CSCI 132:
Basic Data Structures and Algorithms

Sorting (Bubble Sort)

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Spring 2024

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

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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

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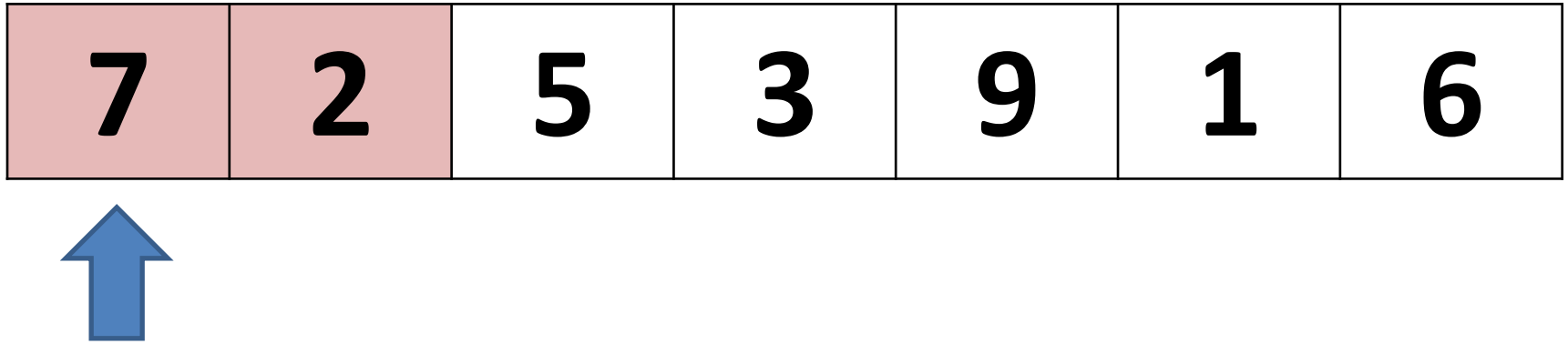

Is 7 greater than 2? → SWAP

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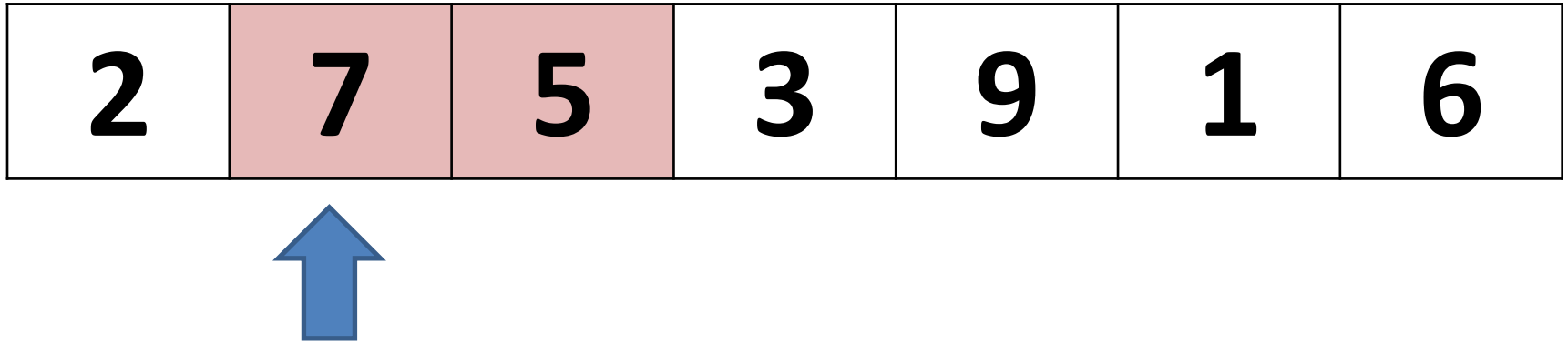

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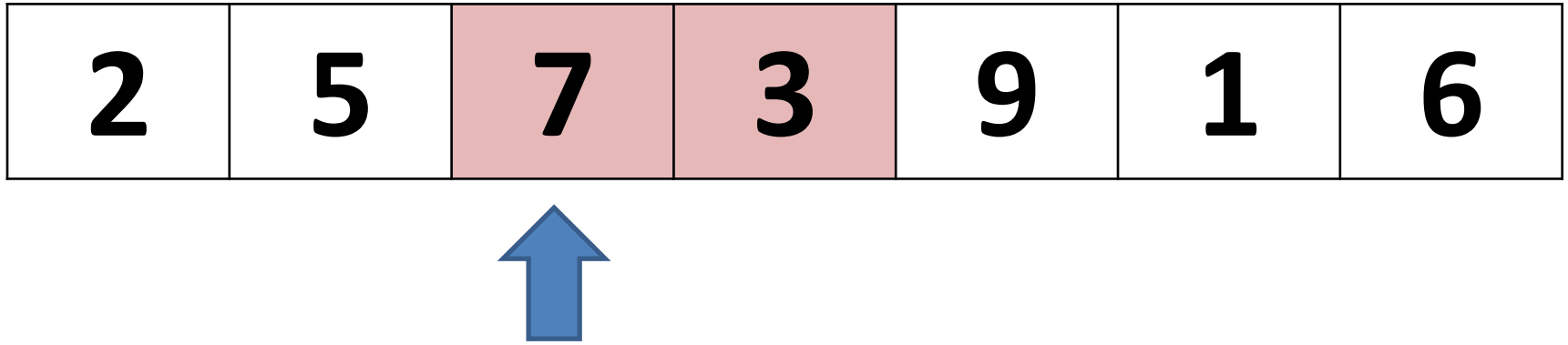

