CSCI 132:
Basic Data Structures and Algorithms

Sorting (Bubble Sort)

Reese Pearsall

Spring 2023

Announcements

Lab 10 due tomorrow @ 11:59 PM

Program 4 Due April 19th

Sorting

We will spend the next several lectures discussing how to **sort** a set of values (typically an Array of ints)

Sorting a dataset is a very frequently done task, and working with a sorted dataset is much easier than working with an unsorted dataset

Instead of saying `Array.Sort()`, we will write **four** different sorting algorithms

Sorting

We will spend the next several lectures discussing how to **sort** a set of values (typically an Array of ints)

Sorting a dataset is a very frequently done task, and working with a sorted dataset is much easier than working with an unsorted dataset

Instead of saying `Array.Sort()`, we will write **four** different sorting algorithms

First, let's write a method that will generate an N-sized array filled with random integers (1-100)

Sorting

```
public int[] getRandomArray(int n) {
    int[] array = new int[n];
    Random rand = new Random();
    for(int i = 0; i < array.length; i++) {
        array[i] = rand.nextInt(101);
    }
    return array;
}
```

Bubble Sort

Iterate through an array and compare **pairs** in the array. When comparing two numbers, if one is bigger than the other, **swap.** Keep iterating until array is sorted

7	2	5	3	9	1	6

Bubble Sort

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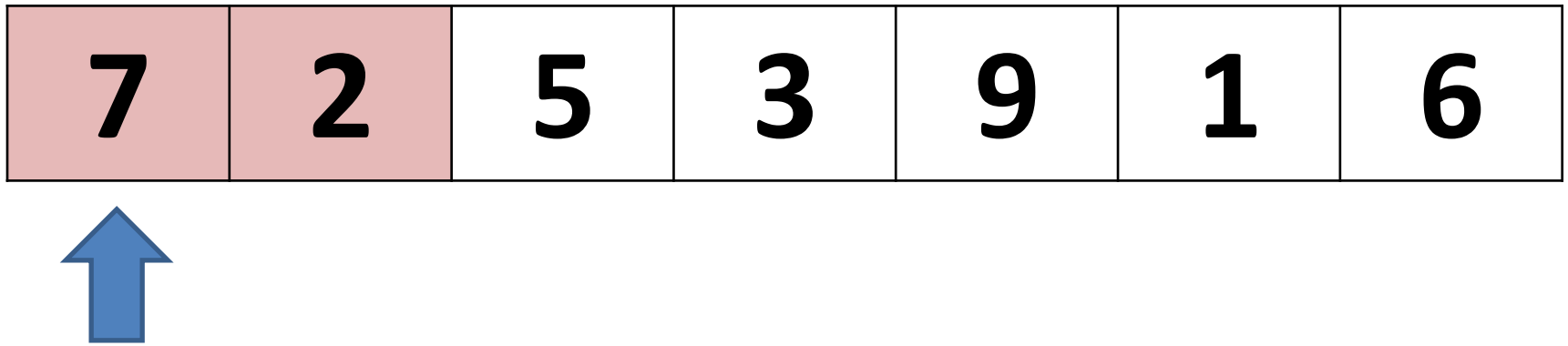

Is 7 greater than 2? → SWAP

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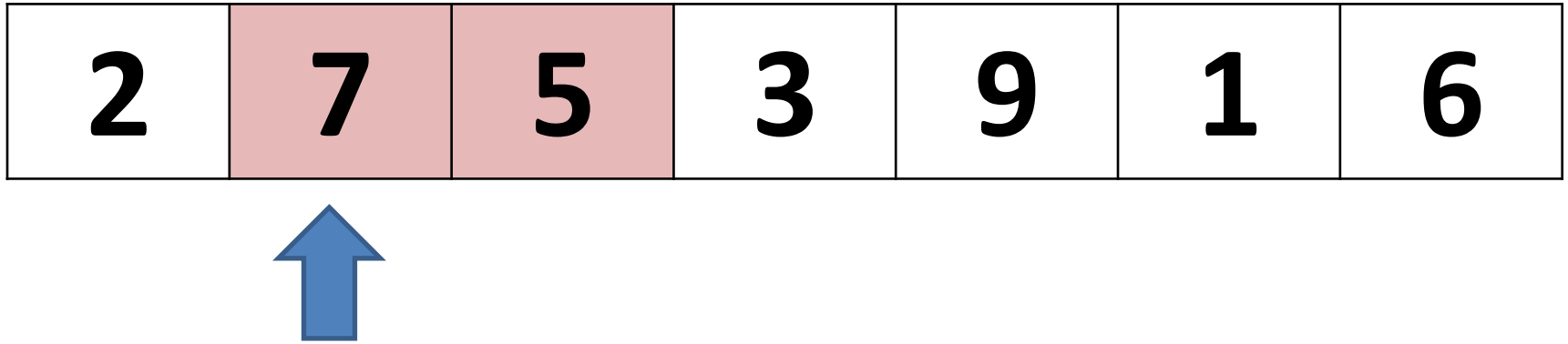

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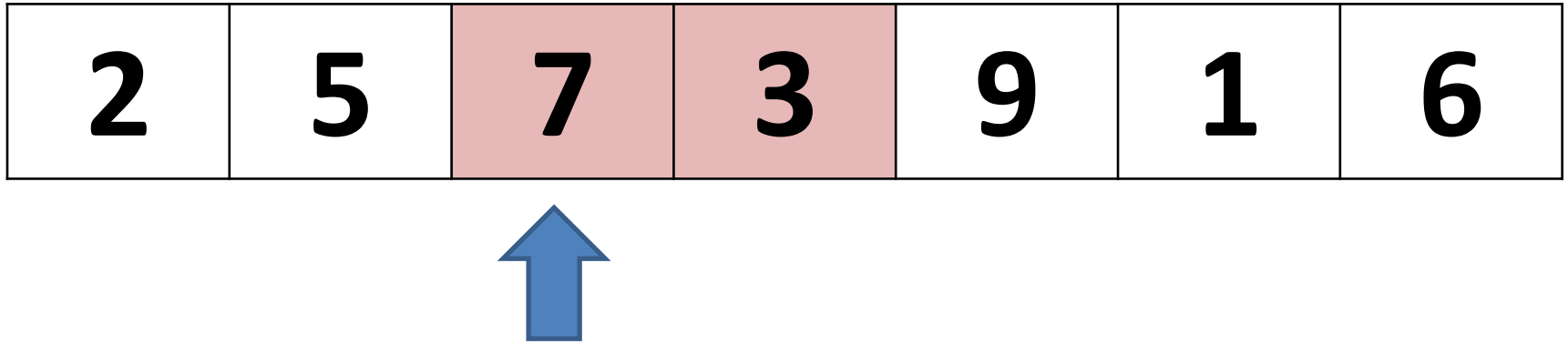

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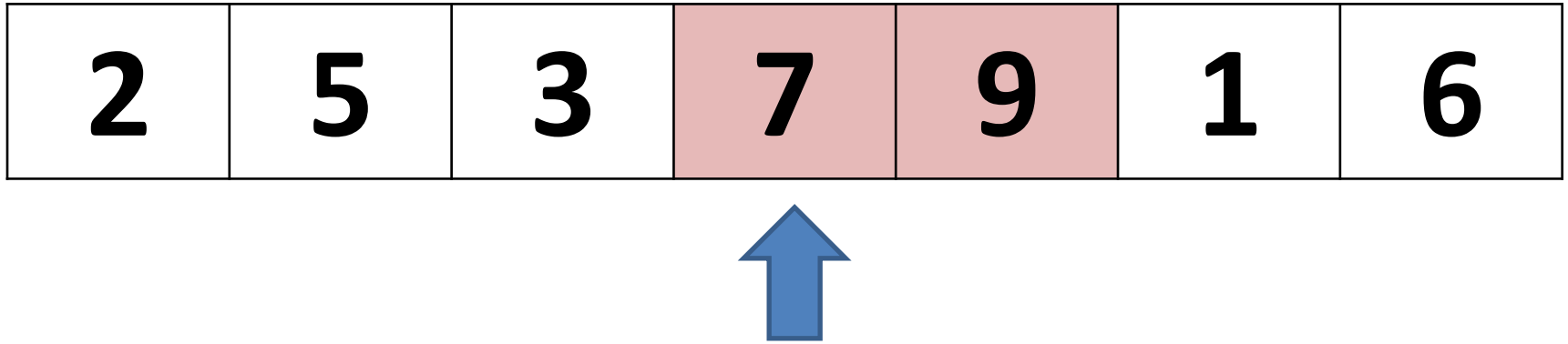

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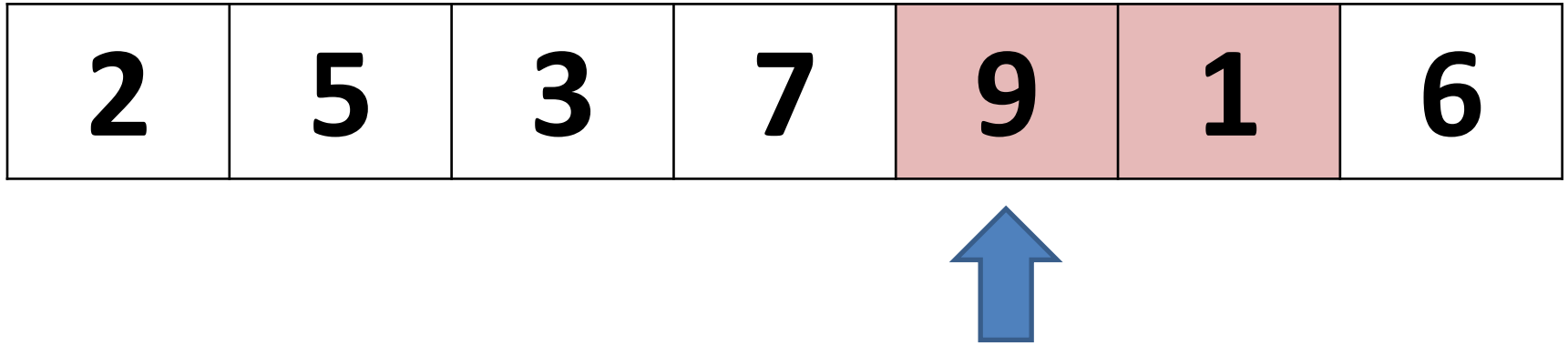

