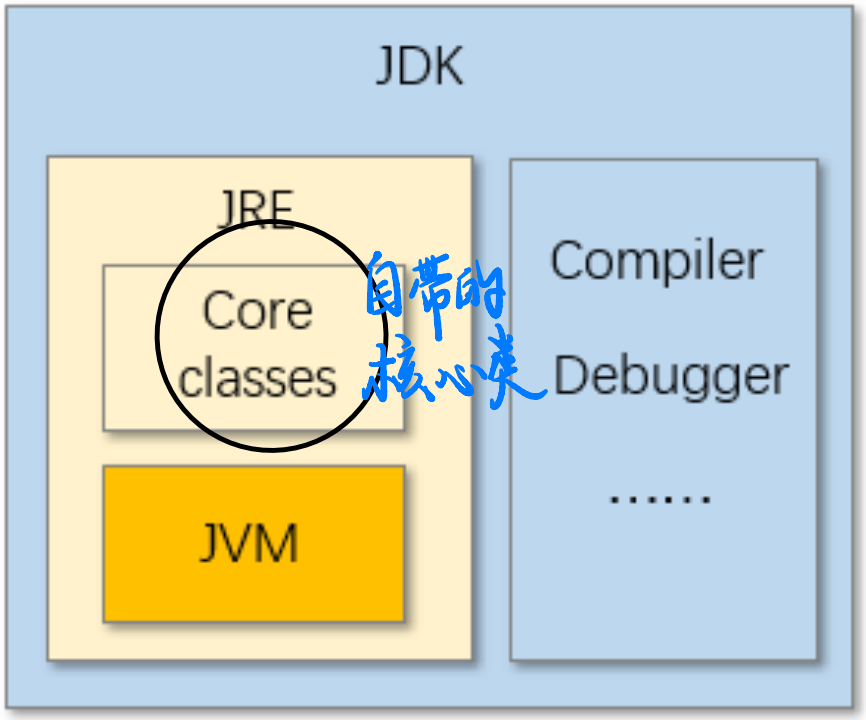
`String` is a core class frequently used in practice



Objectives

不可改变的

- Immutable character-string objects of class `String`
- Mutable character-string objects of class `StringBuilder`

The `String` Type

- `String` represents a string of characters
- `String` is a predefined class in Java.
- `String` is a *reference type*

String, like any class, has fields, constructors and methods

```
char[] value;
```

Creating String Objects (Instantiation)

- `String` objects can be created by using the `new` keyword and various `String` constructors
  - `String s1 = new String("hello world");`
  - `String s2 = new String(); // empty string (length is 0)`
  - `String s3 = new String(s1);`
  - `char[] charArray = {'h', 'e', 'l', 'l', 'o'};`
  - `String s4 = new String(charArray);`
  - `String s5 = new String(charArray, 3, 2); // string "lo"`

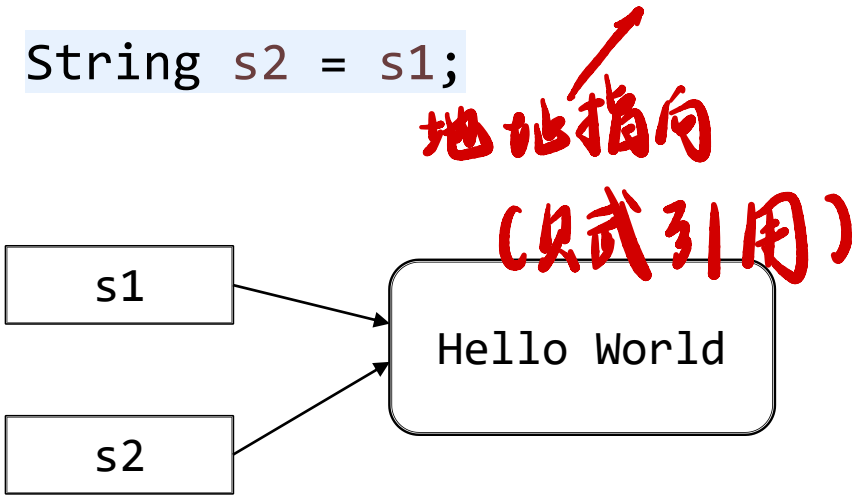
More at: https://docs.oracle.com/javase/10/docs/api/java/lang/String.html