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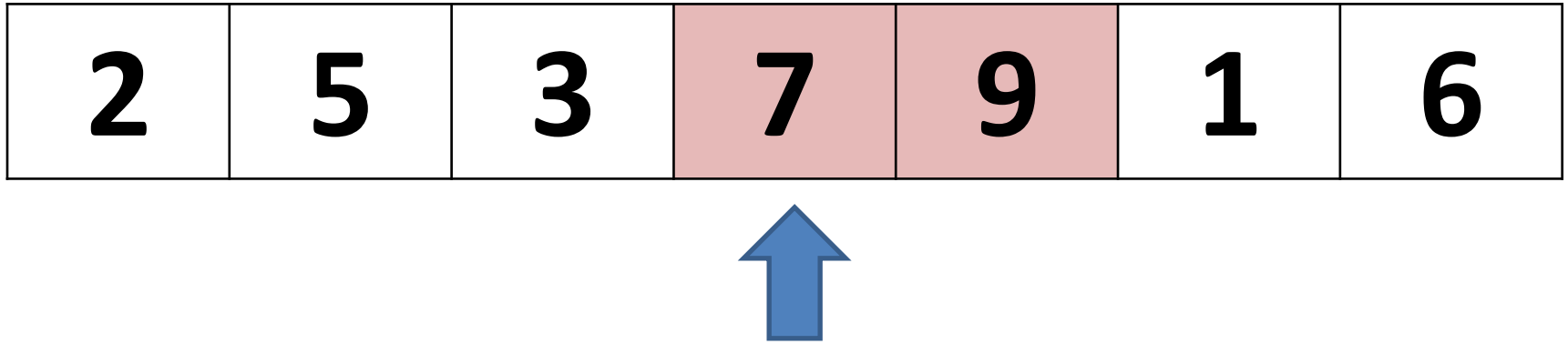

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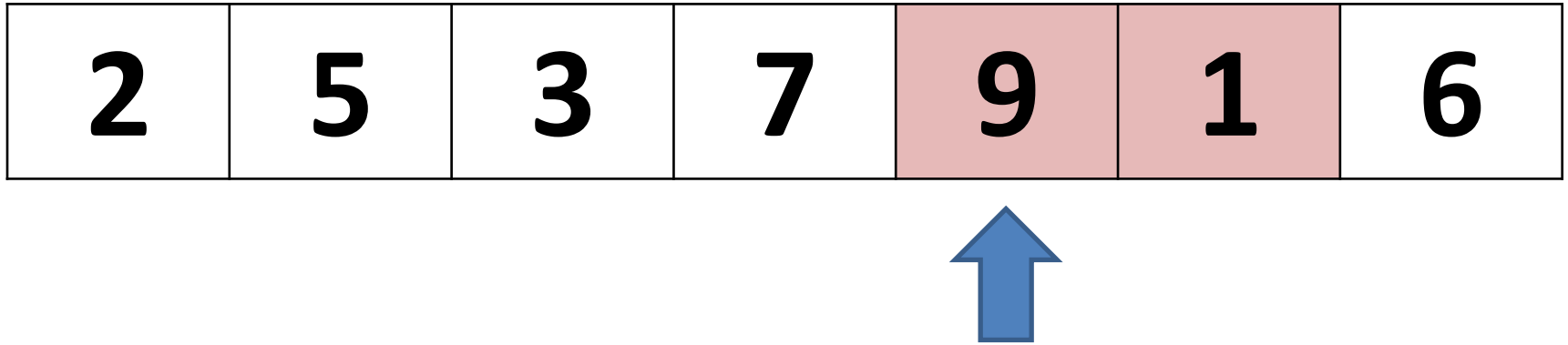

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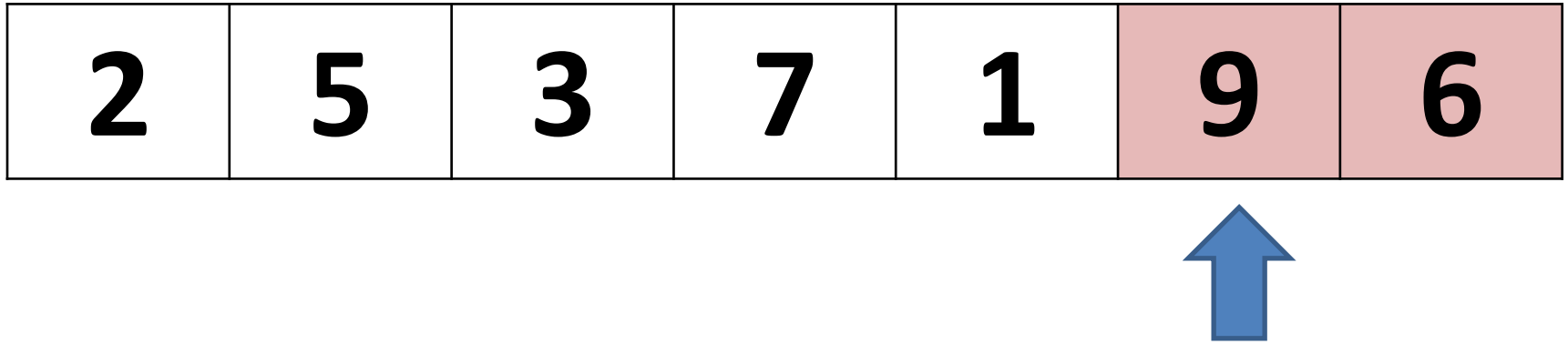

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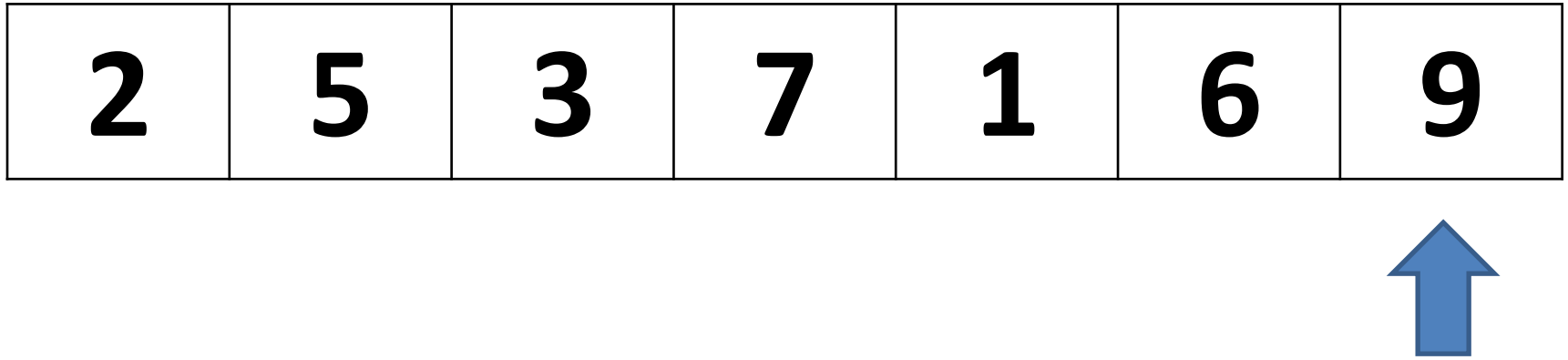