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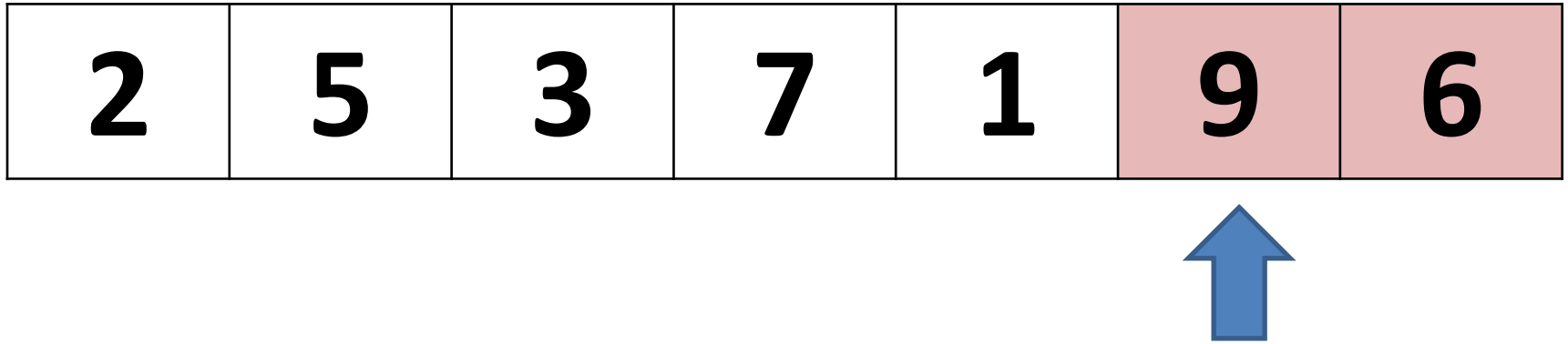

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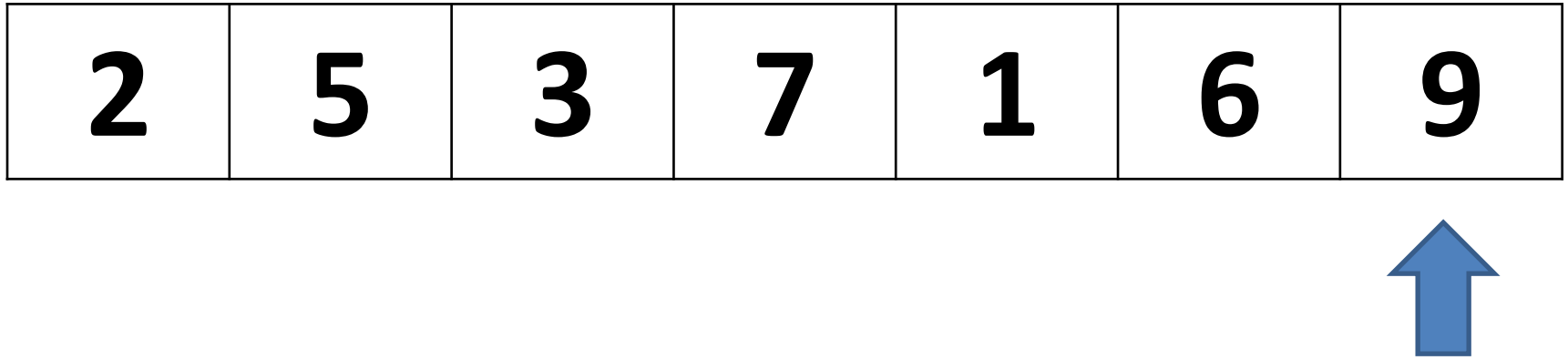

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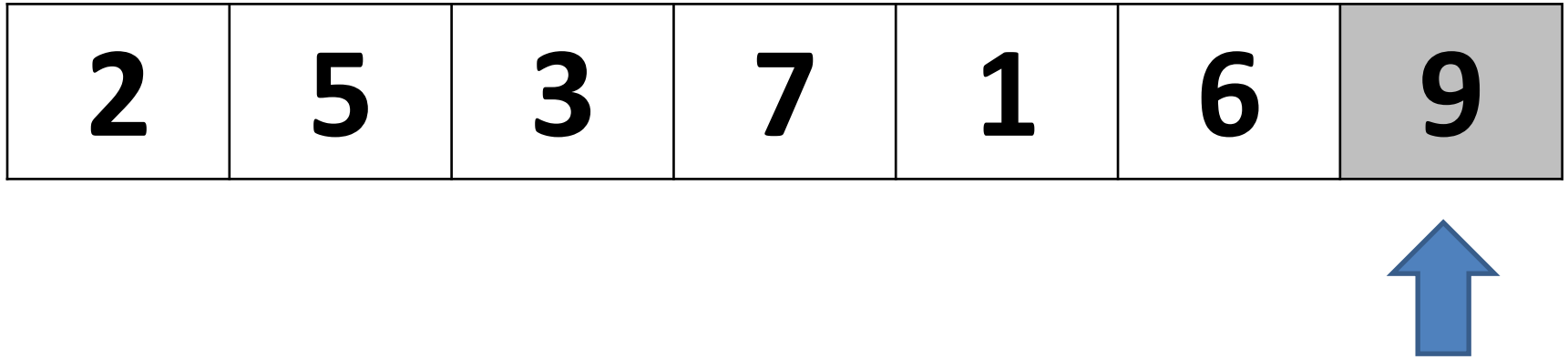

At this point, 9 (the biggest number) is at the correct spot in the array.

So, we no longer need to check that index!

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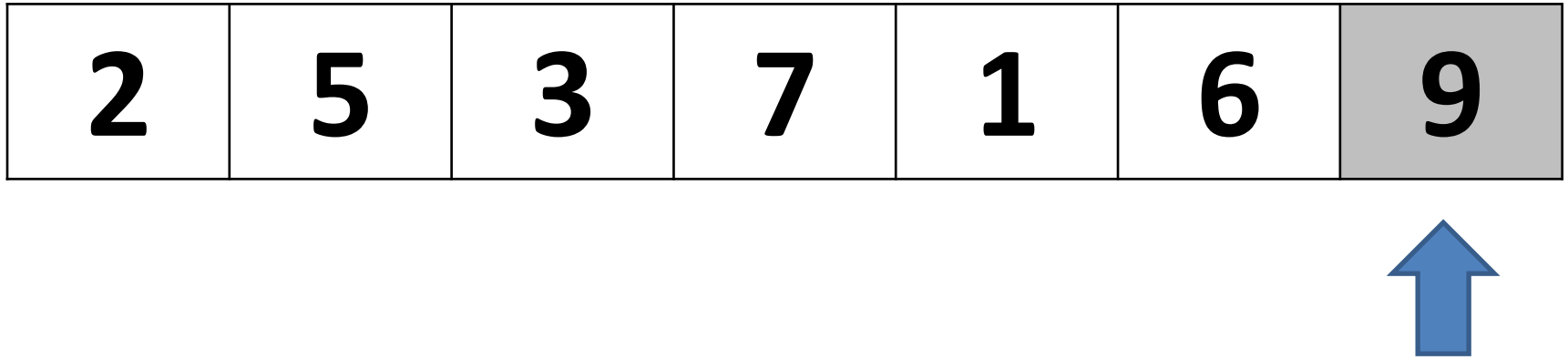

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Bubble Sort → “The biggest bubbles rise to the top naturally”

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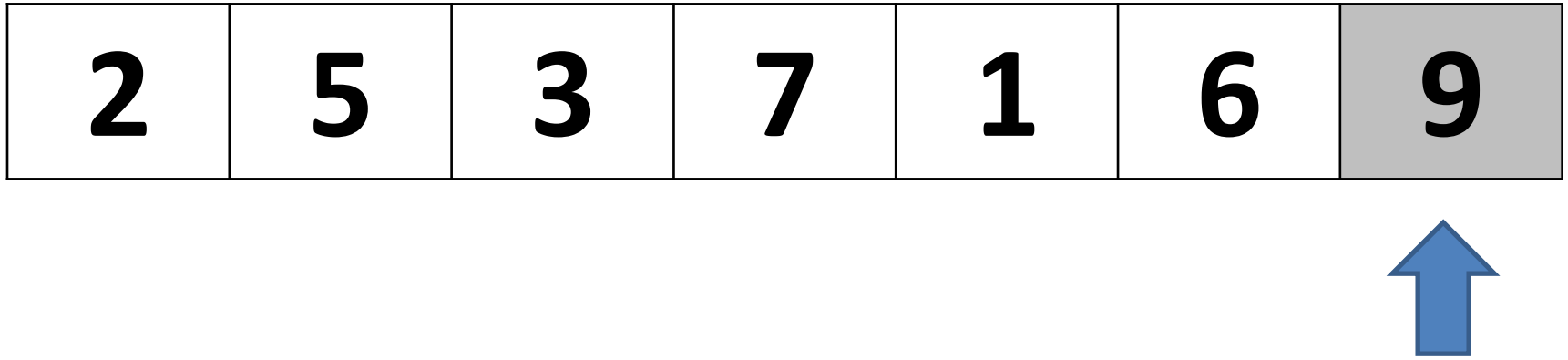

At this point, 9 (the biggest number) is at the correct spot in the array.

So, we no longer need to check that index!

Now, we start over again, but now we check one less spot!

Bubble Sort

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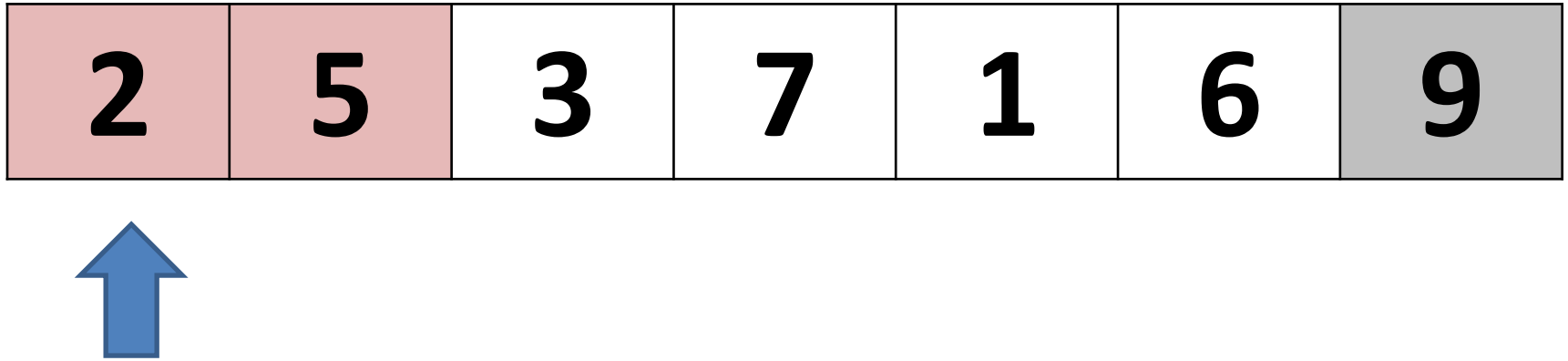