Creating String Objects (Instantiation)

- `String` objects can also be created by string literals (字面常量, a sequence of characters in double quotes)

```
String s1 = "Hello World";

String s2 = s1;
```

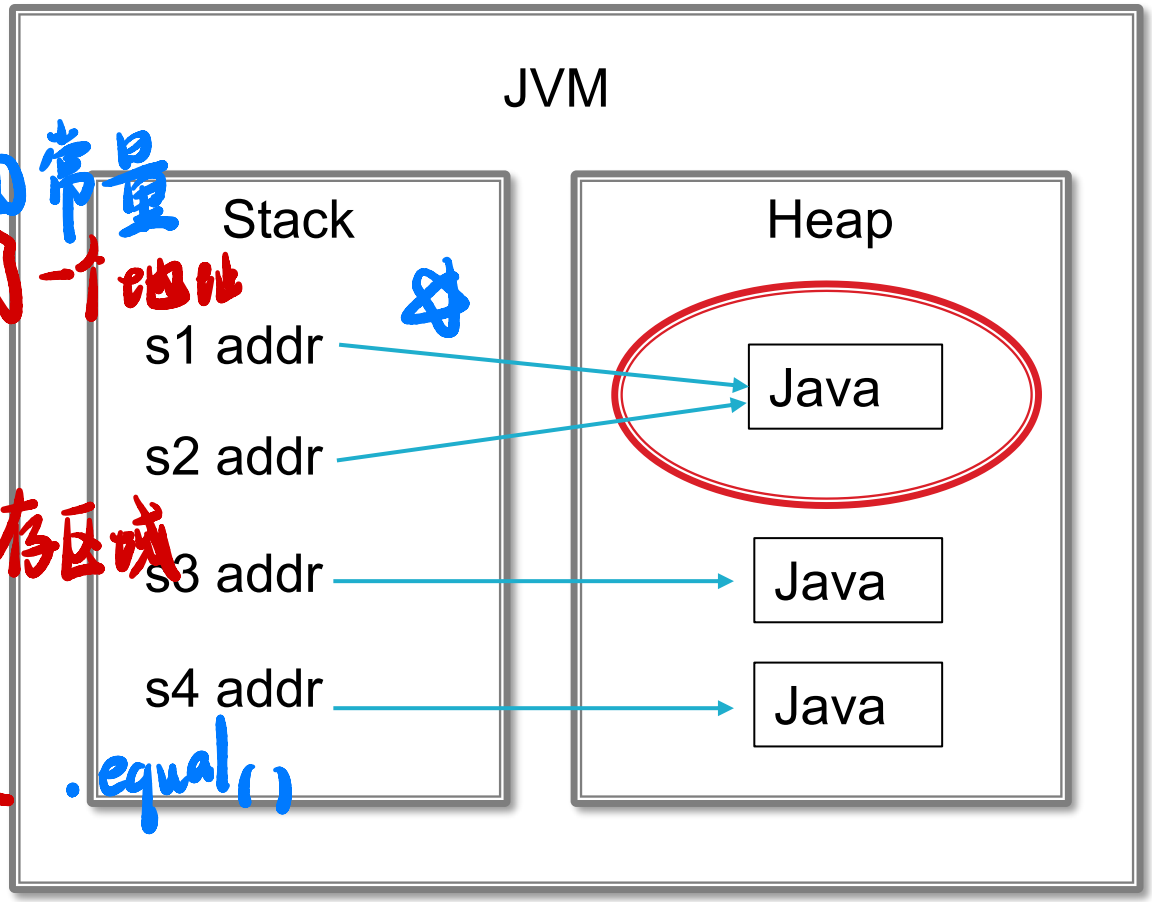


Using String literal vs new keyword

String Constant Pool:
Store string objects created by string literals

```
String s1 = "Java";
String s2 = "Java";

String s3 = new String("Java");
String s4 = new String("Java");
```




```
System.out.println(s1 == s2); // true
System.out.println(s3 == s4); // false
```

