CS106 W21

Week 02

Arrays and Strings

Reference

Arrays are examples of:

JavaScript p5 **Objects**

JavaScript p5 knows they can get big.
Copying big things can make our program slow.

What does this print?

```
let a = 1;
let b = 2;
a = b;
b = 3;
print(a + b);
```

(A) 3
(B) 4
(C) 5
(D) 6
(E) 7

What does this print?

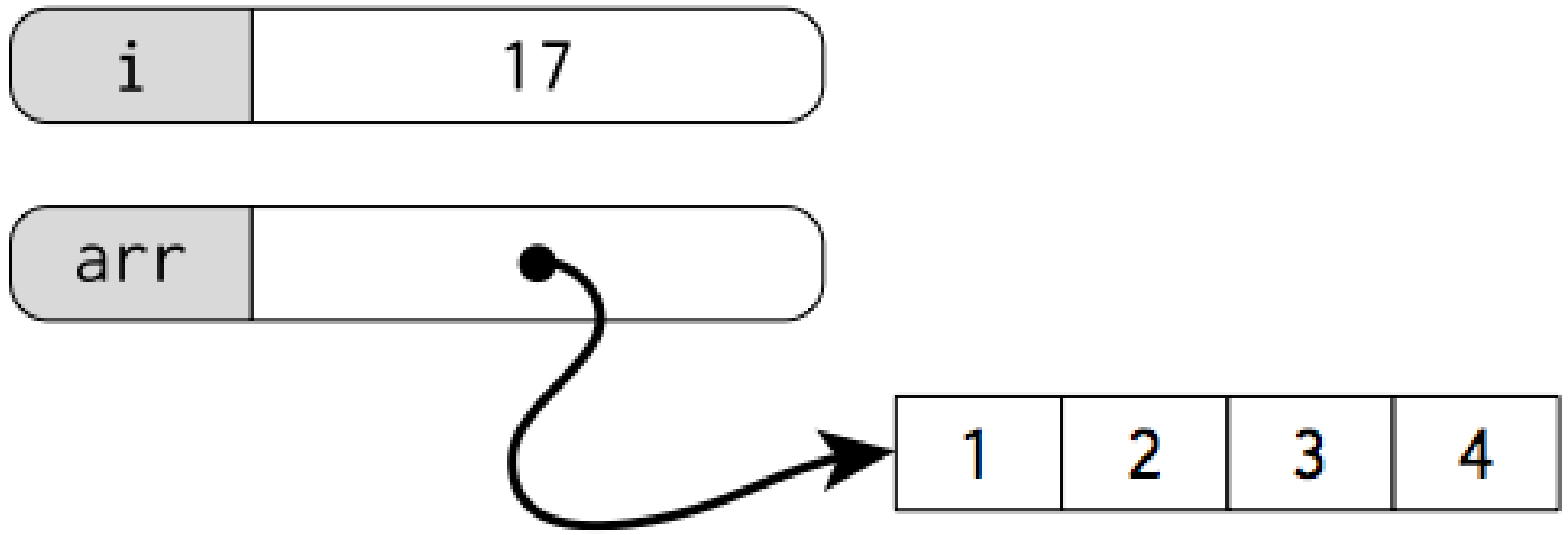
```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print( a[0] + b[0] );
```

(A) 3
(B) 4
(C) 5
(D) 6
(E) 7

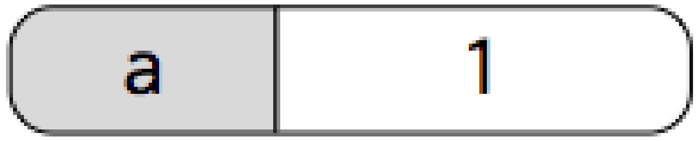
Arrays are just values…aren't they?

An array value is really an arrow pointing to the place in memory where all the array elements are stored. We say that an array variable is a *reference*.

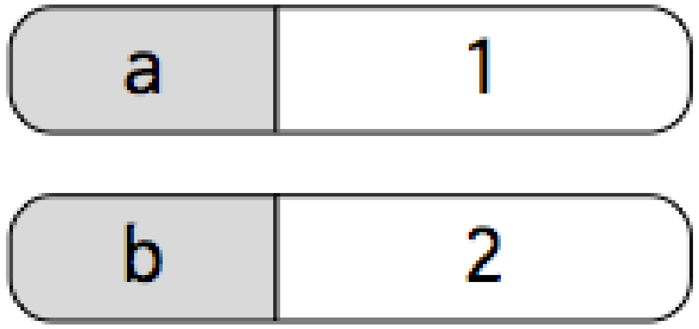
```
let i = 17;
let arr = [1, 2, 3, 4];
```