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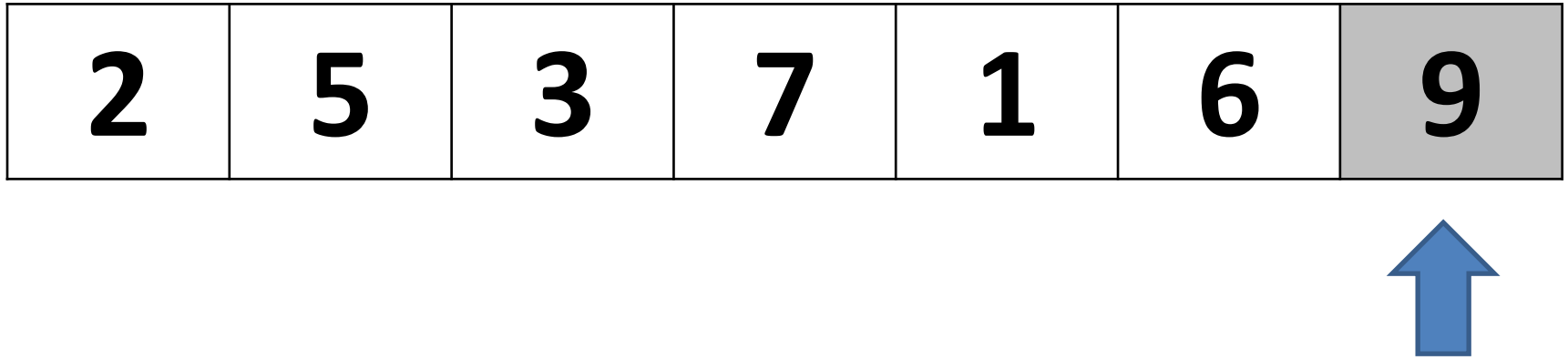

At this point, 9 (the biggest number) is at the correct spot in the array.

So, we no longer need to check that index!

Bubble Sort

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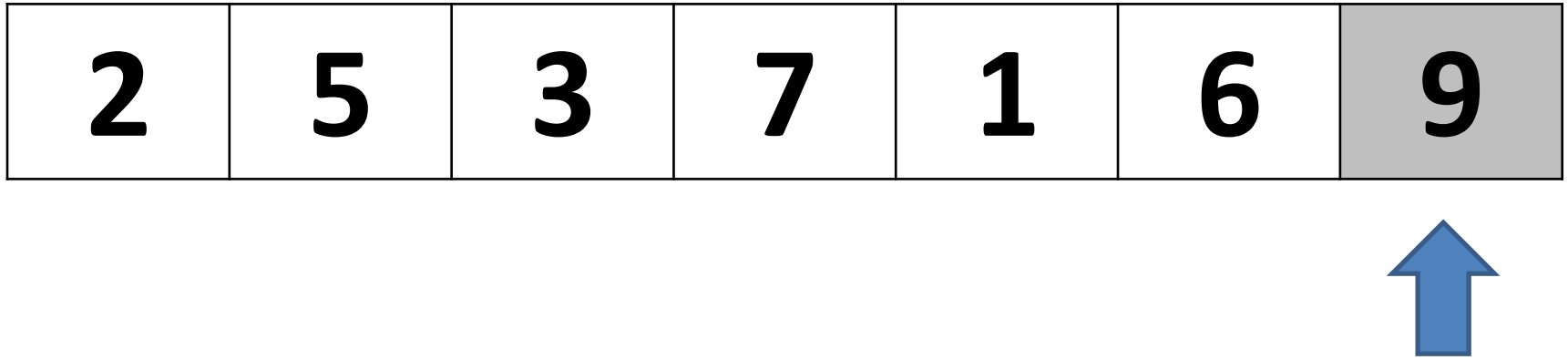

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Bubble Sort → “The biggest bubbles rise to the top naturally”

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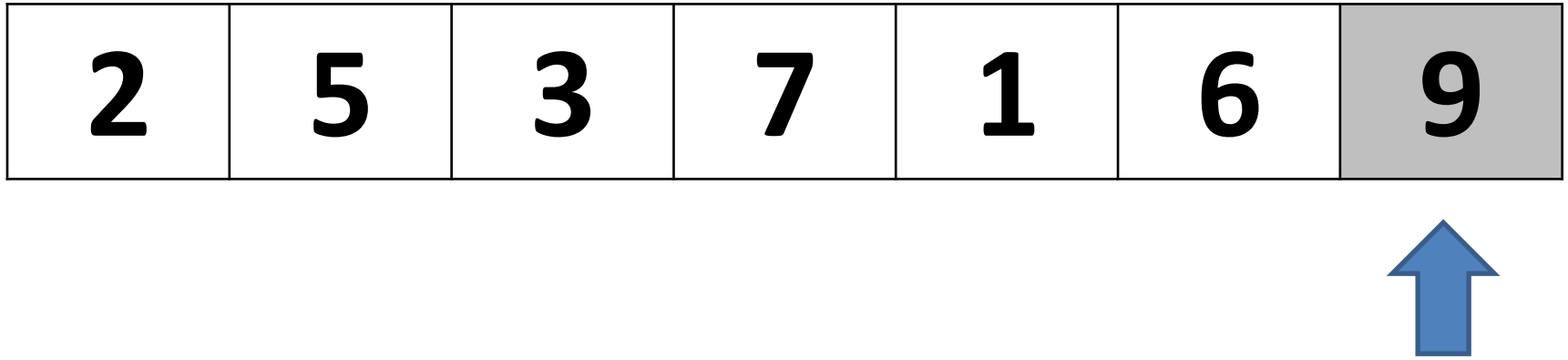

At this point, 9 (the biggest number) is at the correct spot in the array.