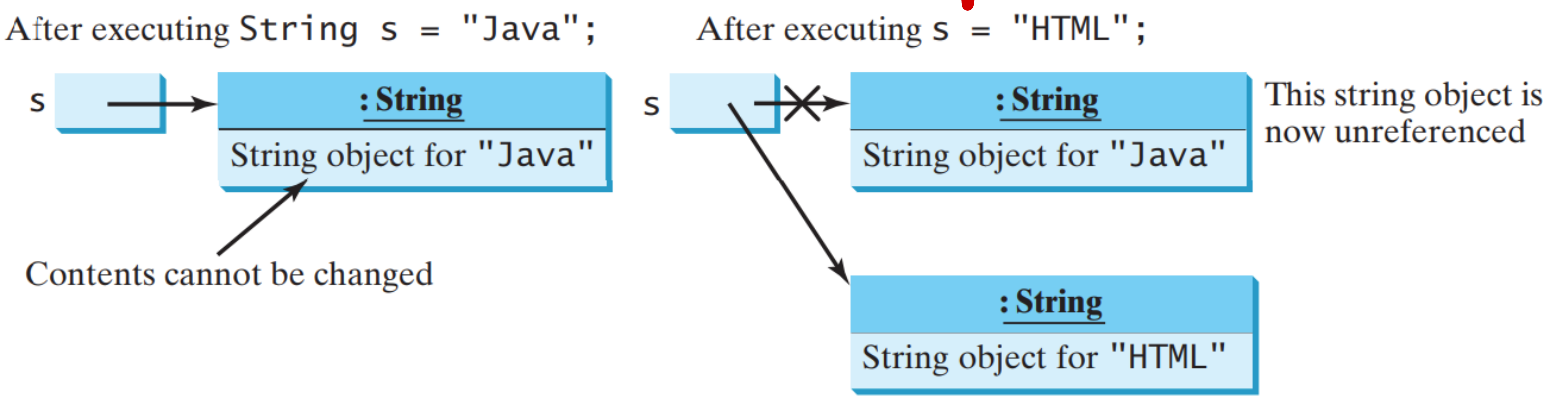

Immutability（不可变性）

- In Java, `String` objects are immutable: their values cannot be changed after they are created.
- Any modification creates a new `String` object

不改已创建好的字符串

```
String s = "Java";
s = "HTML";
```

指向新的字符串



String Methods

实例方法！

- `length` returns the length of a string (i.e., the number of characters)
- `charAt` obtains the character at a specific location in a string

某下标字符

- `getChars` retrieves a set of characters from a string as a `char` array

These are instance methods that can be invoked on specific objects. Calling them requires a non-null object reference.

静态 ~ 与实例无关

The Method length

`int length()`	Returns the length of this string.

String.length()
Array.length

```
public class StringExamples {
    public static void main(String[] args) {
        String s1 = "hello world";
        System.out.printf("s1: %s", s1);
        System.out.printf("\nLength of s1: %d", s1.length());
    }
}
```

实例.调用方法

11 (含空)

```
s1: hello world
Length of s1: 11
```

The Method charAt

char	**charAt**(int index)	Returns the char value at the specified index.

```
public class StringExamples {
    public static void main(String[] args) {
        String s1 = "hello world";
        System.out.printf("s1: %s", s1);

        for(int count = s1.length()-1; count >=0; count--) {
            System.out.printf("%c", s1.charAt(count));
        }
    }
}
```

What's the output?

The Method getChars

```
void  getChars(int srcBegin, int srcEnd, char[] dst, int dstBegin)
```

Copies characters from this string into the destination character array.

变成字符数组

```
public class StringExamples {
    public static void main(String[] args) {
        String s1 = "hello world";
        char[] charArray = new char[6];
        System.out.printf("s1: %s\n", s1);
        s1.getChars(0, 5, charArray, 1);
        for(char c : charArray) {
            System.out.print(c);
        }
    }
}
```

放在哪 0 起始放的位置

对于Java 左闭右开 [,) 50⇒[0,5)

```
s1: hello world

 hello
```

数组为空.