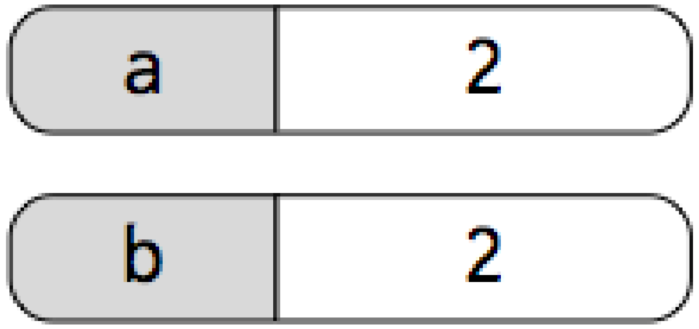
```
let a = 1;
```



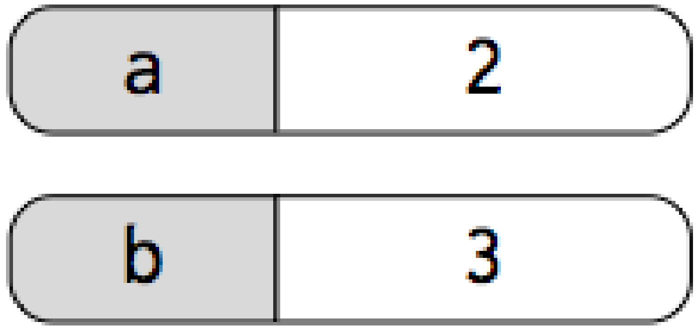
```
let b = 2;
```



```
a = b;
```

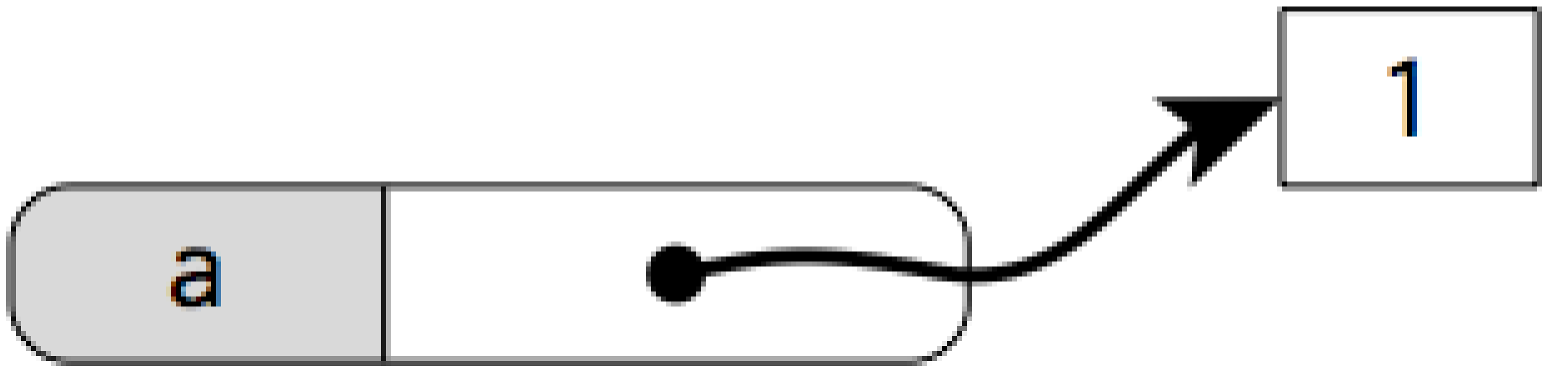


```
b = 3;
```

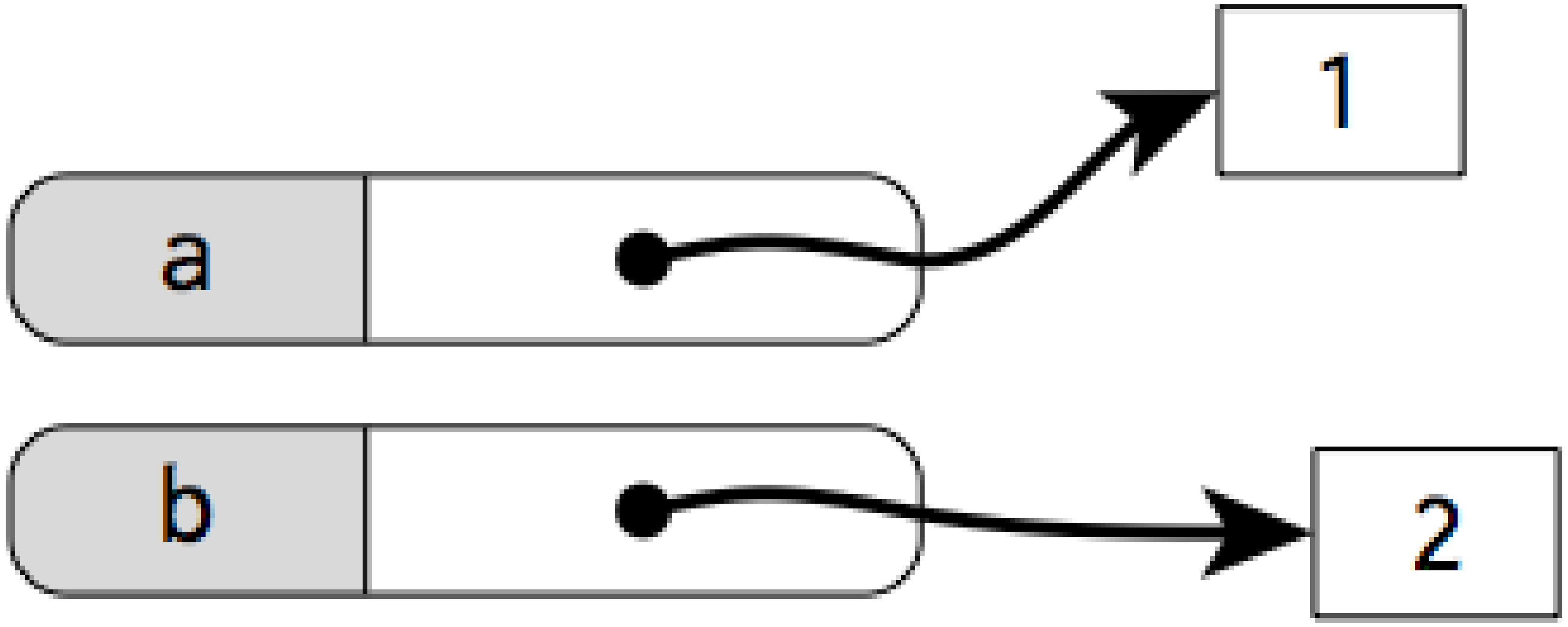


```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print(a[0] + b[0]);
```

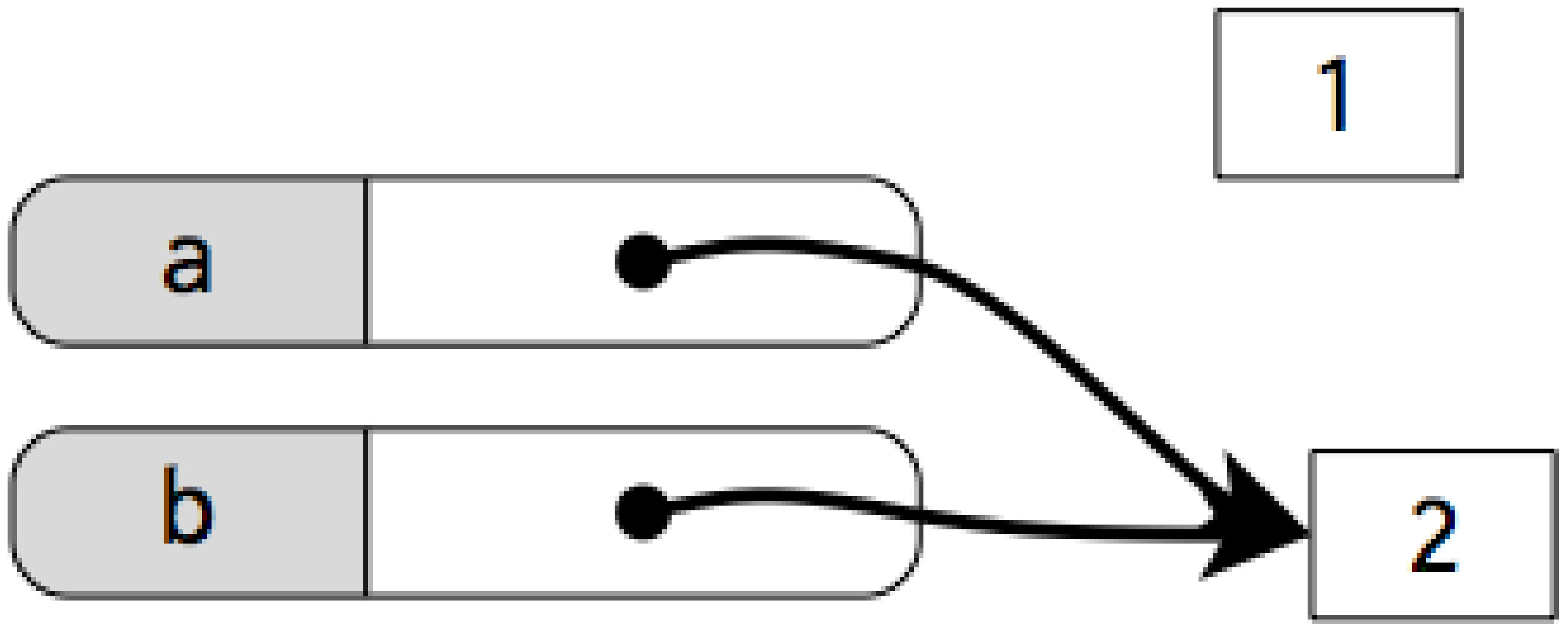
```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print(a[0] + b[0]);
```



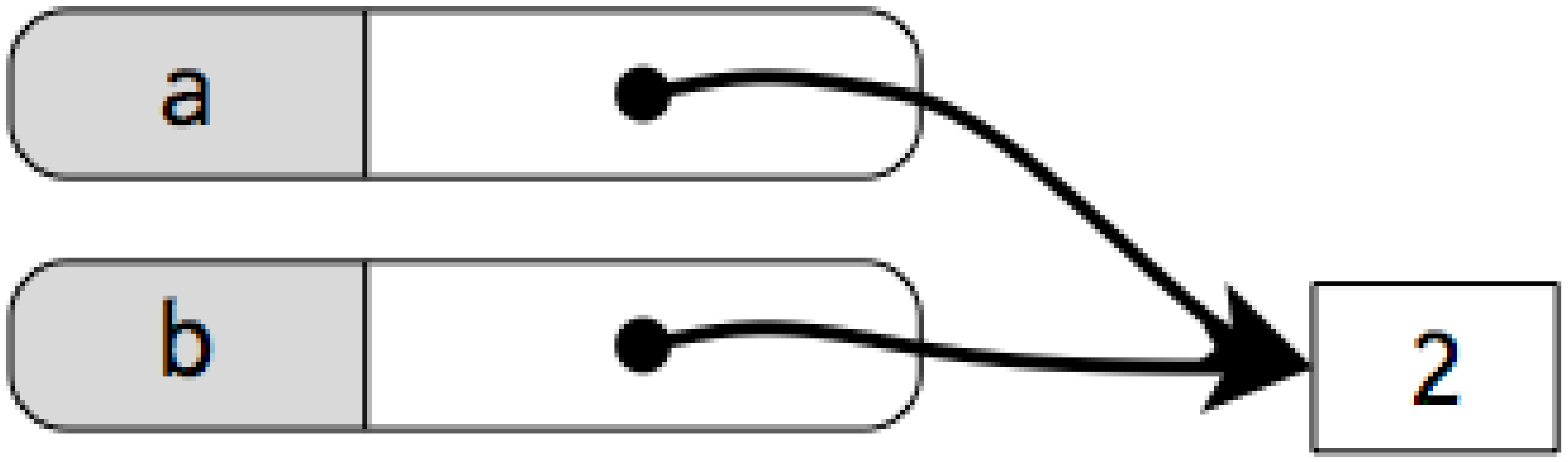
```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print(a[0] + b[0]);
```