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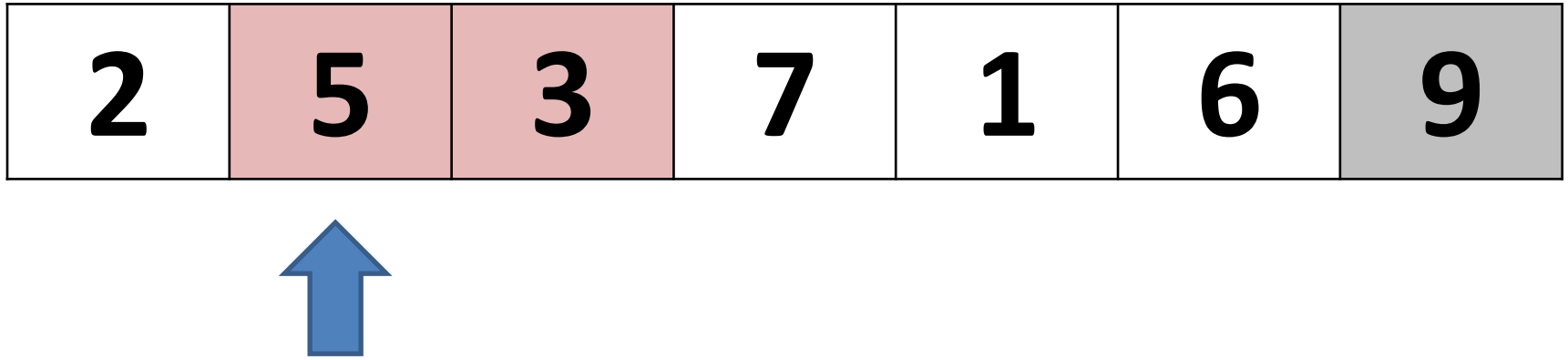

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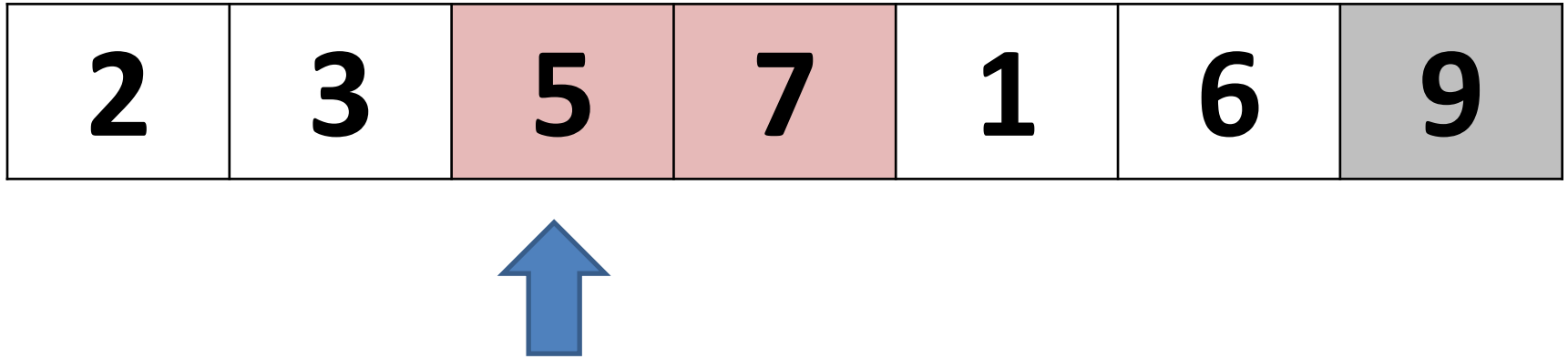

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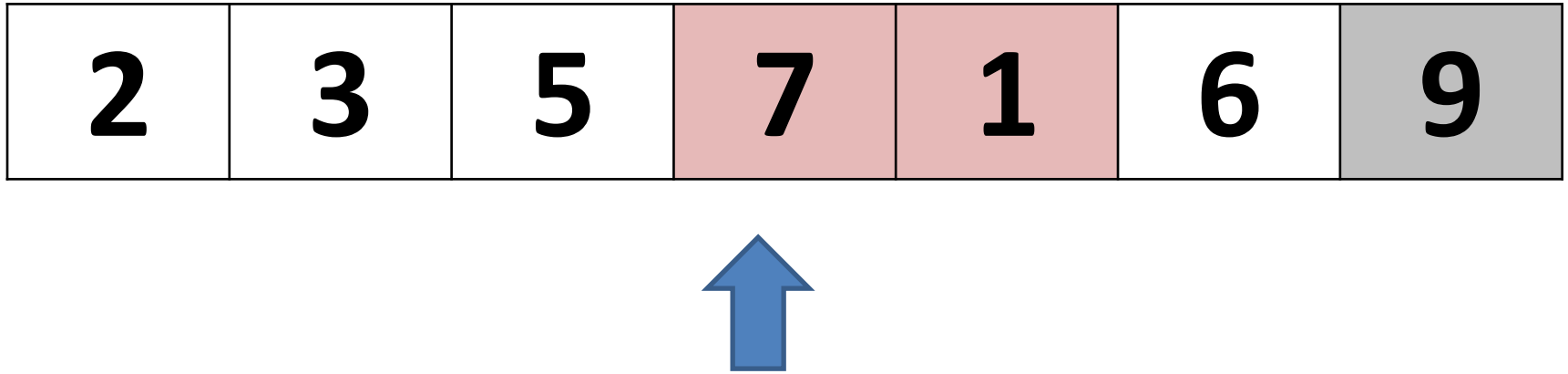

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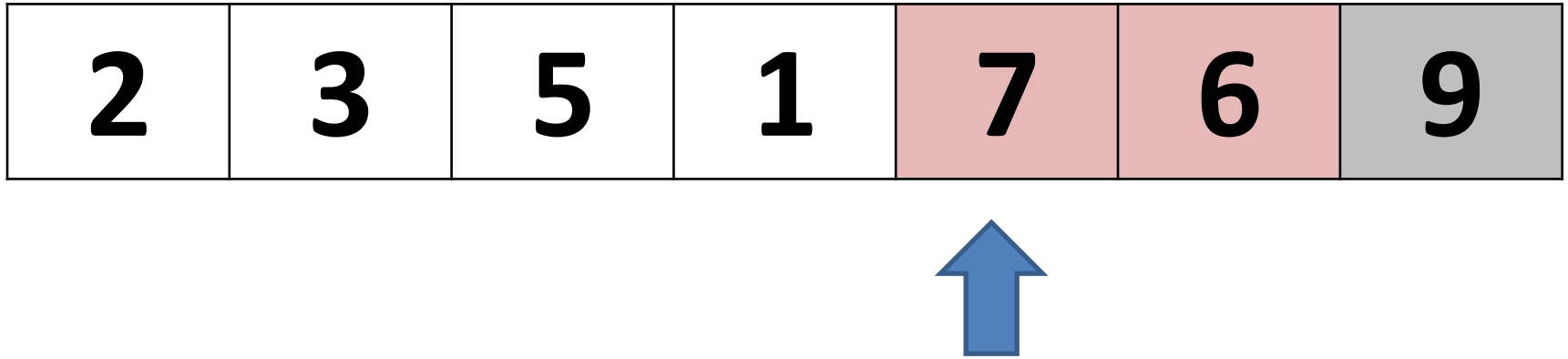

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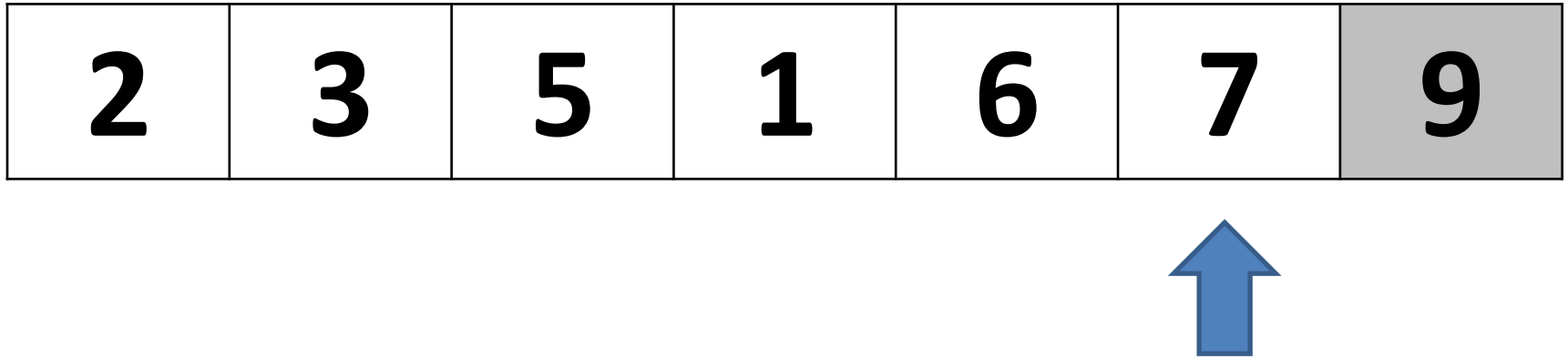

7 is now in the correct spot of the array

Bubble Sort

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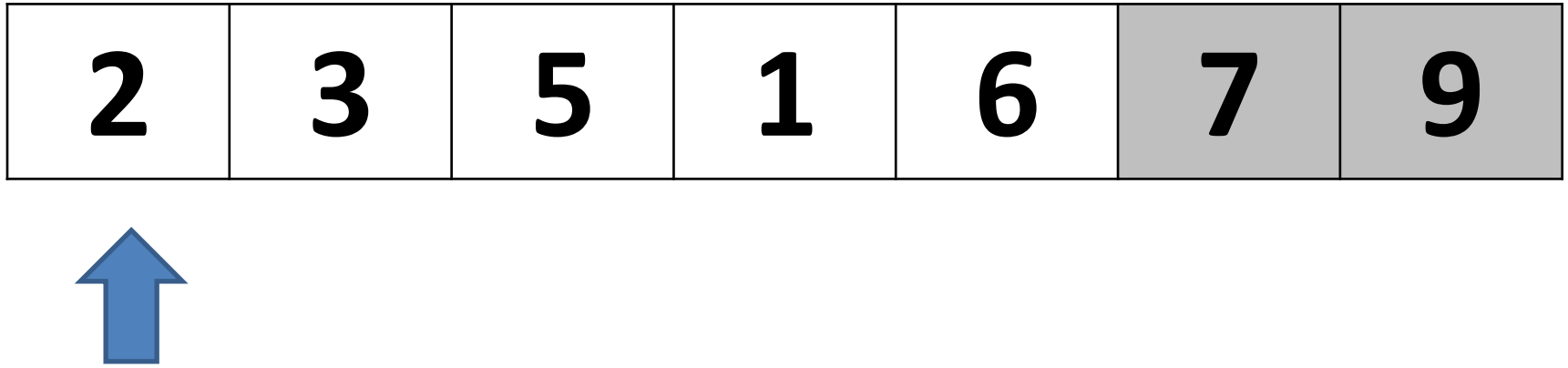

Repeat again!