Comparing Strings

- When primitive-type values are compared with ==, the result is `true` if both values are identical.

```
int a = 2, b =2;
if (a == b) System.out.println("a = b"); // prints a = b
```

- When references (memory addresses) are compared with ==, the result is `true` if both references refer to the same object in memory.

```
String s1 = "Hello World";
String s2 = "Hello World";
if(s1 == s2) System.out.println("s1 = s2"); // prints s1 = s2
```

同一个地址

Comparing Strings

```
String s1 = "Hello World";
String s2 = s1 + "";
if(s1 == s2) System.out.println("s1 = s2"); // prints s1 = s2?
```

- No. The condition will evaluate to `false` because the `String` variables `s1` and `s2` refer to two different `String` objects, although the strings contain the same sequence of characters.
- To compare the actual contents (or state information) of objects (strings are objects) for equality, a method `equals` must be invoked.

The Method `equals`

- Method `equals` tests any two objects for equality—the strings contained in the two `String` objects are identical.

```
String s1 = "Hello World";
String s2 = s1 + "";
if(s1.equals(s2)) System.out.println("s1 = s2"); // true
```

```
String s1 = "hello";
String s2 = "HELLO";
if(s1.equals(s2)) System.out.println("s1 = s2"); // false
```

大小写敏感

The Method `equalsIgnoreCase`

- Method `equalsIgnoreCase` ignores whether the letters in each String are uppercase or lowercase when performing a comparison.

```
String s1 = "hello";

String s2 = "HELLO";

if(s1.equalsIgnoreCase(s2)) System.out.println("s1 = s2");
```

忽略大小写

The condition evaluates to `true` and the program prints "`s1 = s2`"

Comparing Strings

- What does it mean when we say a string `s1` is greater than another string `s2`?
  - When we sort last names, we naturally consider that "Jones" < "Smith", because the letter 'J' comes before 'S' in the alphabet of 26 letters.
  - All characters in computers are represented as numeric codes. The characters form an ordered set (a very large alphabet: Unicode Table).
  - When the computer compares `String`s, it actually compares the numeric codes of the characters in the `String`s.