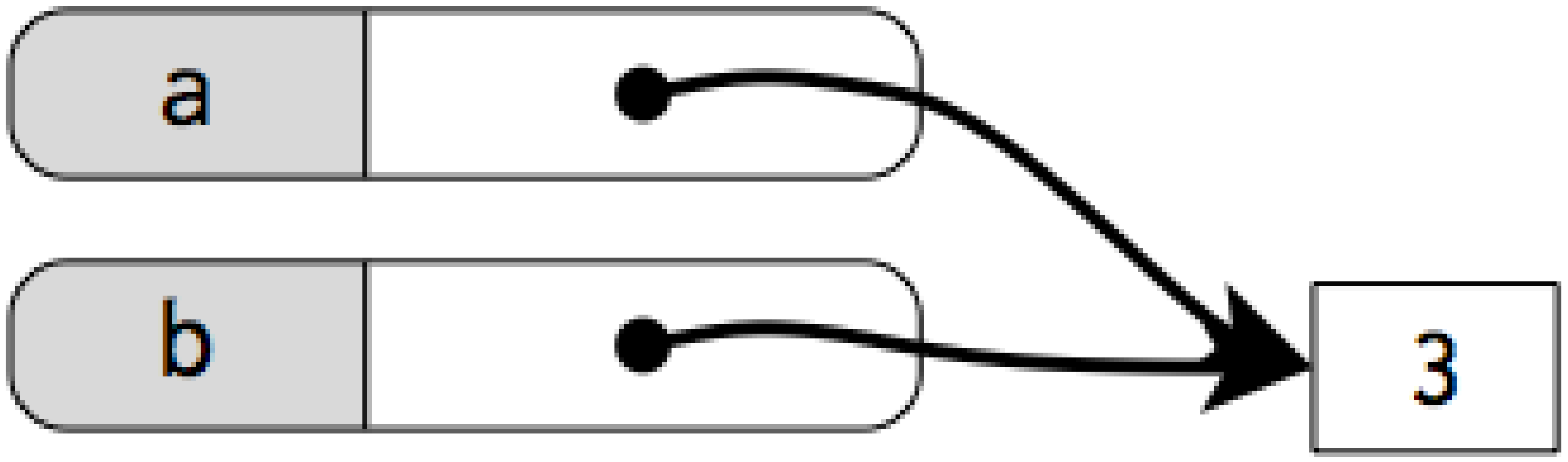
```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print(a[0] + b[0]);
```



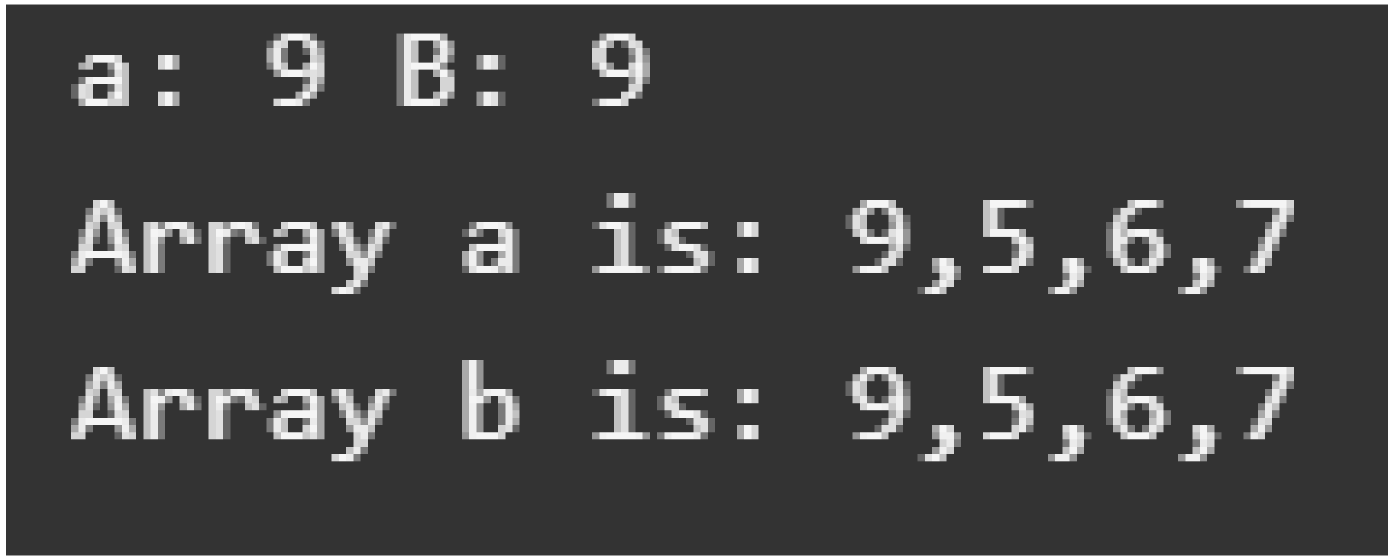
```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print(a[0] + b[0]);
```



```
let a = [1];
let b = [2];
a = b;
b[0] = 3;
print(a[0] + b[0]);
```



```
function setup() {
   let a = [1, 2, 3];
   let b = [4, 5, 6, 7];
   a = b;
   b[0] = 9;
   print("a: " + a[0] + " B: " + b[0]);
   print("Array a is: " + a);
   print("Array b is: " + b);
}
```



```
a: 9 B: 9
Array a is: 9,5,6,7
Array b is: 9,5,6,7
```

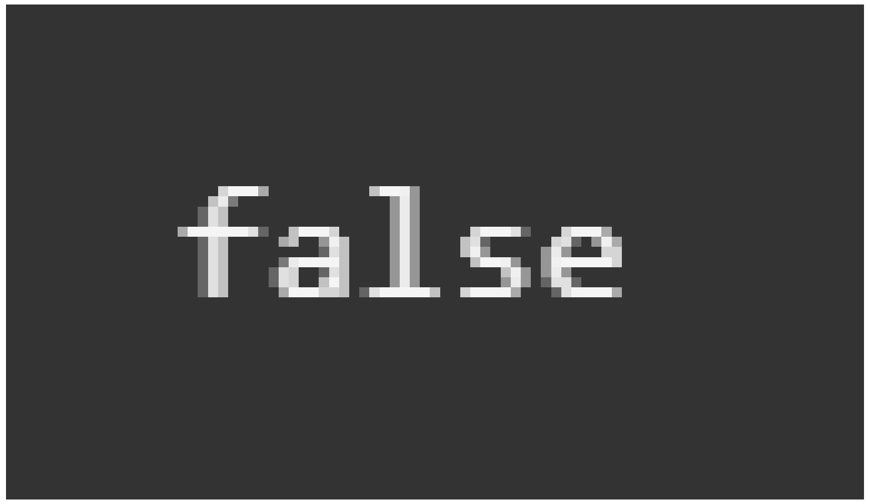
References

The basic types Number and Boolean are “primitive”: their values are “naked” and copied around directly.

Arrays are passed around by reference (arrows).