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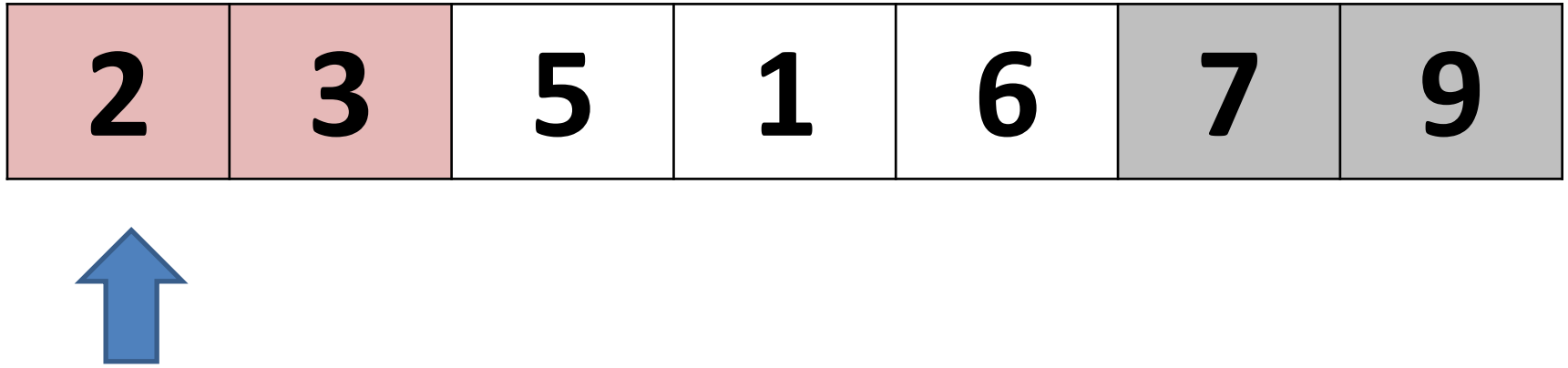

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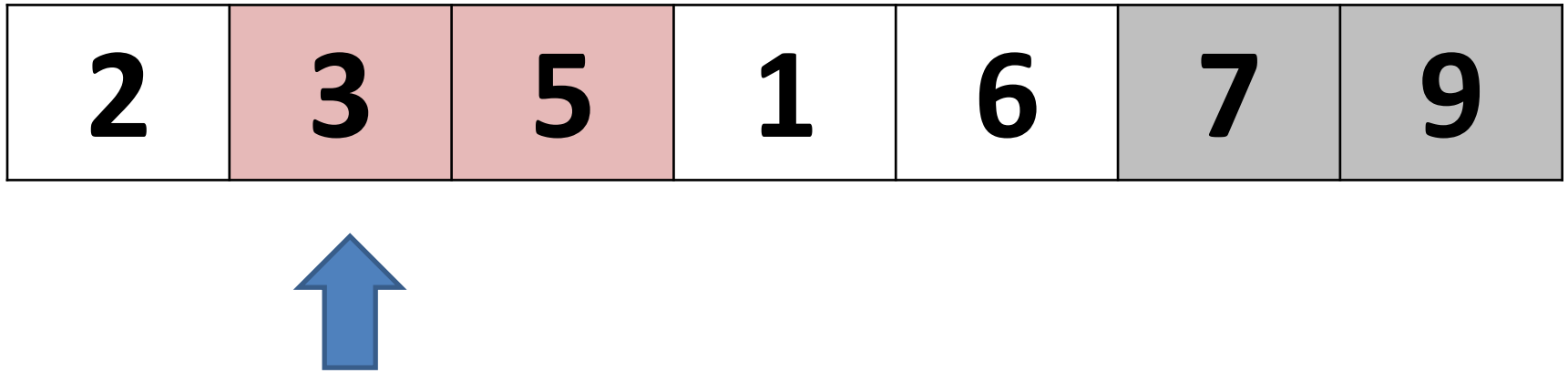

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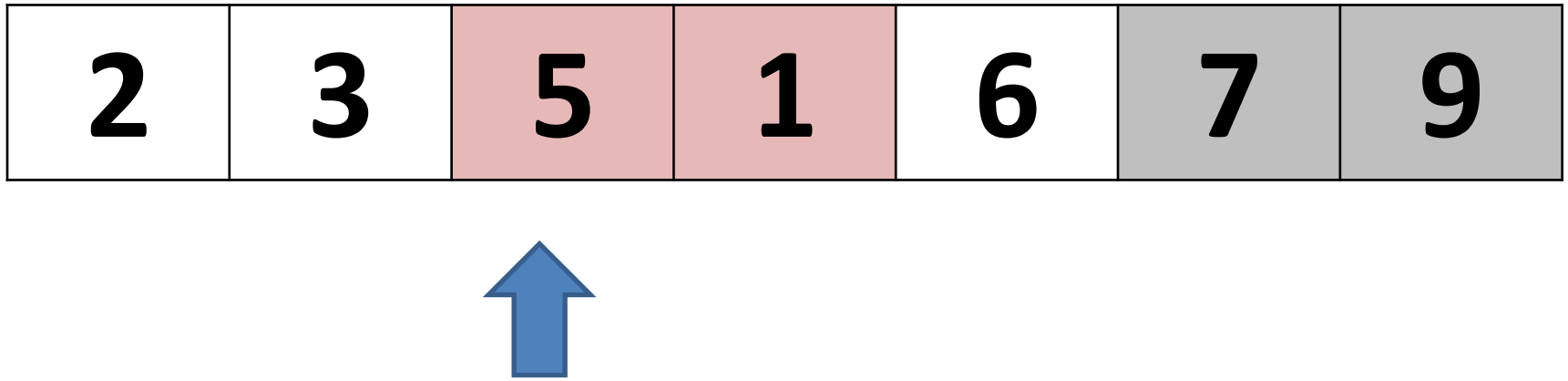

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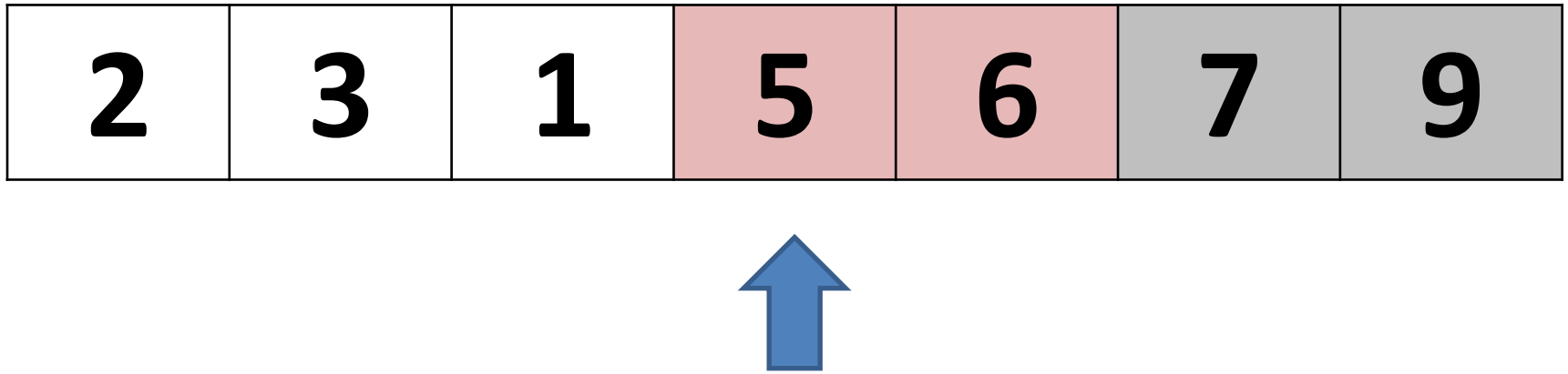

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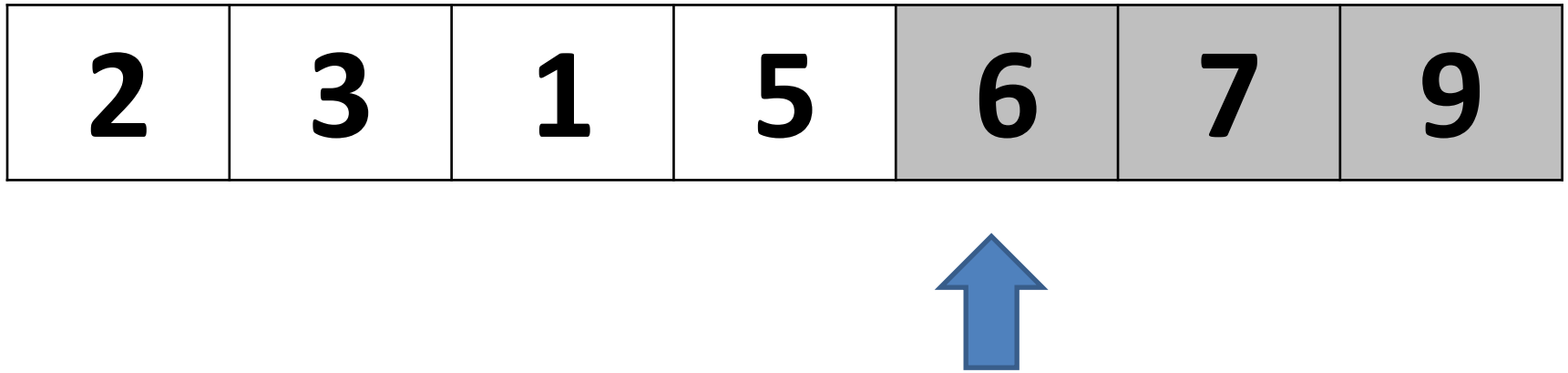

Repeat again!

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1	2	3	5	6	7	9

(fast forwarding….)

Bubble Sort

Iterate through an array and compare **pairs** in the array. When comparing two numbers, if one is bigger than the other, **swap.** Keep iterating until array is sorted

1	2	3	5	6	7	9

All done!

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1	2	3	5	6	7	9

All done!