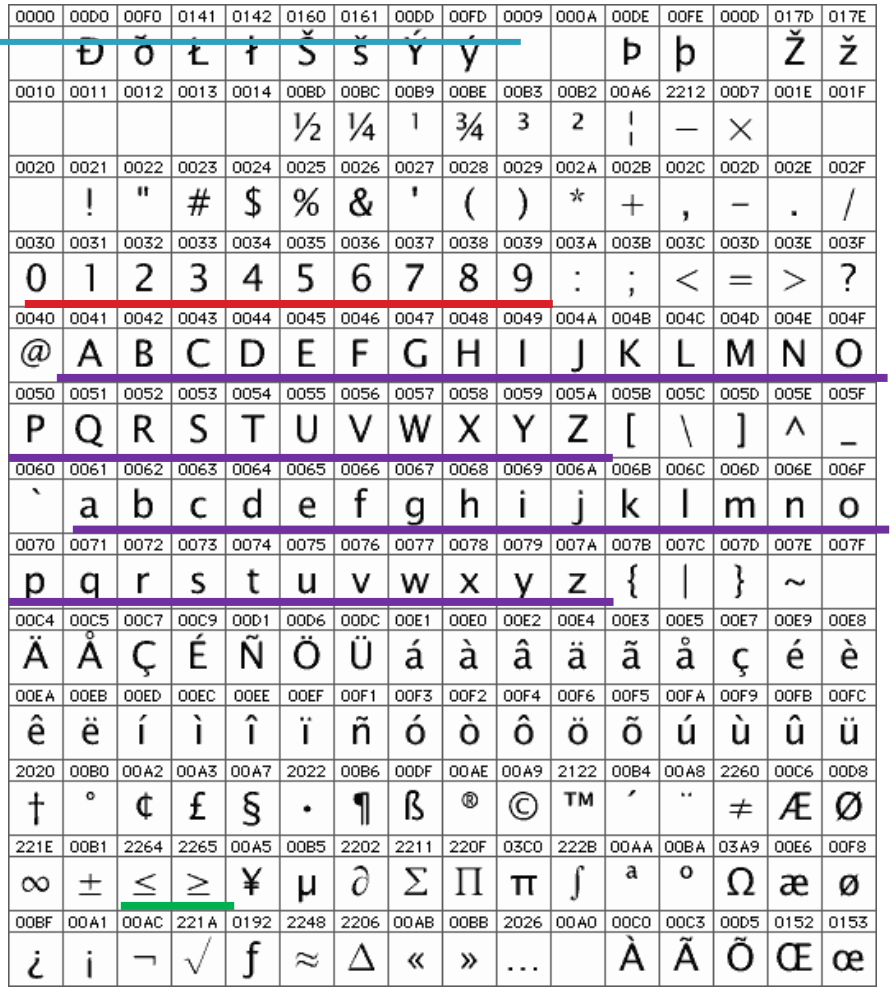
Unicode Table

Line Feed
'\n' (LF)
(a white-space char)

Digits

Letters

Operators



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0010	0011	0012	0013	0014	00BD	00BC	00B9	00BE	00B3	00B2	00A6	2212	00D7	001E	001F
					½	¼	¹	¾	³	²	¦	−	×		
0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	002A	002B	002C	002D	002E	002F
	!	"	#	$	%	&	'	(	)	*	+	,	−	.	/
0030	0031	0032	0033	0034	0035	0036	0037	0038	0039	003A	003B	003C	003D	003E	003F
0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
0040	0041	0042	0043	0044	0045	0046	0047	0048	0049	004A	004B	004C	004D	004E	004F
@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	005A	005B	005C	005D	005E	005F
P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
0060	0061	0062	0063	0064	0065	0066	0067	0068	0069	006A	006B	006C	006D	006E	006F
`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	007A	007B	007C	007D	007E	007F
p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	
00C4	00C5	00C7	00C9	00D1	00D6	00DC	00E1	00E0	00E2	00E4	00E3	00E5	00E7	00E9	00E8
Ä	Å	Ç	É	Ñ	Ö	Ü	á	à	â	ä	ã	å	ç	é	è
00EA	00EB	00ED	00EC	00EE	00EF	00F1	00F3	00F2	00F4	00F6	00F5	00FA	00F9	00FB	00FC
ê	ë	í	ì	î	ï	ñ	ó	ò	ô	ö	õ	ú	ù	û	ü
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221E	00B1	2264	2265	00A5	00B5	2202	2211	220F	03C0	222B	00AA	00BA	03A9	00E6	00F8
∞	±	≤	≥	¥	µ	∂	Σ	∏	π	∫	ª	º	Ω	æ	ø
00BF	00A1	00AC	221A	0192	2248	2206	00AB	00BB	2026	00A0	00C0	00C3	00D5	0152	0153
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The Method compareTo

```
String s1 = "hello";
String s2 = "HELLO";
int result = s1.compareTo(s2); // value of result?
```