Comparing Arrays: be careful

```
let arr1 = [1, 2, 3];
let arr2 = [1, 2, 3];
print(arr1 === arr2); // false
```

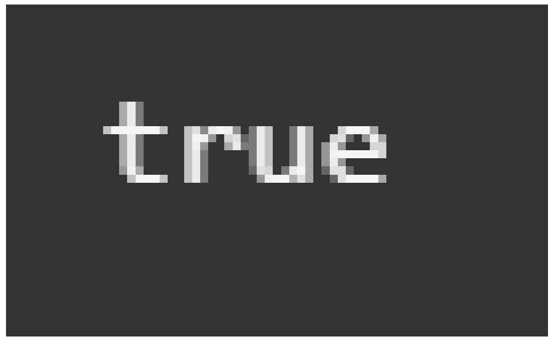


```
false
```

- JavaScript p5 compares the arrows
- The arrows point to different places
- So JavaScript p5 determines that the arrays are not equal

Comparing Arrays: be careful

```
let arr1 = [1, 2, 3];
let arr2 = arr1;
print(arr1 === arr2); // true
```



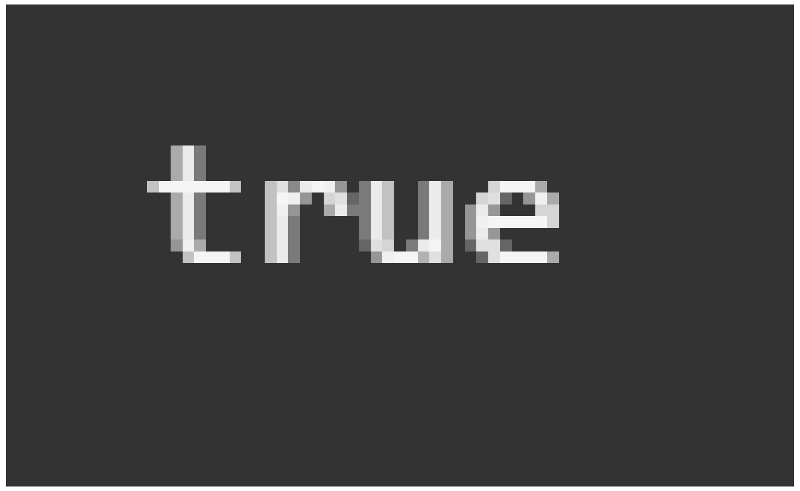
```
true
```

- JavaScript p5 compares the arrows
- The arrows point at the same place
- So JavaScript determines that the arrays are equal

Comparing Arrays: be careful

```
let arr1 = [1, 2, 3];
    let arr2 = [1, 2, 3];
    let eql = true;
    for (let i = 0; i < arr1.length; i++) {
        if (arr1[i] != arr2[i]) {
            eql = false;
        }
    }
    print(eql); // true
```

- One solution: Use a loop to check each array element.



```
true
```

What does this print?

```
let arr1 = [1, 2, 3, 4];
let arr2 = [];
arr2[0] = arr1[2];
print(arr1);
```

```
A) [1, 2, 3, 4]
B) 2
C) [2, 1, 2, 3, 4]
D) [1, 1, 2, 3, 4]
E) Error
```

Functions on Arrays

Recall Array idioms

An idiom is not a single algorithm or line of code. It's a rough template that can be customized to a specific situation.

```
for (let i = 0; i < arr.length; i++) {
    …
    …
}
```

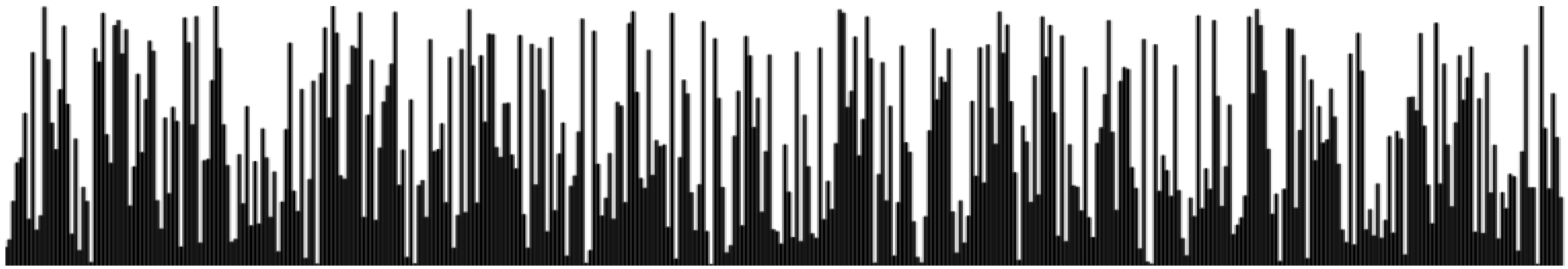
We can use more than one at once.
We should know them, recognize them.

Array idioms

1. Item Consumption

“Do” the same action per element.   Action like draw.
Well seen in CS 105.

```
// visualize each element as a thin vertical bar
for (let i = 0; i < arr.length; i++) {
  line(i, height, i, height - arr[i]);
}
```



Array functions

1. Item Consumption

“Do” the same action per element.   Action like draw.

```
function drawBars(arr) {
  for (let i = 0; i < arr.length; i++) {
    line(i, height, i, height - arr[i]);
  }
  // no return
}
```

Array idioms

2. Distillation

“Reduce” the array down to a single value.
Well seen in CS 105.

- Largest element
- Smallest element
- Is X in the array?
- Find the index of X
- Sum of elements
- Average of elements
- Number of positive elements

```
let largest = arr[0];

for (let i = 1; i < arr.length; i++) {
  if (arr[i] > largest) {
    largest = arr[i];
  }
}
```

Array functions

2. Distillation

“Reduce” the array down to a single value.

```
function largestElement(arr) {
  let largest = arr[0];

  for (let i = 1; i < arr.length; i++) {
    if (arr[i] > largest) {
      largest = arr[i];
    }
  }

  return largest;
}
```

Array idioms

3. Generation

“Conjure” an array from nothing (or a simple value).
Well seen in CS 105.

Example: given an integer n, produce the integer array
[0, 1, 2, …, n-1].

```
let arr = [];
for (let i = 0; i < n; i++) {
  arr[i] = i;
}
```

Array functions

3. Generation

“Conjure” an array from nothing (or a simple value).

```
function upto(n) {
  let arr = [];
  for (let i = 0; i < n; i++) {
    arr[i] = i;
  }
  return arr;
}
```

An object+function idiom

4. Parameter Mutation

“Work on” the array that was passed in.
This is new. And unlike the others.

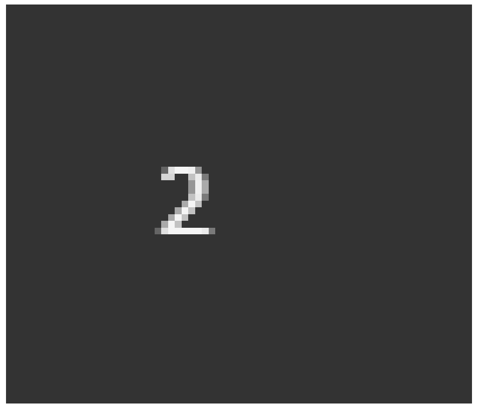
Example, replace all the a’s with b’s.

```
function replaceAll(arr, a, b) {
  for (let i = 0; i < arr.length; i++) {
    if (arr[i] === a) {
      arr[i] = b;
    }
  }
}
```

Dot Notation

- We have seen dot notation syntax before with .length
- Here we show “.indexOf()”

```
function setup() {
	let q = "c";
	let arr = ['a', 'b', 'c', 'd'];
	let result = arr.indexOf(q);
	print(result);
}
```



```
2
```

Built-in array functions

First Group: No mutation, result is returned

```
let a = ['a','b','c','d'];
let b = ['x','y'];

print(a.concat(b));          // a,b,c,d,x,y
print(a.includes('c'));      // true
print(a.indexOf('c'));       // 2
print(shuffle(a, false)); // e.g. b,a,d,c

let startAt = 2;
let stopBefore = 4;
print(a.slice(startAt, stopBefore)); //c,d
```

Built-in array functions

Second Group: With mutation, original is modified

```
let a = ['d','c','b','a'];
let extraItem = 'x';

a.push(extraItem);
print(a); // d,c,b,a,x

a.pop();
print(a); // d,c,b,a

a.unshift(extraItem);
print(a); // x,d,c,b,a
```

```
let a = ['d','c','b','a'];
let extraItem = 'x';

a.shift();
print(a); // d,c,b,a

a.sort();
print(a); // a,b,c,d

a.reverse();
print(a); // d,c,b,a

shuffle(a, true);
print(a); // e.g. a,d,c,b
```

Built-in array functions

An extra: With mutation, original is modified

```
let a = ['d','c','b','a'];
let extraItem = 'x';
let midpoint = 2;

// delete 1 item at midpoint
a.splice(midpoint, 1);
print(a); // d,c,a

// delete 0 items at midpoint and add extraItem
a.splice(midpoint, 0, extraItem);
print(a); // d,c,x,a
```

Strings

In many programming situations, we want to deal with blocks of text.