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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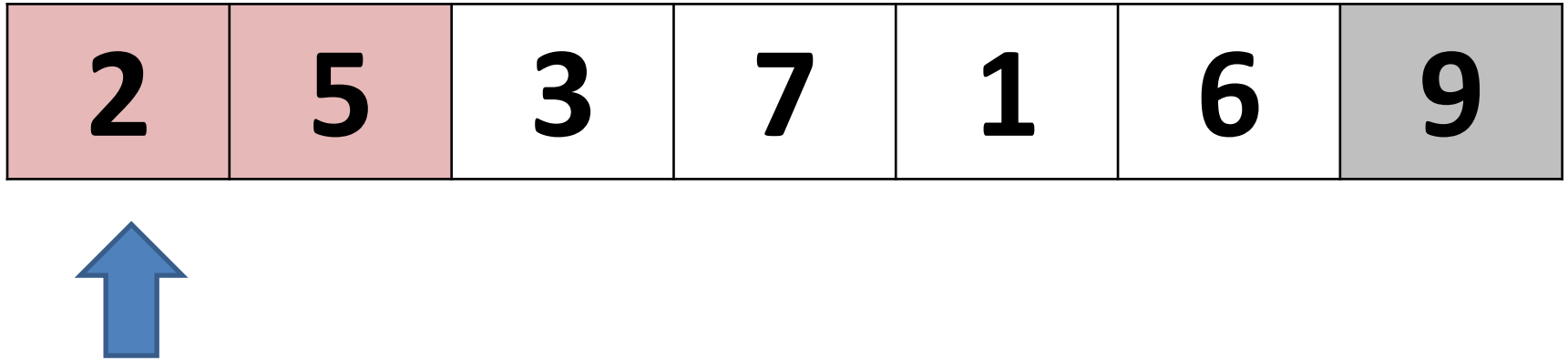

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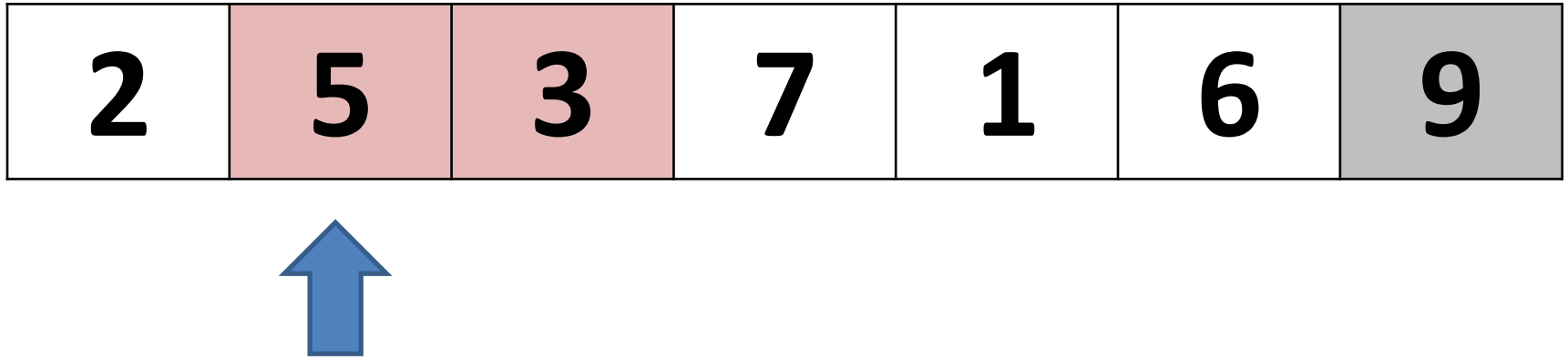

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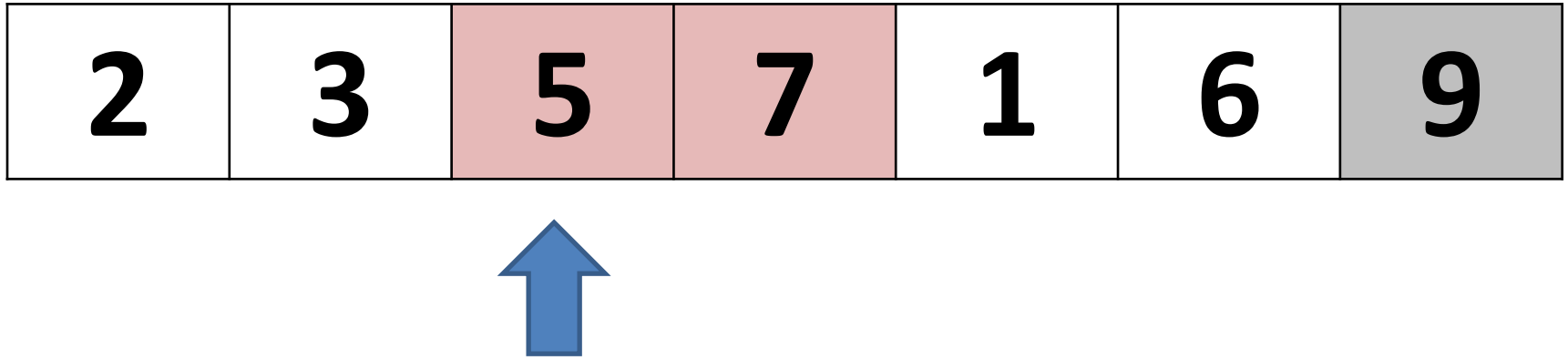

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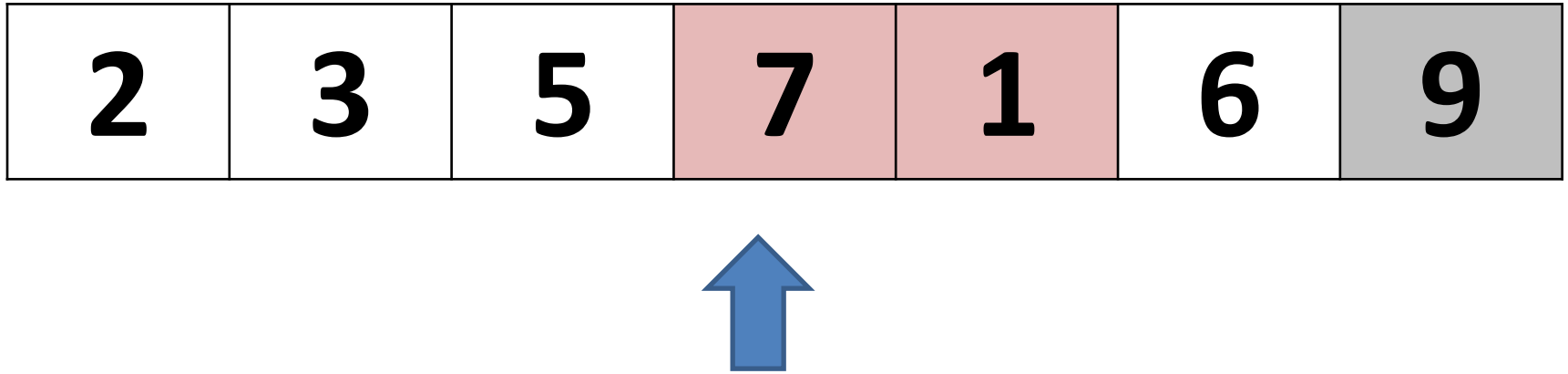