Bubble Sort

```
public void bubbleSort(int[] array) {
    int n = array.length;
    for(int i = 0; i < n - 1; i++) {
        for(int j = 0; j < n - i - 1; j++) {
            if( array[j] > array[j + 1]) {
                //swap
                int temp = array[j];
                array[j] = array[j+1];
                array[j + 1] = temp;
            }
        }
    }
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```

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```

Running time?

Bubble Sort

```
public void bubbleSort(int[] array) {
    int n = array.length;O(1)
    for(int i = 0; i < n - 1; i++) { O(n)
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            if( array[j] > array[j + 1]) {  O(1)
                //swap
                int temp = array[j];  O(1)
                array[j] = array[j+1]; O(1)
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            }
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            }
        }
    }
}
```

Running time? $O(n^2)$

For loop in a for loop = **n * n**

n = | array |

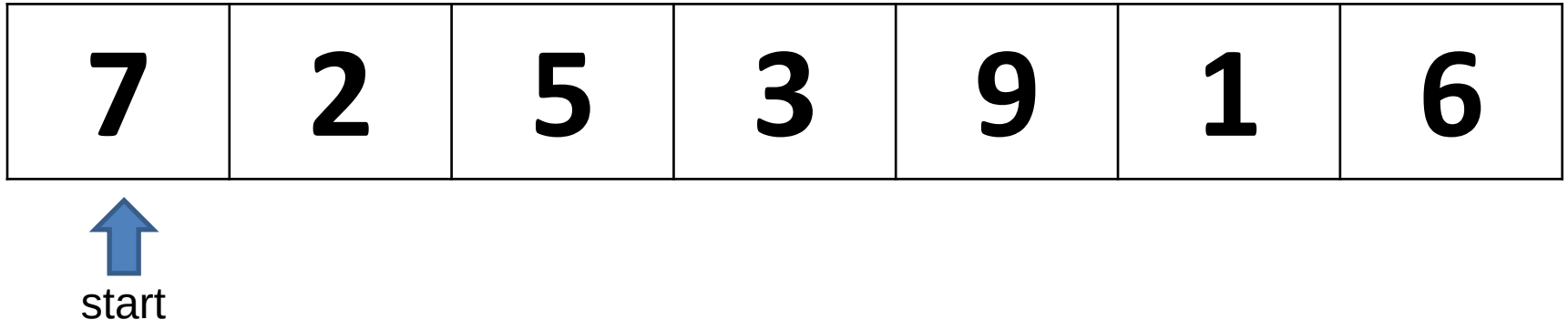
Bubble Sort

Bubble Sort Gif

https://upload.wikimedia.org/wikipedia/commons/c/c8/Bubble-sort-example-300px.gif

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



Goal: Find the minimum element