- Text boxes in a web form
- Text drawn to the screen
- Analyzing text documents for patterns

We need a type to hold blocks of text. JavaScript includes the “String” type to do exactly this.

Literals

To give an explicit string in your program (a *literal*), put it in quotes.

```
let a = 'hello';
let b = 'world';
let c = ' ';
let d = '*';
let e = '';
let f = 'Lorem ipsum dolor sit amet, elit.';
```

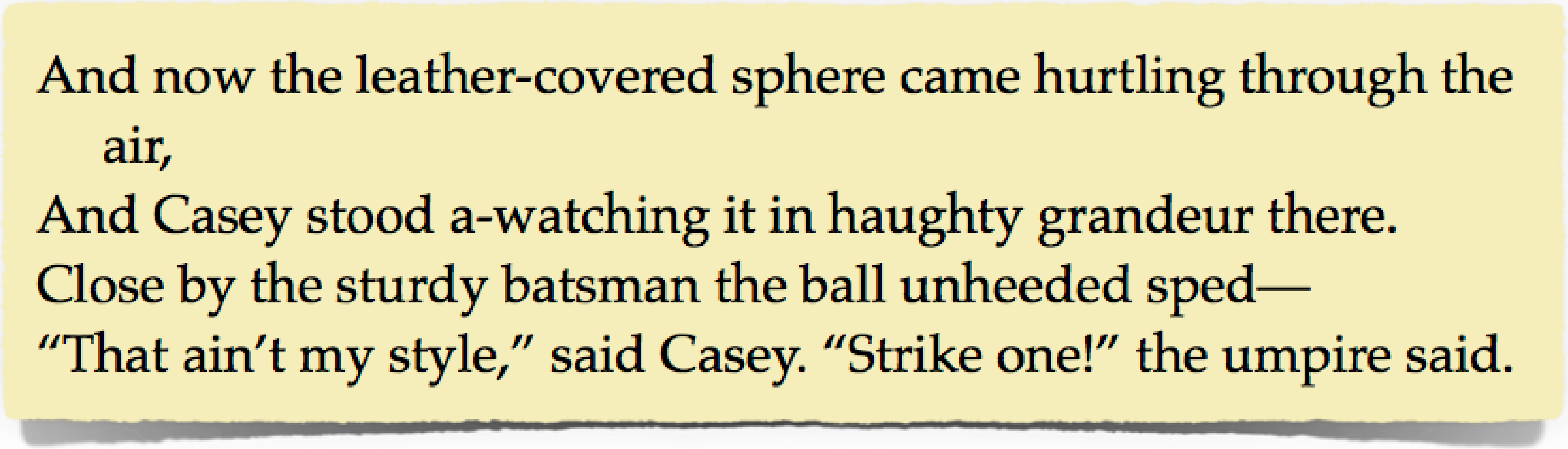
… and any quotes will do.

```
let x = "hello";
print(a===x); // true
print( "mouse is pressed" );
```

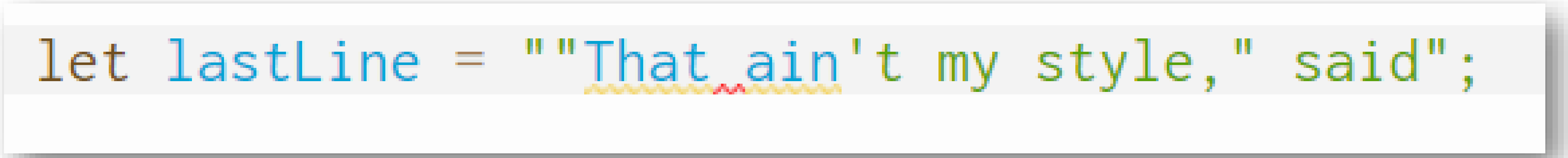
String literals

```
img = loadImage( "bird.png" );
```

Literals: special characters



And now the leather-covered sphere came hurtling through the
    air,
And Casey stood a-watching it in haughty grandeur there.
Close by the sturdy batsman the ball unheeded sped—
“That ain’t my style,” said Casey. “Strike one!” the umpire said.



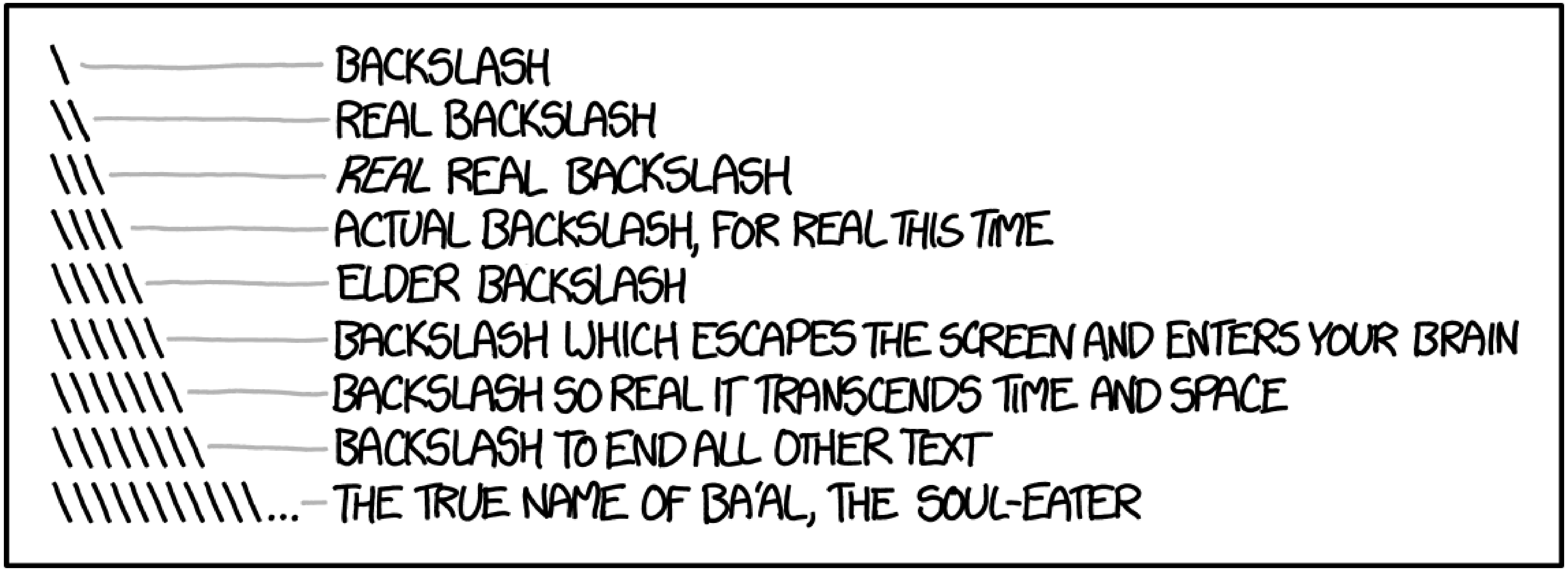
```
let lastLine = ""That ain't my style," said";
```

Ernest Lawrence Thayer, *Casey at the Bat* (1888)

Literals: special characters

Use the backslash \ to tell JS about upcoming special characters.

```
let singleqt    = "\'";
let doubleqt    = "\"";
let newline     = "\n";      // like return
let dbldagger1 = "\u2021"; // Unicode num for ‡
let dbldagger2 = "‡";      // often paste is fine

let backslash  = "\\";
```


\ BACKSLASH
\\ REAL BACKSLASH
\\\ *REAL* REAL BACKSLASH
\\\\ ACTUAL BACKSLASH, FOR REAL THIS TIME
\\\\\ ELDER BACKSLASH
\\\\\\ BACKSLASH WHICH ESCAPES THE SCREEN AND ENTERS YOUR BRAIN
\\\\\\\ BACKSLASH SO REAL IT TRANSCENDS TIME AND SPACE
\\\\\\\\ BACKSLASH TO END ALL OTHER TEXT
\\\\\\\\\\\\... THE TRUE NAME OF BA'AL, THE SOUL-EATER

https://xkcd.com/1638/

Literals: pick your quote

```
let abbrev1    = 'didn\'t';
let abbrev2    = "didn't" ;

let dialogue1 = 'Now hear, "this!"'   ;
let dialogue2 = "Now hear, \"this!\"";

print(abbrev1  === abbrev2  ); // true
print(dialogue1=== dialogue2); // true
```

Strings are just values

```
let str1 = "Hello";
let str2 = str1;

function processString(str,  num) {
   …
}

let str3 = processString(str1, 3.14);

let columns = ["Doric", "Ionic", "Corinthian"];
```

String equality

We often want to compare two strings to see whether they have the same text. They are values, after all!

```
if (str1 === str2) {
  // the strings have the same text
}
```

Concatenation and equality

+ gives LHS then RHS. It concatenates.