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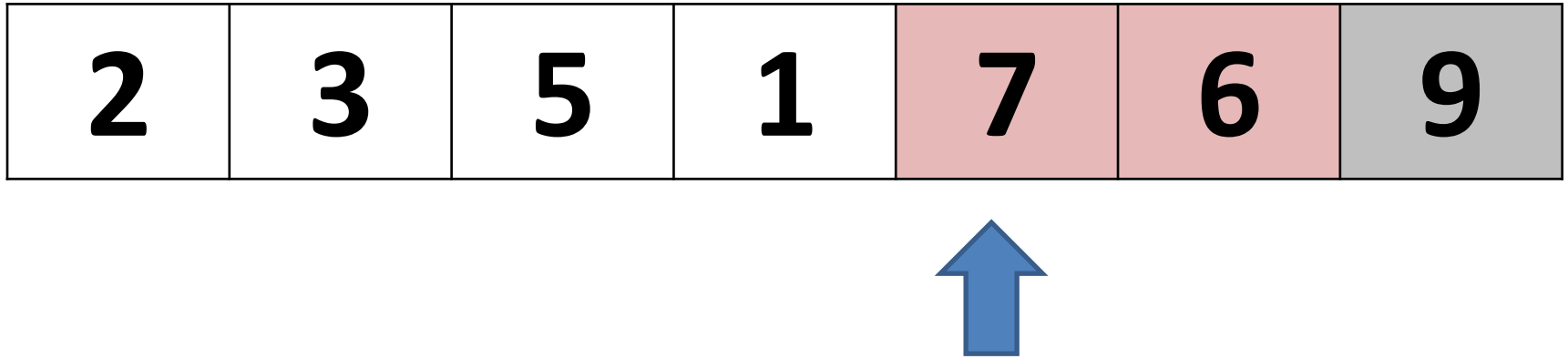

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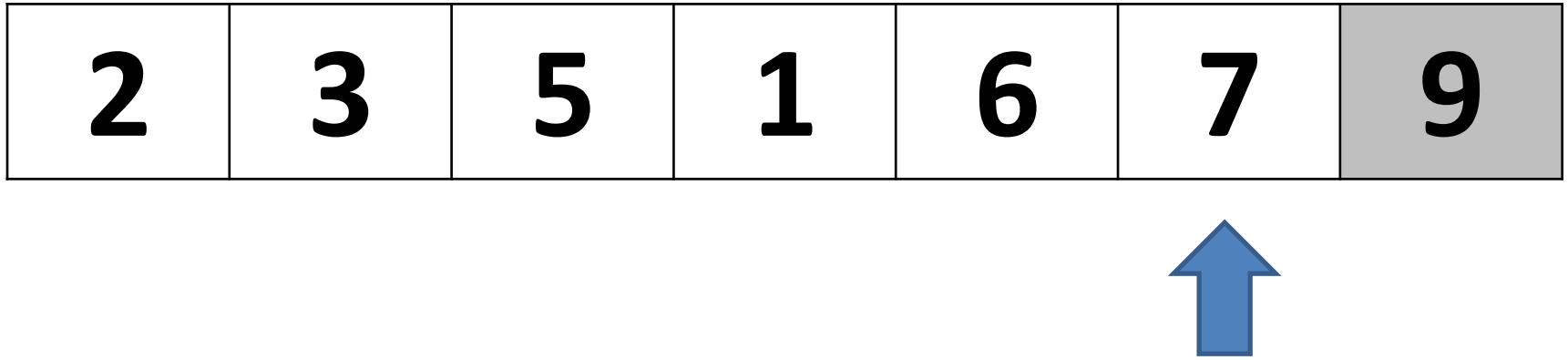

7 is now in the correct spot of the array

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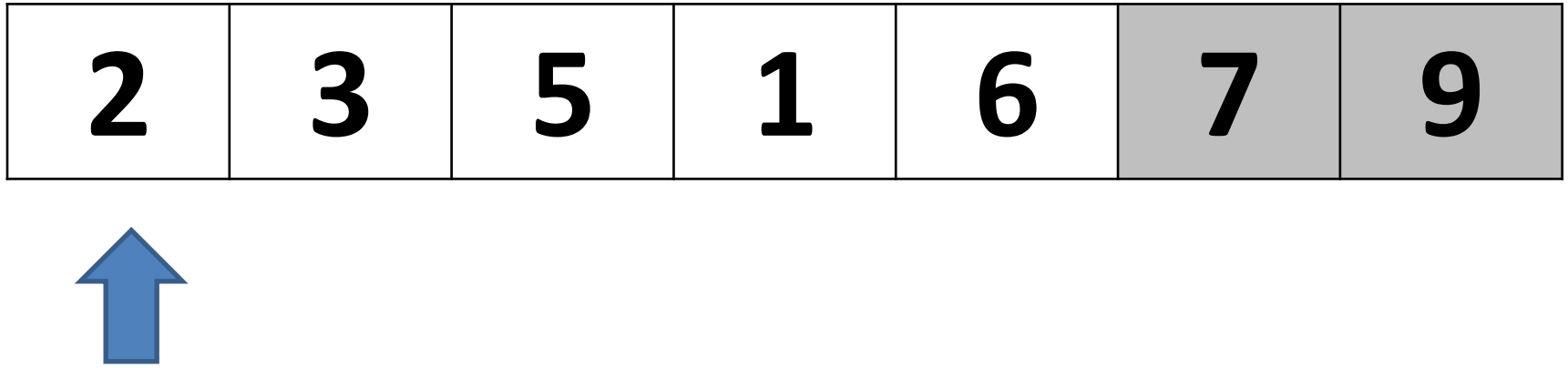

Repeat again!