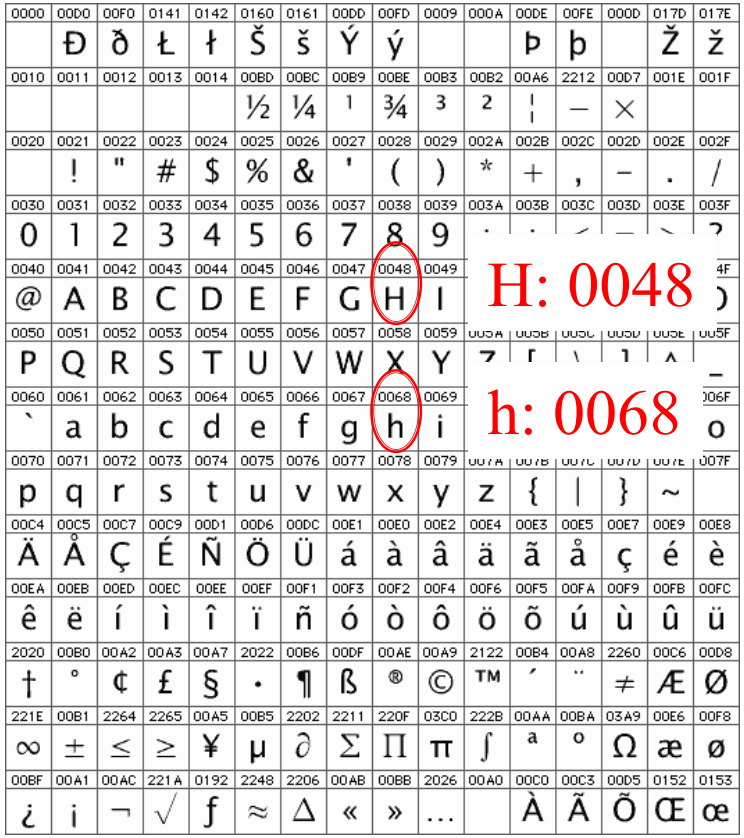
实现 extends 接口

compareTo compares two strings (lexicographical comparison):

- Returns 0 if the Strings are equal (identical contents).
- Returns a negative number if the String that invokes compareTo (s1) is less than the String that is passed as an argument (s2).
- Returns a positive number if the String that invokes compareTo (s1) is greater than the String that is passed as an argument (s2).

this < other 负数

Comparing Strings




```
String s1 = "hello", s2 = "HELLO";
int result = s1.compareTo(s2));
```

32 = 0068 (HEX) – 0048 (HEX) (s1 > s2)

第一位字符不同

十六进制！

找到首次字符不同作差

```
String s1 = "HE", s2 = "HELLO";
int result = s1.compareTo(s2));
```

-3 (s1 < s2, s2 has three more letters)

前完全一样 后长度不同：为△length.

字符一样比较

```
String s1 = "HEL", s2 = "HEllo";
int result = s1.compareTo(s2));
```

-32 (s1 < s2)

a-A=32

Methods startsWith & endsWith

The methods `startsWith` and `endsWith` determine whether a string starts or ends with the method argument, respectively

```
String s1 = "Hello World";
if(s1.startsWith("He")) System.out.print("true"); // true
```

```
String s1 = "Hello World";
if(s1.startsWith("llo", 2)) System.out.print("true"); // true
```

```
String s1 = "Hello World";
if(s1.endsWith("ld")) System.out.print("true"); // true
```

Locating Characters in Strings

```
String s = "abcdefghijklmabcdefghijklm";
System.out.println(s.indexOf('c'));  // 2
System.out.println(s.indexOf('$'));  // -1
System.out.println(s.indexOf('a', 1));  // 13
```

- `indexOf` locates the first occurrence of a character in a `String`.
  - If the method finds the character, it returns the character's index in the `String`; otherwise, it returns `-1`.
- Two-argument version of `indexOf`:
  - Take one more argument: the starting index at which the search should begin.

Locating Characters in Strings

```
String s = "abcdefghijklmabcdefghijklm";
System.out.println(s.lastIndexOf('c')); // 15
System.out.println(s.lastIndexOf('$')); // -1
System.out.println(s.lastIndexOf('a', 8)); // 0
```

- `lastIndexOf` locates the last occurrence of a character in a `String`.
  - The method searches from the end of the `String` toward the beginning.
  - If it finds the character, it returns the character's index in the `String`; otherwise, it returns –1.
- Two-argument version of `lastIndexOf`:
  - The character and the index from which to begin searching backward.

Locating Substrings in Strings

```
String s = "abcdefghijklmabcdefghijklm";
System.out.println(s.indexOf("def"));     // 3
System.out.println(s.indexOf("def", 7));  // 16
System.out.println(s.indexOf("hello"));   // -1
System.out.println(s.lastIndexOf("def")); // 16
System.out.println(s.lastIndexOf("def", 7));  // 3
System.out.println(s.lastIndexOf("hello"));   // -1
```

- The versions of methods `indexOf` and `lastIndexOf` that take a `String` as the first argument perform identically to those described earlier except that they search for sequences of characters (or substrings) that are specified by their `String` arguments.