Strings are values.

Values don't care how you got them.

```
let s = "He" ;
print( "Hello"                 );   // Hello
print(             s + "llo"   );   // Hello
print( "Hello" === (s + "llo") );   // true

let n = 2    ;
print( 102                     );   // 102
print(             n + 100     );   // 102
print( 102     === (n + 100)   );   // true
```

Are Strings just, like, Arrays?

Almost, but not quite.

Strings wish they were arrays of characters, but they aren’t.

Still, your knowledge of arrays will help you.

```
let wd = ['h','e','l','l','o'];
```

```
let wd = "hello";
```

String vs. Array

Strings are almost like arrays.

JS doesn’t have a type for characters.

Dissecting a string gives length-one strings.

```
let s = 'abc';
print(s[1] === 'b'); // true
```

String vs. Array

Strings wish they were arrays of
… well … length-one strings? (Wait, what?)
Even *still*, your knowledge of arrays will help you.

```
let w1 = ['a','b','c'];   let w2 = 'abc';
let len1 = w1.length;     let len2 = w2.length;
let char1 = w1[2];        let char2 = w2[2];
```

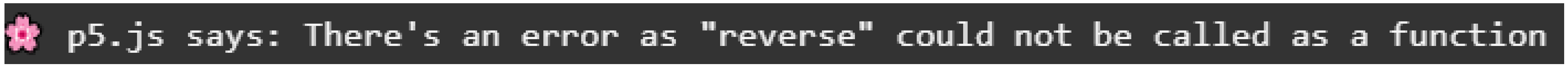
String vs. Array

Strings wish they were arrays of

… well … length-one strings? (Wait, what?)

Even *still*, your knowledge of arrays will help you, to a point.

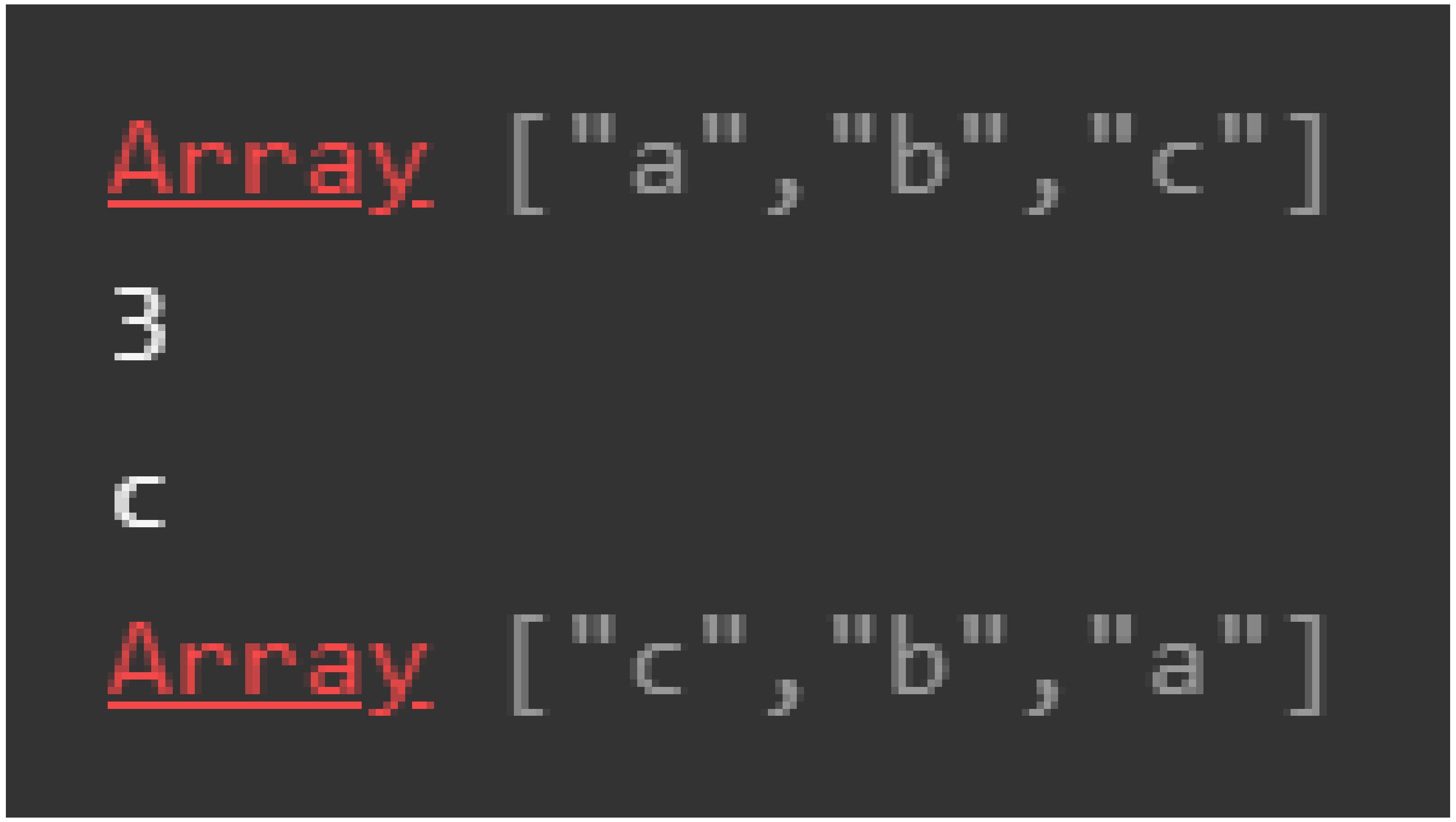
```
let w1 = ['a','b','c'];    let w2 = 'abc';
let len1 = w1.length;      let len2 = w2.length;
let char1 = w1[2];         let char2 = w2[2];
w1.reverse();              w2.reverse();
```



p5.js says: There's an error as "reverse" could not be called as a function

An Array of Strings

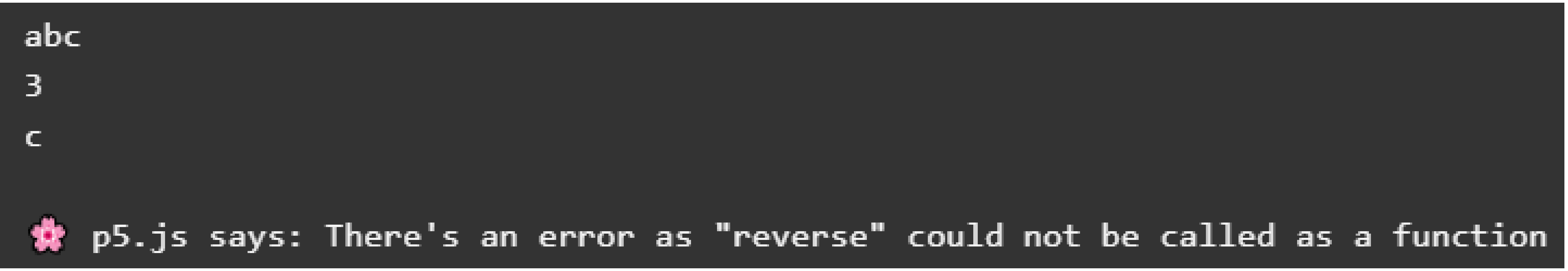
```
let w1 = ['a', 'b', 'c'];

let len1 = w1.length;

let char1 = w1[2];


print(w1);

print(len1);

print(char1);


w1.reverse();

print(w1);
```



```
Array ["a","b","c"]
3
c
Array ["c","b","a"]
```