```
minimum_so_far = 7
```

Selection Sort

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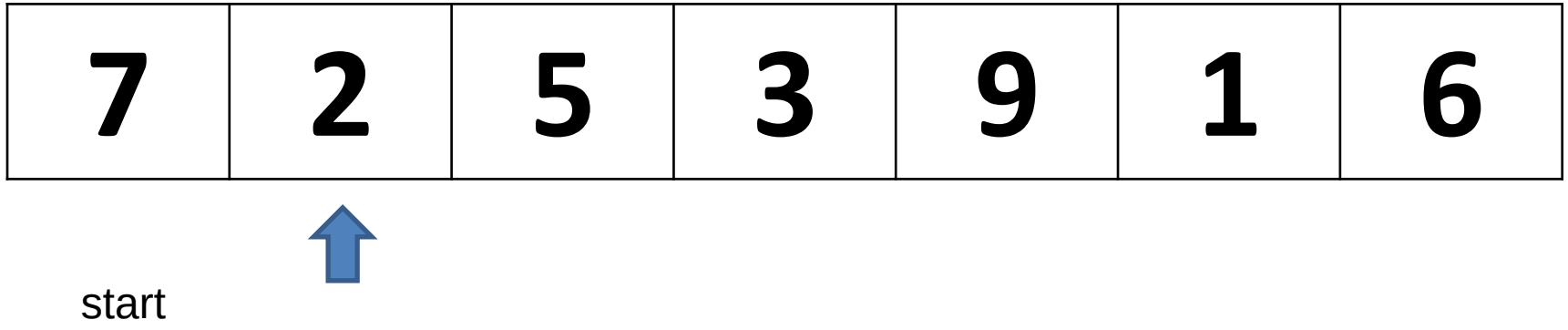

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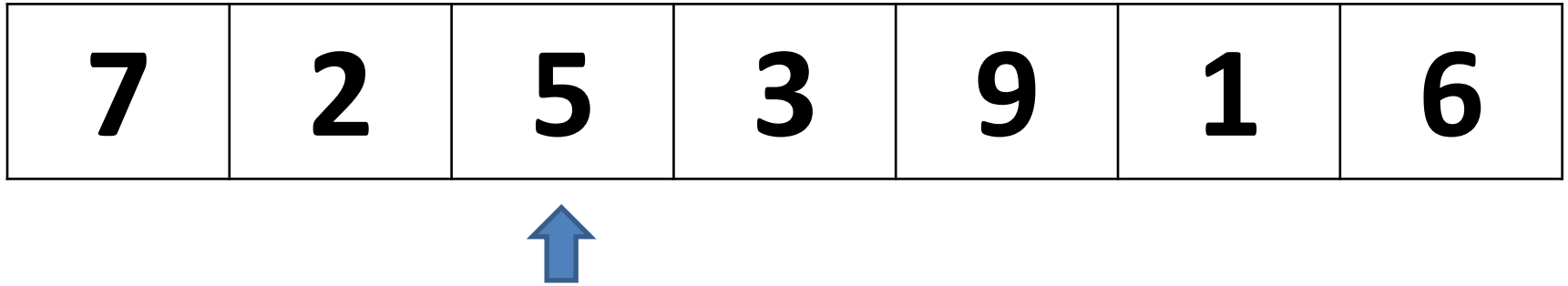


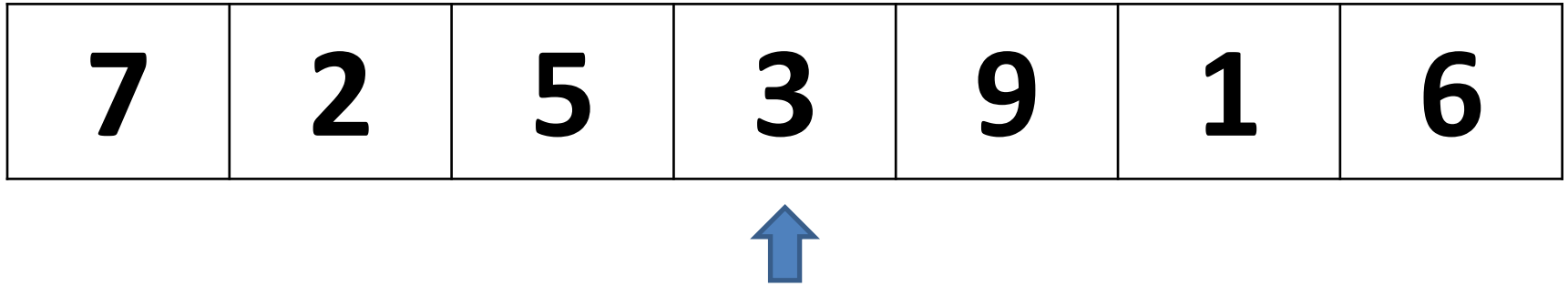
start

Goal: Find the minimum element

`minimum_so_far` = 2

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



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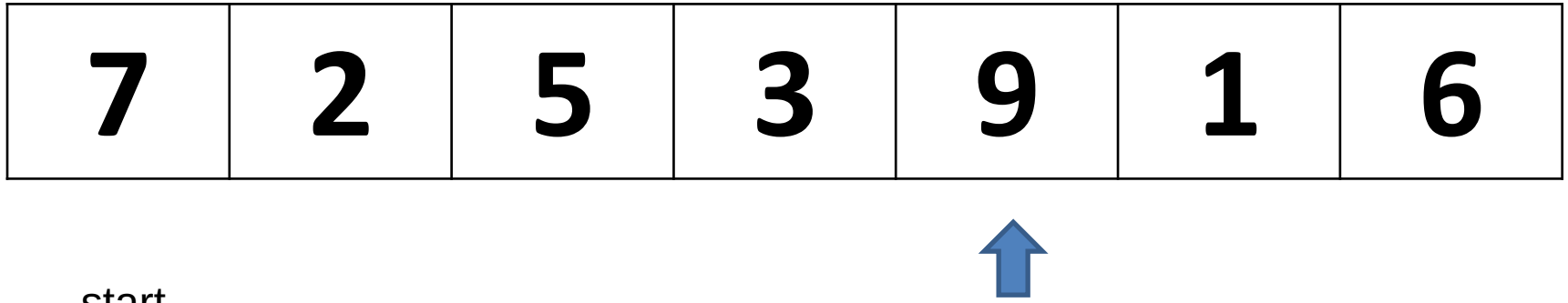

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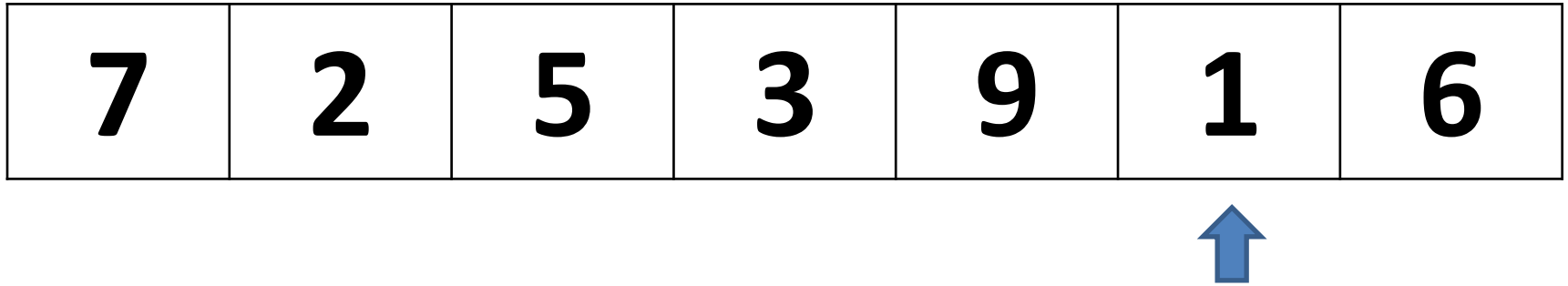

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Goal: Find the minimum element

`minimum_so_far` = 2

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot

7	2	5	3	9	1	6

start

Goal: Find the minimum element

`minimum_so_far` = 1

Selection Sort

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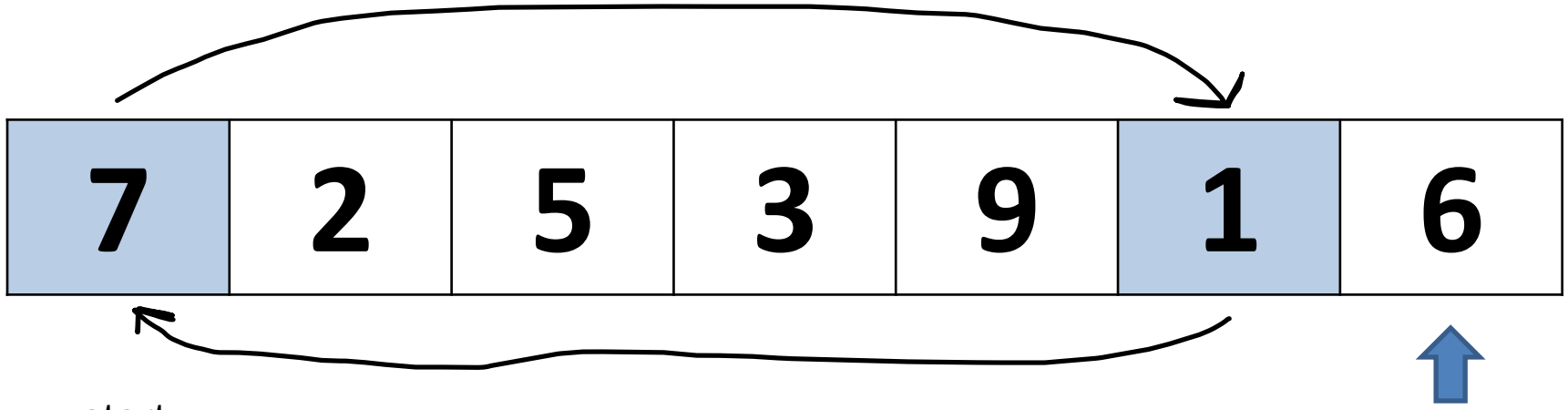

Goal: Find the minimum element

`minimum_so_far` = 1

Now that we've found the minimum value, swap it with the spot that we started at

Selection Sort

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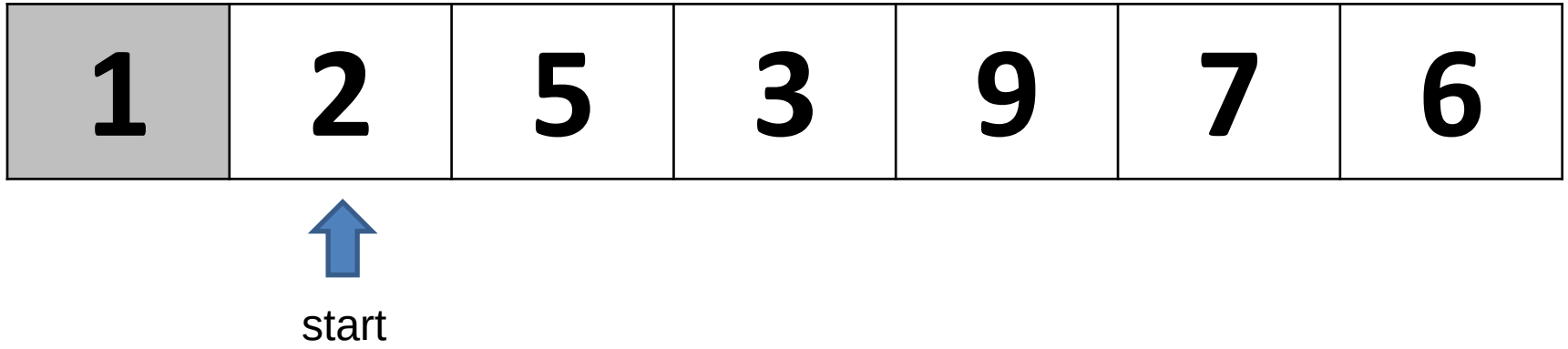

Goal: Find the minimum element

`minimum_so_far` = 2

1 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

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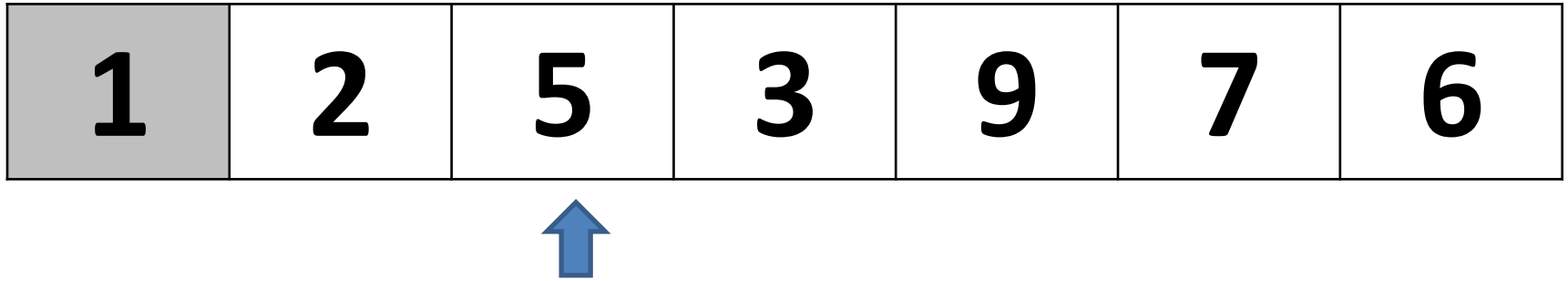

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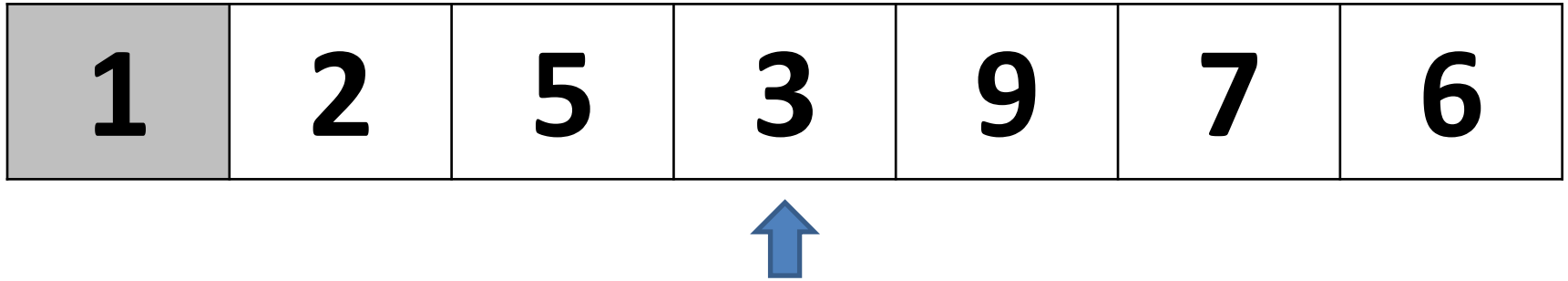

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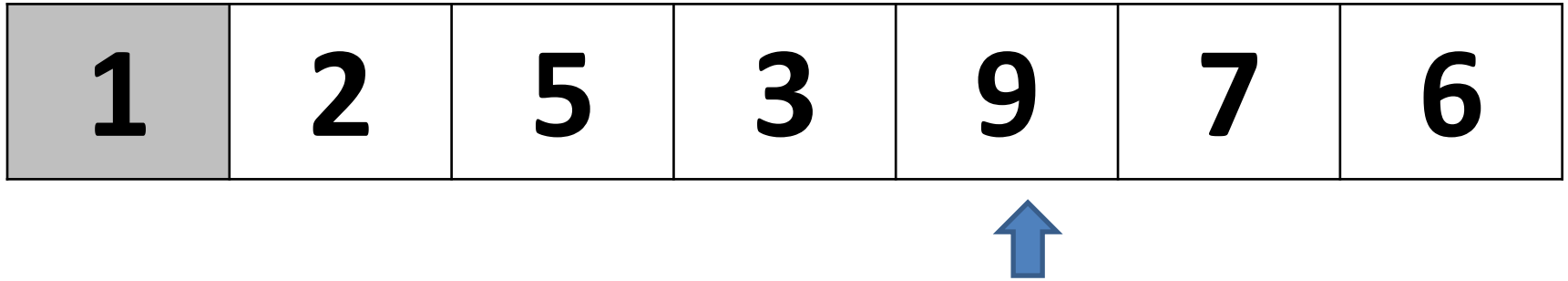

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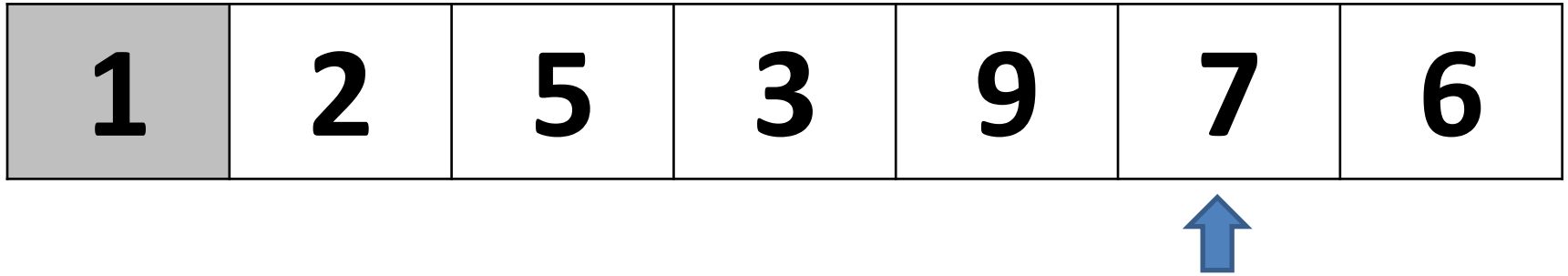

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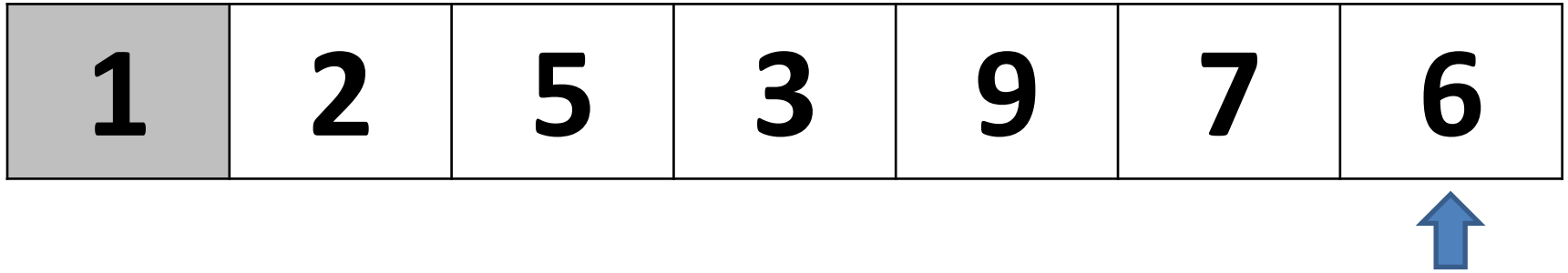

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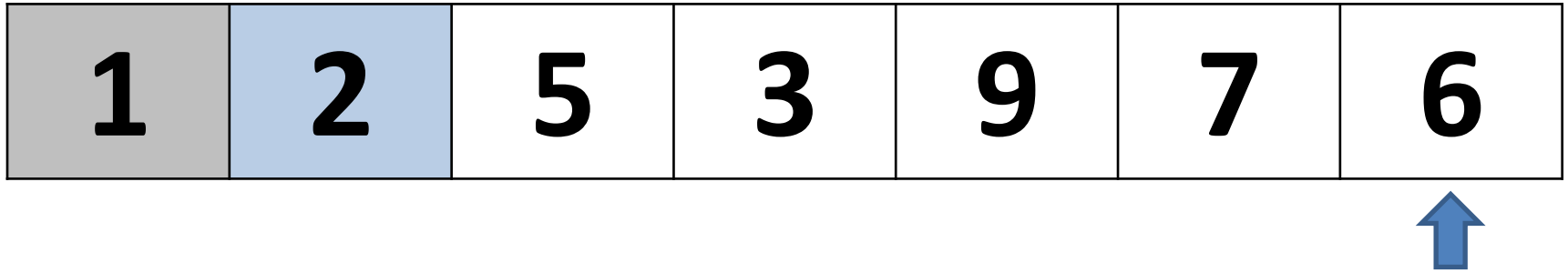