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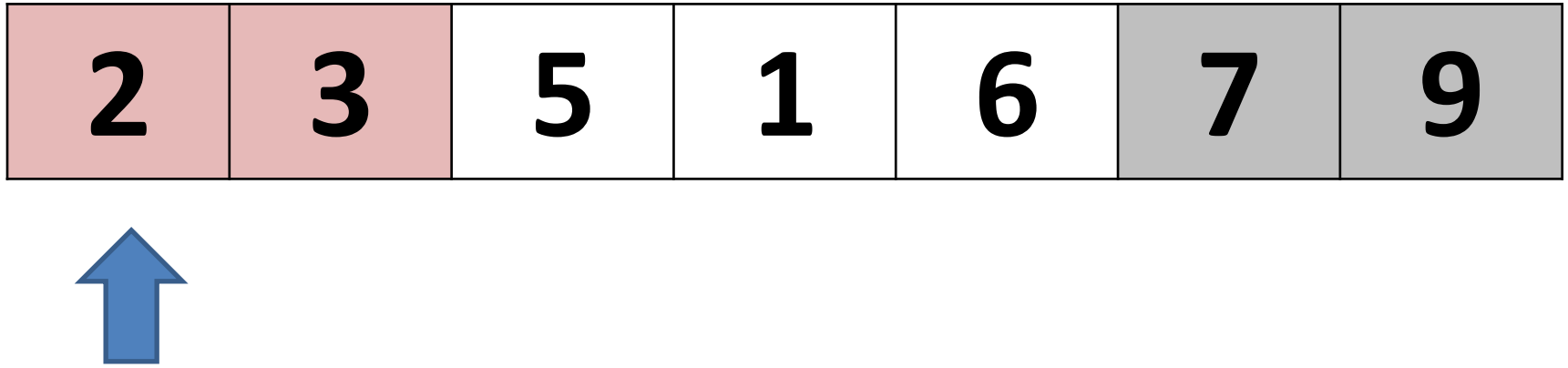

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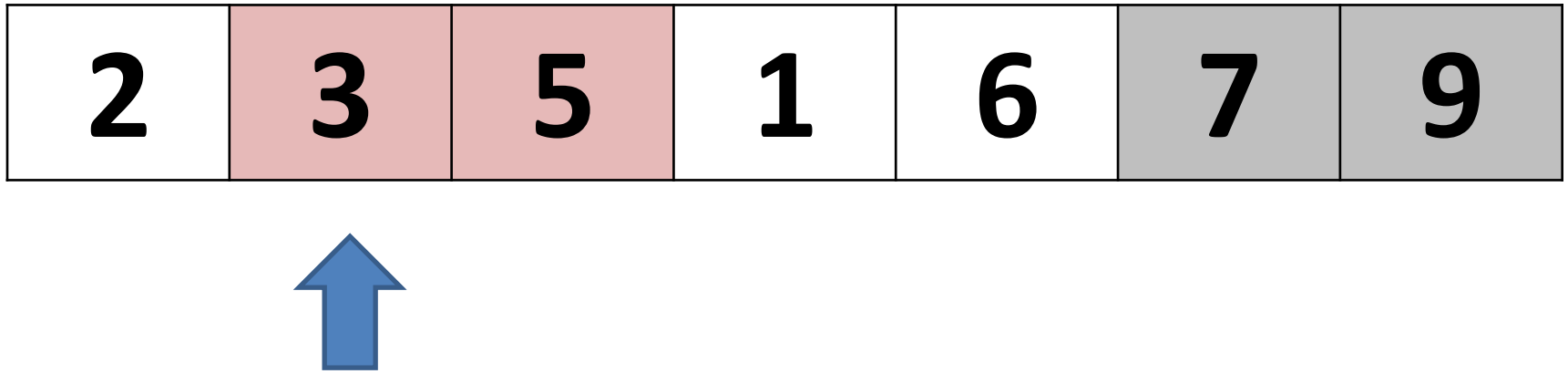

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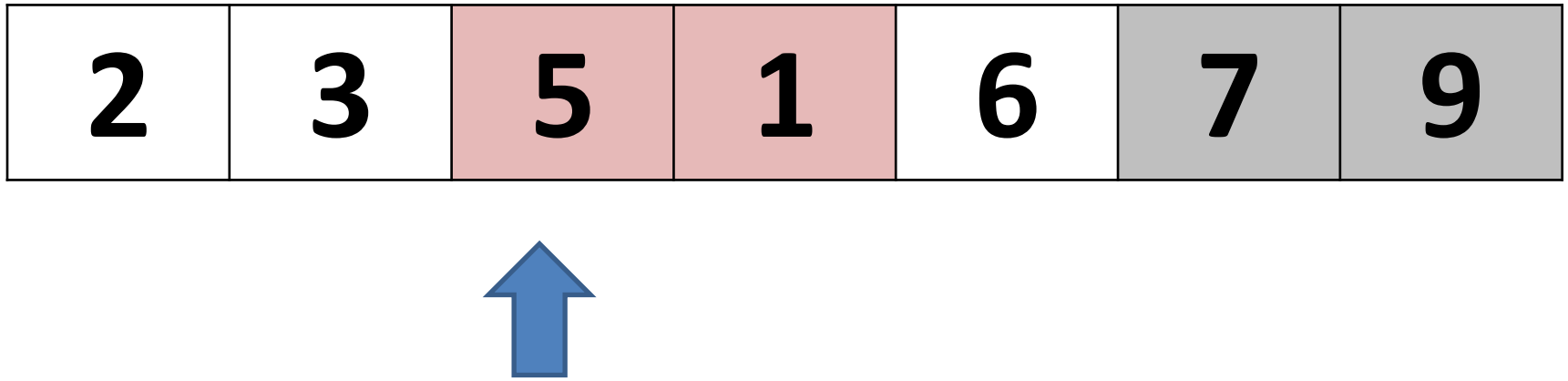