Extracting Substrings from Strings

```
String s = "abcdefghijklmabcdefghijklm";
System.out.println(s.substring(20));  // hijklm
System.out.println(s.substring(3, 6)); // def
```

- `substring` methods create a new `String` object by copying part of an existing `String` object.
- The one-integer-argument version specifies the starting index (inclusive) in the original `String` from which characters are to be copied.
- Two-integer-argument version specifies the starting index (inclusive) and ending index (exclusive) to copy characters in the original `String`.

String Method replace

```
String s1 = "Hello";
System.out.println(s1.replace('l', 'L')); // HeLLo
System.out.println(s1.replace("ll", "LL")); // HeLLo
```

- `replace` returns a new `String` object in which every occurrence of the first character argument is replaced with the second character argument.
- Another version of method `replace` enables you to replace substrings rather than individual characters (every occurrence of the first substring is replaced).

String Case Conversion Methods

```
String s1 = "Hello";
System.out.println(s1.toUpperCase());  // HELLO
System.out.println(s1.toLowerCase());  // hello
```

转大/小写

- `String` method `toUpperCase` returns a new `String` object with uppercase letters where corresponding lowercase letters exist in the original.
- `String` method `toLowerCase` returns a new `String` object with lowercase letters where corresponding uppercase letters exist in the original.

String Method trim

- `trim` returns a new `String` object that removes all white-space characters at the beginning or end of the `String` on which `trim` operates.

```
String s1 = " spaces ";

System.out.println(s1.trim());  //prints “spaces”
```

去空格

String Method toCharArray

- `toCharArray` creates a new character array containing a copy of the characters in the string.

```
String s1 = "hello";
char[] charArray = s1.toCharArray();
for(char c : charArray) System.out.print(c);
```

The `for` loop prints each of the five chars in "`hello`"

`String` Method `split`

- When you read a sentence, your mind breaks it into tokens—individual words and punctuation marks that convey meaning to you. 分成数组

- `String` method `split` breaks a `String` into its component tokens, separated from each other by delimiters (分隔符), typically white-space characters such as space, tab, new line, carriage return.

String Method split

```
Scanner input = new Scanner(System.in);
System.out.println("Enter a sentence and press Enter");
String sentence = input.nextLine();
String[] tokens = sentence.split(" ");
System.out.printf("Number of tokens: %d\n", tokens.length);
for(String token : tokens) System.out.println(token);
input.close();
```

split

String[] split(" ")

用" "分开成String数组

How about sentence.split("is")?

```
Enter a sentence and press Enter
This is a sentence with seven tokens
Number of tokens: 7
This
is
a
sentence
with
seven
tokens
```

Q: is分隔 Th a... 不再包含分隔符

Concatenating Strings

```
String s1 = "Happy ";
String s2 = "Birthday";
System.out.println(s1.concat(s2)); // Happy Birthday
System.out.println(s1); // Happy
```

仍不变

不改变原始地——不可变性

- `String` method `concat` concatenates two `String` objects and returns a new `String` object containing the characters from both original `String`s.
- The original `String`s to which `s1` and `s2` refer are not modified

原字符不改变

Concatenating Strings

```
public static void main(String[] args) {
    String s = "";
    for (int i = 0; i < 1000; i++) {
        s = s + " " + i;
    }
}
```

- We can use "+" for `String` concatenation
- However, when + is used in a loop, a new string will be created in every iteration (because of immutability), which is inefficient
- Better to use `StringBuilder`, which is mutable

Objectives

- Immutable character-string objects of class `String`
- Mutable character-string objects of class `StringBuilder`

Class `StringBuilder`

- `String` objects are immutable. Can we create mutable character-string objects in Java?
- Yes. The class `StringBuilder` helps create and manipulate dynamic string information, i.e., modifiable, mutable strings.
- You can add, insert, or append new contents into StringBuilder

StringBuilder Constructors

- Every `StringBuilder` is capable of storing a number of characters specified by its capacity.
- If a `StringBuilder`'s capacity is exceeded, the capacity automatically expands to accommodate additional characters.

java.lang.StringBuilder	
`+StringBuilder()`	Constructs an empty string builder with capacity 16.
`+StringBuilder(capacity: int)`	Constructs a string builder with the specified capacity.
`+StringBuilder(s: String)`	Constructs a string builder with the specified string.