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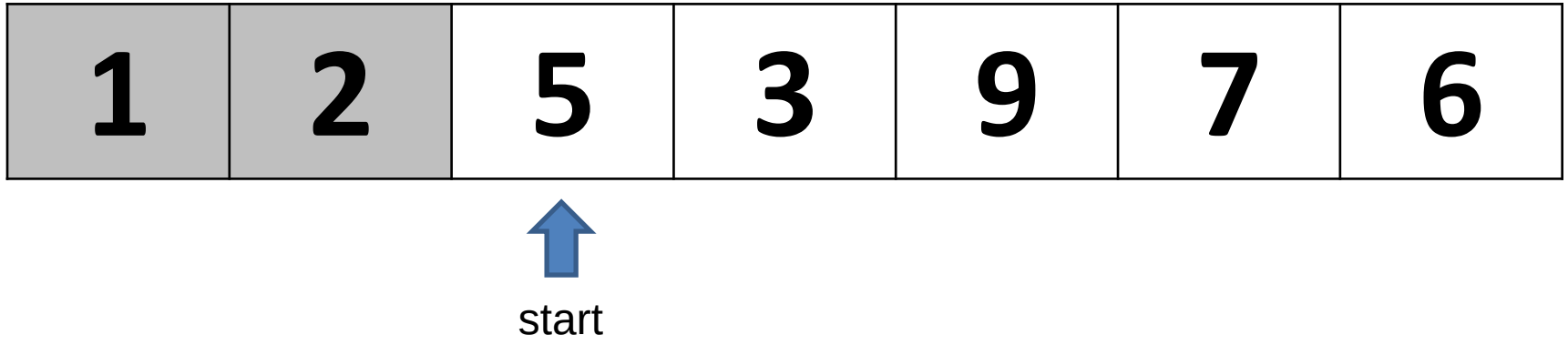
1 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



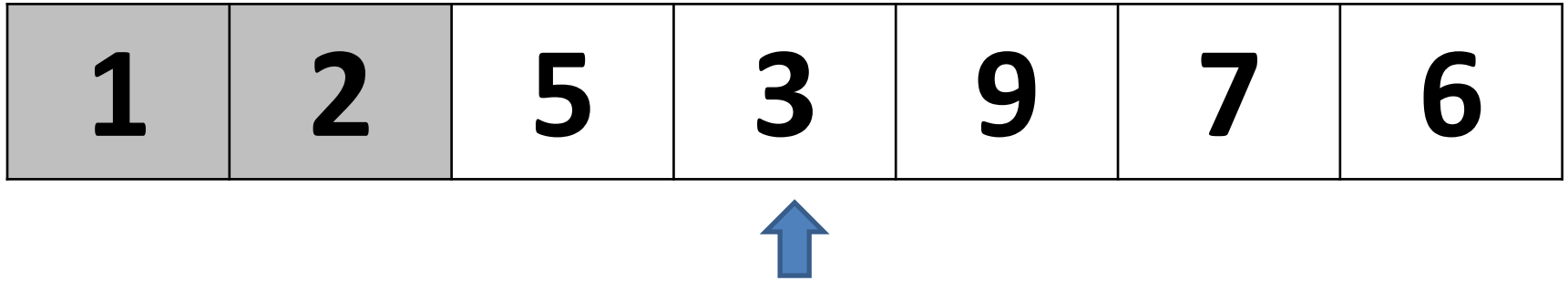
Goal: Find the minimum element

`minimum_so_far` = 5

2 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



start

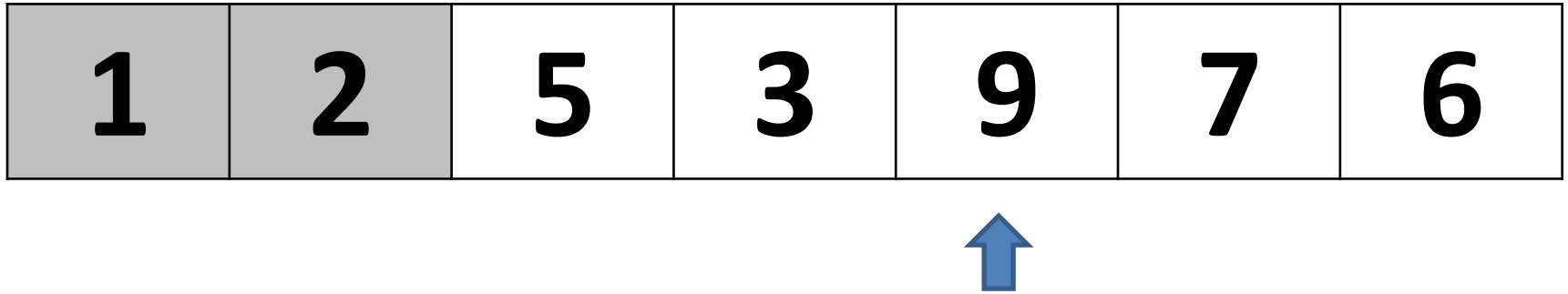
Goal: Find the minimum element

`minimum_so_far` = 5

2 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



start

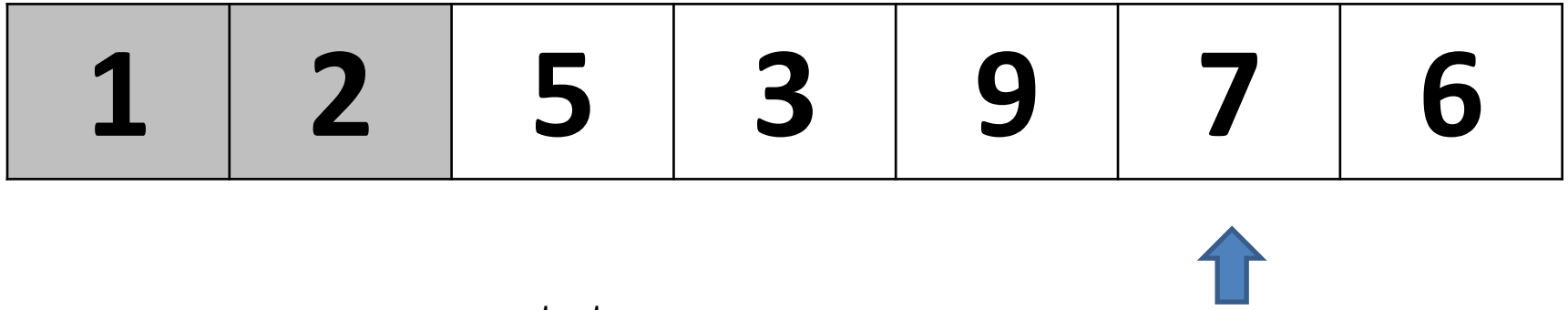
Goal: Find the minimum element

`minimum_so_far` = 3

2 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



start

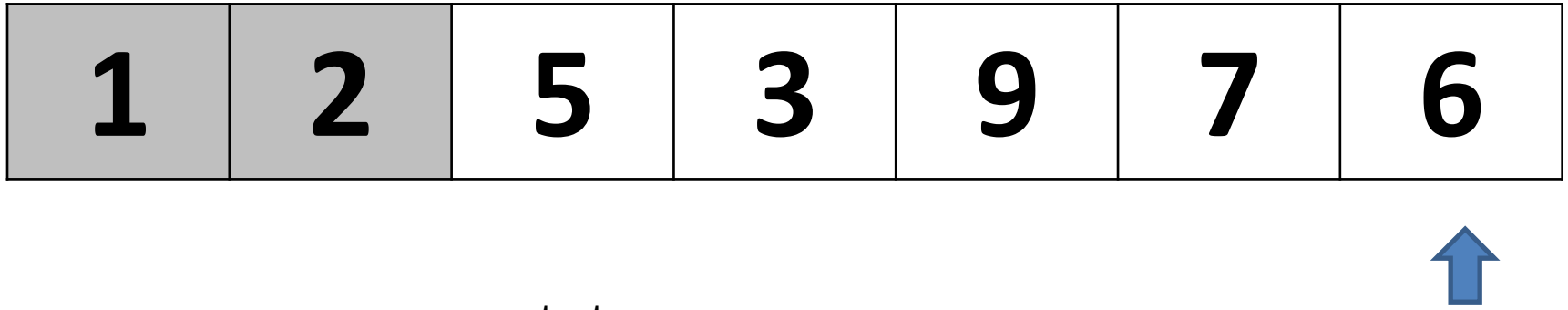
Goal: Find the minimum element

`minimum_so_far` = 3

2 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



start

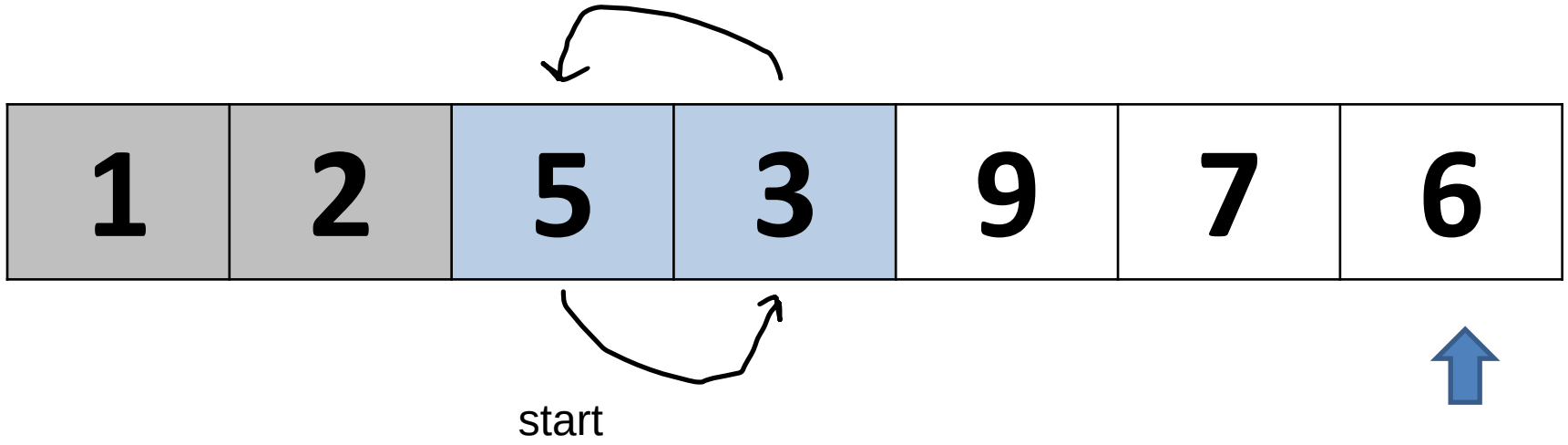
Goal: Find the minimum element

`minimum_so_far` = 3

2 is at the correct spot in the array now, so now we find the next lowest number

Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



Goal: Find the minimum element

`minimum_so_far` = 3

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Selection Sort

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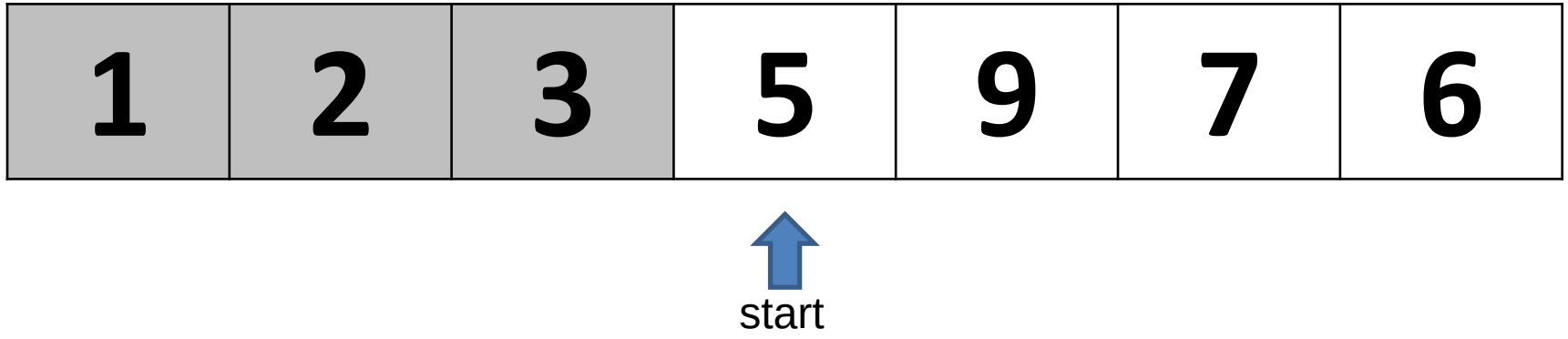

Goal: Find the minimum element

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Selection Sort

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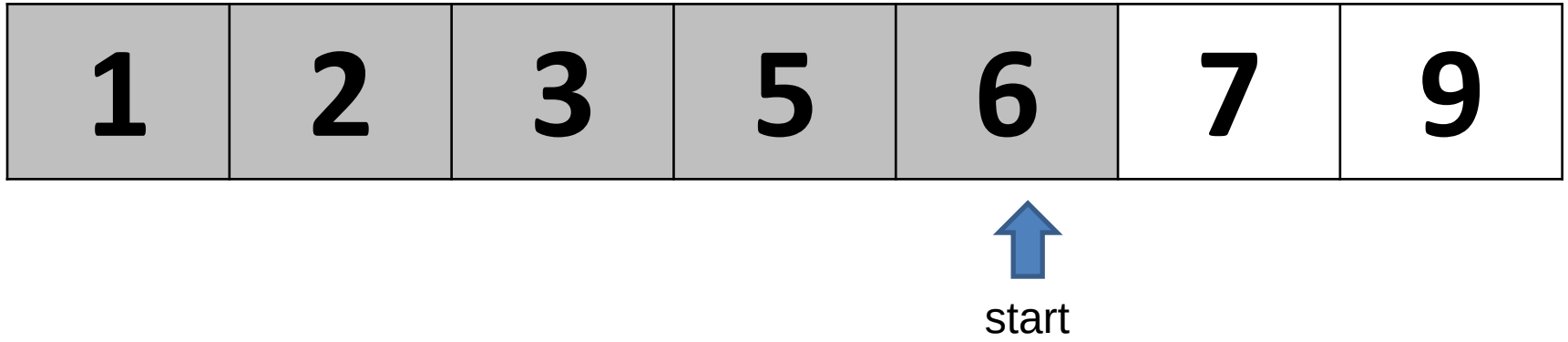
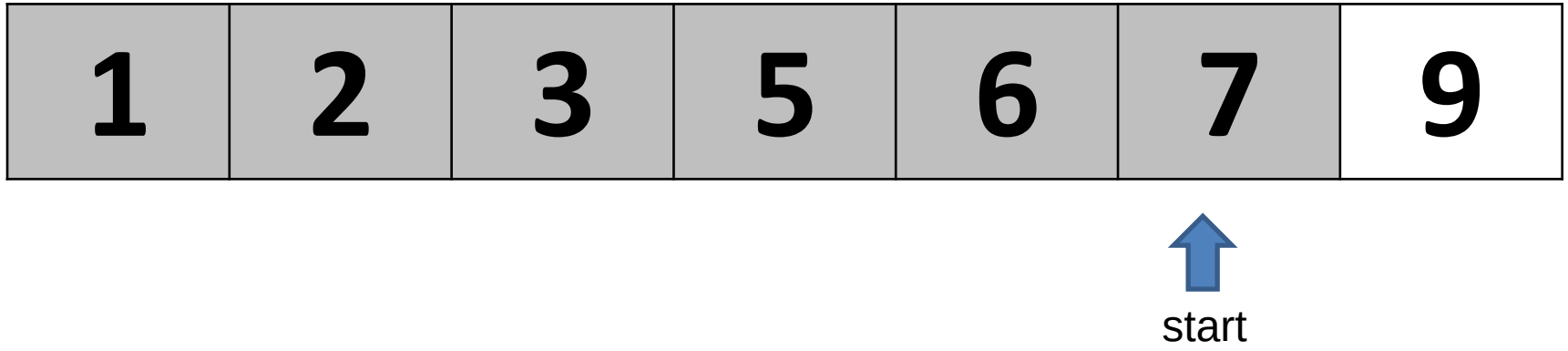


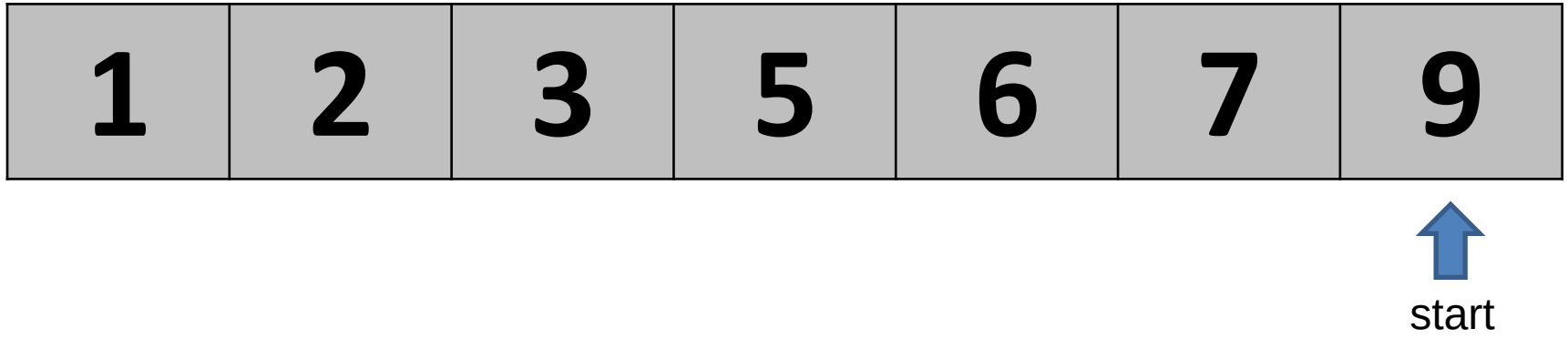
Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



Selection Sort

Iterate through the array N times, and during each iteration, **find the minimum element** and place it in the correct spot



Selection Sort

Selection Sort Gif

https://upload.wikimedia.org/wikipedia/commons/9/94/Selection-Sort-Animation.gif

Selection Sort