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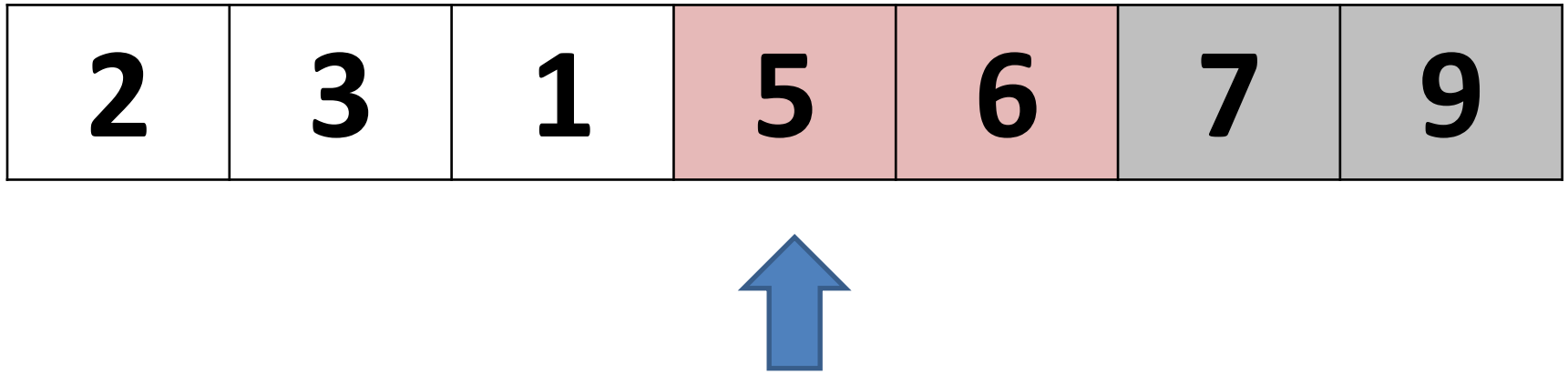

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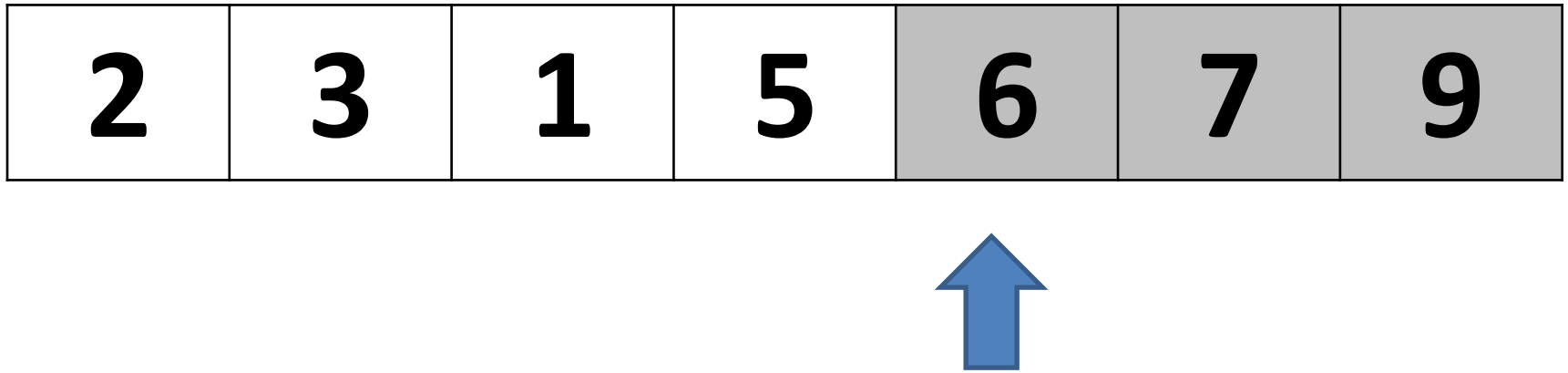

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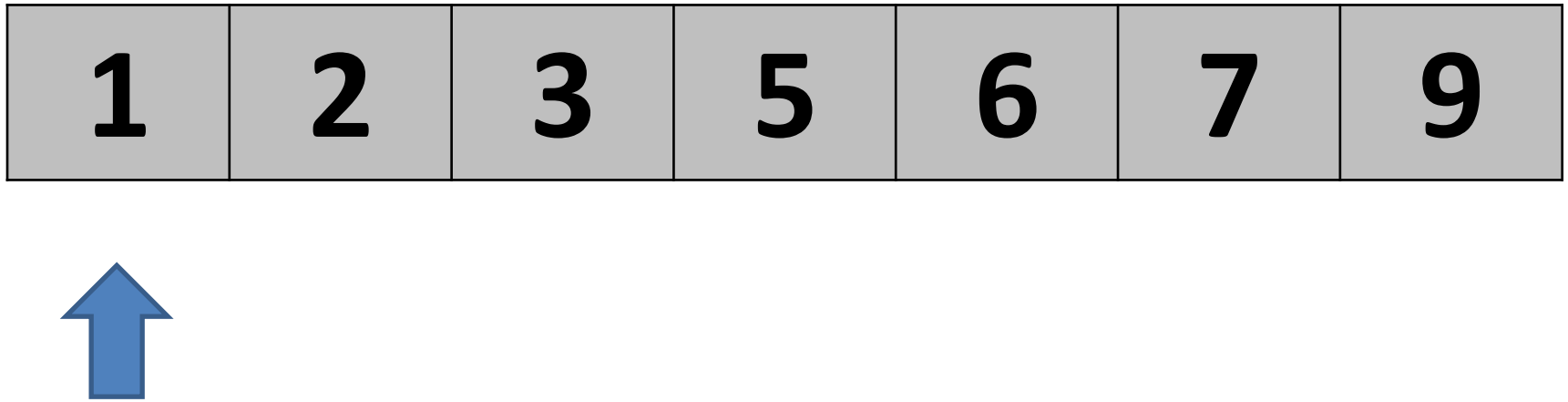

(fast forwarding….)

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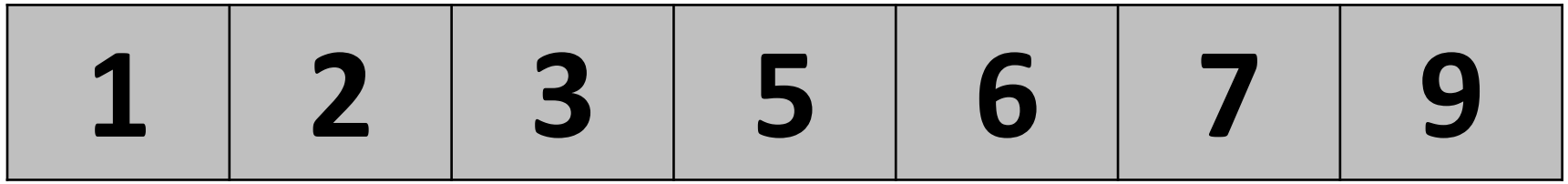

All done!