Strings

```
let w2 = 'abc';

let len2 = w2.length;

let char2 = w2[2];


print(w2);

print(len2);

print(char2);


w2.reverse();

print(w2);
```



```
abc
3
c

🌸 p5.js says: There's an error as "reverse" could not be called as a function
```

String vs. Array

Strings wish they were arrays of

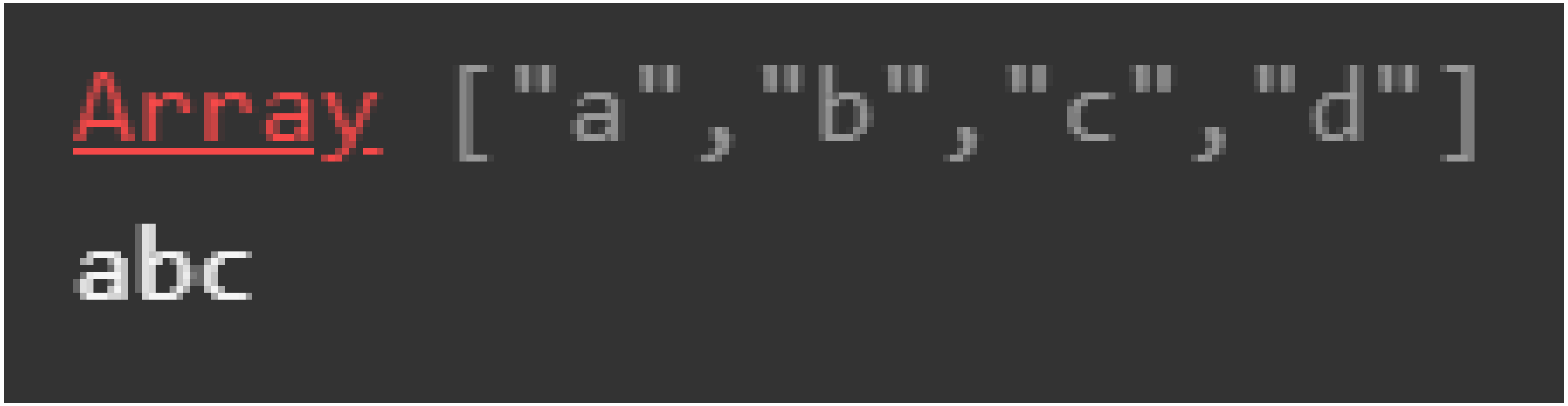
… well … length-one strings? (Wait, what?)

Even *still*, your knowledge of arrays will help you, to a point.

```
let w1 = ['a','b','c'];    let w2 = 'abc';
let len1 = w1.length;      let len2 = w2.length;
let char1 = w1[2];         let char2 = w2[2];

w1[3] = 'd';               w2[3] = ‘d';
print(w1); // a,b,c,d      print(w2); // abc
```

Arrays vs Strings

```
let w1 = ['a', 'b', 'c'];

w1[3] = 'd';

print(w1); // a,b,c,d

let w2 = 'abc';

w2[3] = 'd';

print(w2); // abc
```



```
Array ["a","b","c","d"]
abc
```

String vs. Array

Strings are *immutable*: once you have one, you can’t change it. You can assign a different string to the same variable.

```
let w1 = ['a','b','c'];   let w2 = 'abc';
let len1 = w1.length;     let len2 = w2.length;
let char1 = w1[2];        let char2 = w2[2];
w1.reverse();             // no
w1[3] = 'd';              // no
```

More dot notation on Strings

- Lower-case and upper-case

```
print('--d--'.toUpperCase());          // --D--
print('D'    .toLowerCase());          // d
```

- `print('d' === 'D'.toLowerCase());     // true`

The same comparison works on long strings. Convert everything to lower-case or upper-case:

```
print('aardvark' < 'ant');                       // true
print('aardvark' < 'Ant');                       // false
print('aardvark'.toUpperCase()
                  < 'Ant'.toUpperCase()); // true
```

What does this print?

```
let s = ["CBC", "Global", "CBC", "CTV"];

let result1 = (s[0]    === s[2]   );
let result2 = (s[0][0] === s[3][0]);

print(result1 + " " + result2);
```

A) true true
B) true false
C) false true
D) false false
E) (an error)

String vs. Array

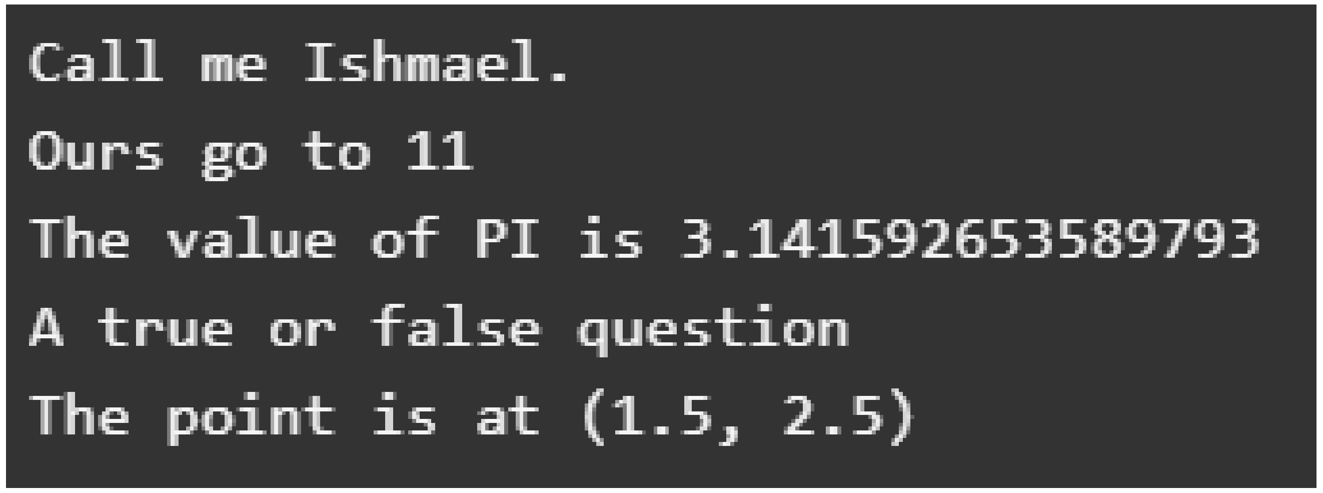
```
let a = ['a','b','c'];
let a2 = ['d','e'];

print(a.concat(a2));
// a,b,c,d,e

print(a.slice(1, 3));
// b,c

print(a.indexOf('b'));
// 1
```

```
let s = 'abc';
let s2 = 'de';

print(s + s2 );
// abcde

print(s.substring(1, 3));
// bc

print(s.indexOf('b'));
// 1

print('z'.repeat(3));
// zzz
```

More on Concatenation

The + operator on strings is very flexible.

```
let a = "Call me" + " " + "Ishmael.";
let b = "Ours go to " + 11;
let c = "The value of PI is " + PI;
let d = "A " + true + " or " + false + " question";
let x = 1.5;
let y = 2.5;
let e = "The point is at (" + x + ", " + y + ")";

print(a, b, c, d, e);
```