StringBuilder Constructors

Default initial capacity is 16 chars

```
StringBuilder buffer1 = new StringBuilder();
StringBuilder buffer2 = new StringBuilder(10);
StringBuilder buffer3 = new StringBuilder("hello");
System.out.printf("buffer1 = \"%s\"\n", buffer1);
System.out.printf("buffer2 = \"%s\"\n", buffer2);
System.out.printf("buffer3 = \"%s\"\n", buffer3);
```

```
buffer1 = ""
buffer2 = ""
buffer3 = "hello"
```

StringBuilder Method append

- Class `StringBuilder` provides several `append` methods to allow values of various types to be appended to the end of a `StringBuilder` object.
- Overloaded append() are provided for each of the primitive types, and for character arrays, Strings, Objects, and more.

```
append(boolean b)
append(char c)
append(char[] str)
append(char[] str, int offset, int len)
append(double d)
append(float f)
append(int i)
append(long lng)
append(CharSequence s)
append(CharSequence s, int start, int end)
append(Object obj)
append(String str)
append(StringBuffer sb)
```

注意：方法是 void / 有 return

```
S = "Hello";
S.append("World");
```

S变化

```
1.  String string = "goodbye";
2.  char[] charArray = {'a', 'b', 'c', 'd', 'e', 'f'};
3.  boolean booleanValue = true;
4.  char charValue = 'Z';
5.  int intValue = 7;
6.  long longValue = 10000000000L;
7.  float floatValue = 2.5f;
8.  double doubleValue = 33.3333;
9.  StringBuilder buffer = new StringBuilder();
10. StringBuilder lastBuffer = new StringBuilder("last buffer");

11. buffer.append(string); buffer.append("\n");
12. buffer.append(charArray); buffer.append("\n");
13. buffer.append(charArray, 0, 3); buffer.append("\n");
14. buffer.append(booleanValue); buffer.append("\n");
15. buffer.append(charValue); buffer.append("\n");
16. buffer.append(intValue); buffer.append("\n");
17. buffer.append(longValue); buffer.append("\n");
18. buffer.append(floatValue); buffer.append("\n");
19. buffer.append(doubleValue); buffer.append("\n");
20. buffer.append(lastBuffer);

21. System.out.printf("buffer contains:\n%s", buffer.toString());
```

```
buffer contains:
goodbye
abcdef
abc
true
Z
7
10000000000
2.5
33.3333
last buffer
```

Here we still use the same `StringBuilder` object reference, because `StringBuilder` objects are mutable.

Other StringBuilder Method

java.lang.StringBuilder	
+toString(): String	Returns a string object from the string builder.
+capacity(): int	Returns the capacity of this string builder.
+charAt(index: int): char	Returns the character at the specified index.
+length(): int	Returns the number of characters in this builder.
+setLength(newLength: int): void	Sets a new length in this builder.
+substring(startIndex: int): String	Returns a substring starting at `startIndex`.
+substring(startIndex: int, endIndex: int): String	Returns a substring from `startIndex` to `endIndex-1`.
+trimToSize(): void	Reduces the storage size used for the string builder.
+deleteCharAt(index: int): StringBuilder	Deletes a character at the specified index.
+insert(index: int, data: char[], offset: int, len: int): StringBuilder	Inserts a subarray of the data in the array into the builder at the specified index.
+insert(offset: int, data: char[]): StringBuilder	Inserts data into this builder at the position offset.
+insert(offset: int, b: *aPrimitiveType*): StringBuilder	Inserts a value converted to a string into this builder.
+insert(offset: int, s: String): StringBuilder	Inserts a string into this builder at the position offset.
+replace(startIndex: int, endIndex: int, s: String): StringBuilder	Replaces the characters in this builder from `startIndex` to `endIndex-1` with the specified string.
+reverse(): StringBuilder	Reverses the characters in the builder.
+setCharAt(index: int, ch: char): void	Sets a new character at the specified index in this builder.

Read the Documentation!

- https://docs.oracle.com/javase/8/docs/api/java/lang/String.html
- https://docs.oracle.com/javase/8/docs/api/java/lang/StringBuilder.html

Read the Documentation in IDEA