```
public void selectionSort(int[] array) {
  System.out.println("Input: " + Arrays.toString(array));
  int n = array.length;
  for(int i = 0; i < n -1; i++) {
     int min_index_so_far = i;
     for (int j = i + 1; j < n; j++) {
        if(array[j] < array[min_index_so_far]) {
          min_index_so_far = j;
        }
     }
     int temp = array[i];
     array[i] = array[min_index_so_far];
     array[min_index_so_far] = temp;
  }
  System.out.println("Output: " + Arrays.toString(array));
}
```

Running time?

Selection Sort

```
public void selectionSort(int[] array) {
  System.out.println("Input: " + Arrays.toString(array));
  int n = array.length;
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          min_index_so_far = j;
        }
     }
     int temp = array[i];
     array[i] = array[min_index_so_far];
     array[min_index_so_far] = temp;
  }
  System.out.println("Output: " + Arrays.toString(array));
}
```

O(1)
O(1)
O(n)
O(1)
O(n)
O(1)
O(1)
O(1)
O(1)
O(1)

Running time?

Selection Sort

```
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        if(array[j] < array[min_index_so_far]) {
          min_index_so_far = j;
        }
     }
     int temp = array[i];
     array[i] = array[min_index_so_far];
     array[min_index_so_far] = temp;
  }
  System.out.println("Output: " + Arrays.toString(array));
}
```

O(1) O(n) O(1) O(n) O(1) O(1) O(1) O(1) O(1)

Running time?

$O(n^2)$

n = # of elements in array