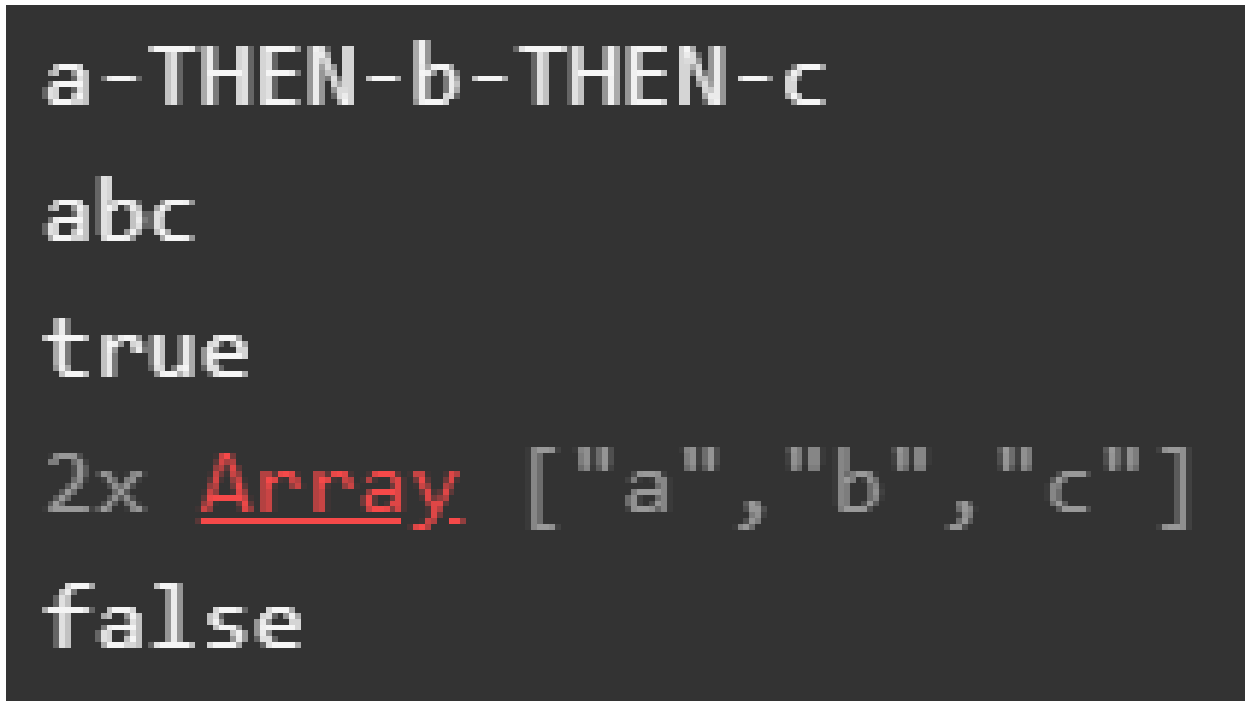


```
Call me Ishmael.
Ours go to 11
The value of PI is 3.141592653589793
A true or false question
The point is at (1.5, 2.5)
```

String and Array: better together

Join and Split are the workhorses of most practical text processing.

```
let a = ['a','b','c'];
let s = 'abc';
// join : array -> string
print( a.join('-THEN-')  );  // a-THEN-b-THEN-c
print( a.join('')        );  // abc
print( a.join('')  === s );  // true

// split : string -> array
print( 'a-THEN-b-THEN-c'.split('-THEN-') ); // a,b,c
print( s.split('')       );  // a,b,c
print( s.split('') === a );  // false
```



```
a-THEN-b-THEN-c
abc
true
2x Array ["a","b","c"]
false
```

What does this print?

```
let d = 39;
print("abc" + d);
```

(A) abc

(B) abcd

(C) ”abc”d

(D) abc39

(E) abcd39

What does this print?

```
print("123" + 456);
```

(A) 123

(B) 123456

(C) 579

(D) 12459

(E) Nothing, it’s an error

What does this print?

```
function setup() {
let s = ["ABC", "NBC", "CBC", "CTV"];
let result;

result = s[1] + ":" + s[2];
print(result);
```

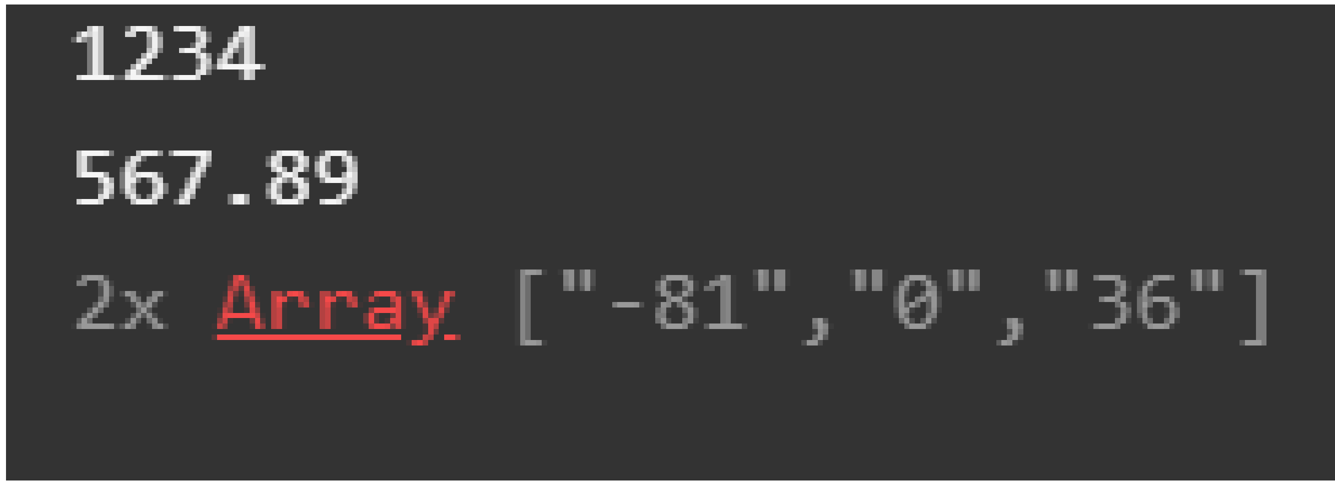
A) ABC:NBC
B) NBC:CBC
C) CBC:CTV
D) ABCNBC
E) NBCCBC

Parsing strings

We often obtain “raw text” from external sources, and need to *parse* it into meaningful data.

The built-in functions int() and float() work on strings and arrays of strings.

```
let a = int("1234");

let b = float("567.89");

let strs = ["-81", "0", "36"];

let arr = int(strs);

print(a, b, strs, arr);
```



```
1234
567.89
2x Array ["-81","0","36"]
```

Outputting text

The p5 print() function will write any text (or really, any value at all) to the console. Handy for debugging!

The built-in text() function will draw text at a given position in the sketch window, using the current fill colour.

See also textSize(), textFont(), textAlign().

Working with Text/Strings

Specify a specific Font

```
      textFont("Georgia");
```

You can use any WebSafeFont (Google to see list).

Load in your favourite Font in preload()

```
let myFont = loadFont("assets/inconsolata.otf");

textFont(myFont);
```

Best Web Safe Fonts for HTML and CSS

The following list are the best web safe fonts for HTML and CSS:

- Arial (sans-serif)
- Verdana (sans-serif)
- Helvetica (sans-serif)
- Tahoma (sans-serif)
- Trebuchet MS (sans-serif)
- Times New Roman (serif)
- Georgia (serif)
- Garamond (serif)
- Courier New (monospace)
- Brush Script MT (cursive)

Credit: w3Schools.com

Sample program using fonts (1 of 2)

```
let index = 0;

let myFonts = [
    "Arial",
    "Verdana",
    "Helvetica",
    "Tahoma",
    "Trebuchet MS",
    "Times New Roman",
    "Georgia",
    "Garamond",
    "Courier New",
    "Brush Script MT"
]
```

Sample program using fonts (2 of 2)

```
function setup() {
   createCanvas(600, 400);
   background(220);
   textFont(myFonts[index]);
   textSize(25);
}
function draw() {
   background(220);
   text("This is font: " + myFonts[index], 25, height / 2);
   text("1 2 3 4 5 6 7 8 9 0", 25, height / 2 + 50);
}
function keyPressed() {
   index = index + 1;
   if (index >= myFonts.length) {
      index = 0;
   }
   textFont(myFonts[index]);
}
```

```
function setup() {
   createCanvas(275, 400);
   textSize(72);
   colorMode(HSB, 255);
   background(0, 0, 255);
   for (let y = 80; y < 380; y += 15) {
      fill(map(y, 80, 380, 0, 255), 255, 255);
      text("CS 106", 10, y);
   }
}
```