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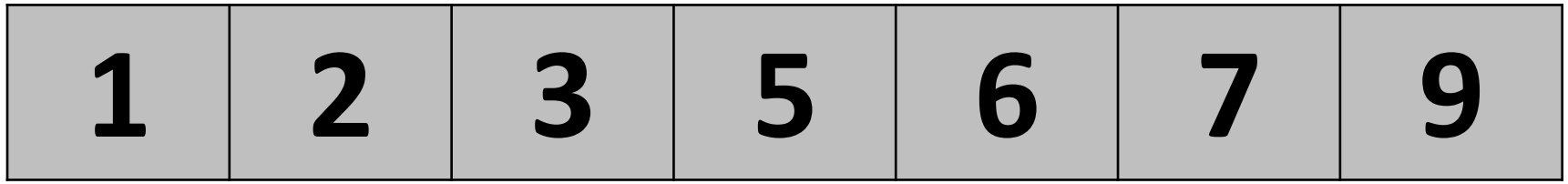

All done!

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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    }
}
```

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)
        for(int j = 0; j < n - i - 1; j++) { O(n)
            if( array[j] > array[j + 1]) {  O(1)
                //swap
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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

Bubble Sort (Recursion)

Base Case:

If we have one array element left to sort, return

Recursive case:

Do one loop of bubble sort, call the method again and pass the array except for the last element (last element is already in place!)

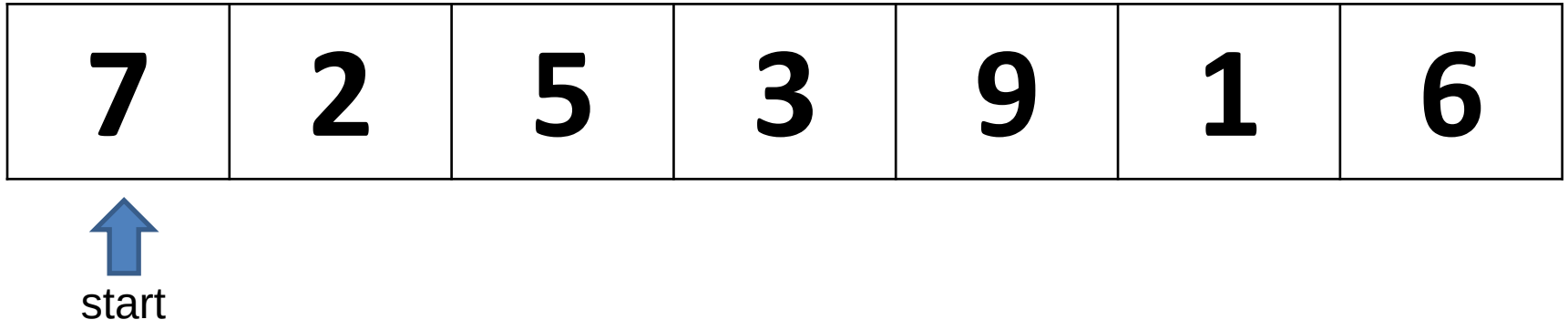
Bubble Sort (Recursion)

```
public void bubbleSortRecursion(int[] array, int n) {
        if (n == 1) {
                return;
        }
        for(int i = 0; i < n -1;i++) {
                if(array[i] > array[i+1]) {
                        int temp = array[i];
                        array[i] = array[i+1];
                        array[i+1] = temp;
                }
        }
        bubbleSortRecursion(array,n-1);
}
```

n = size of unsorted section of array

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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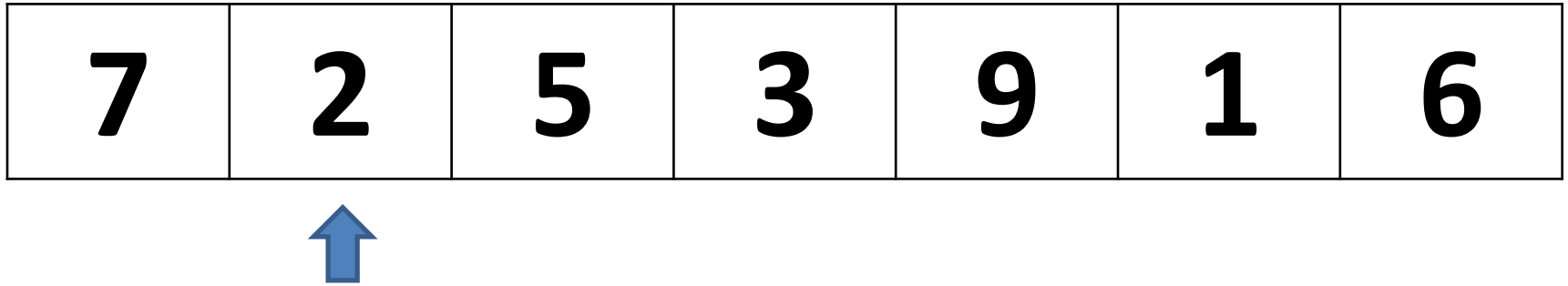

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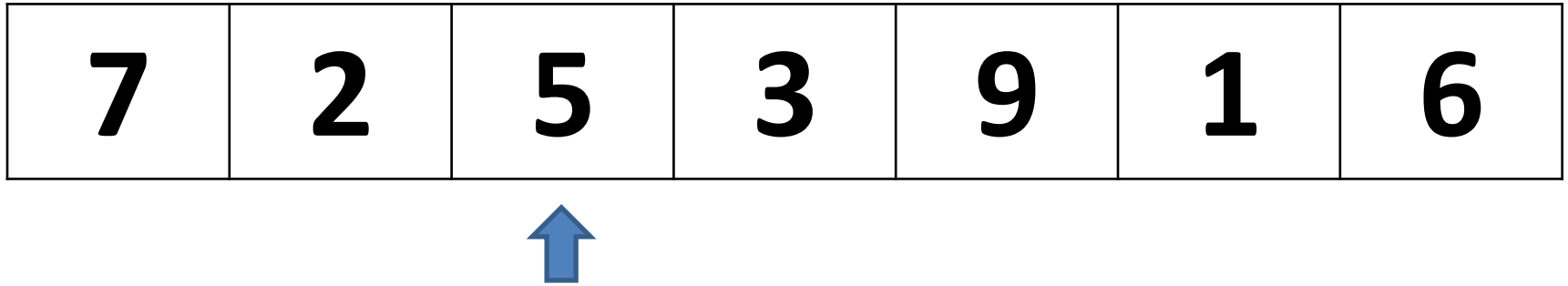


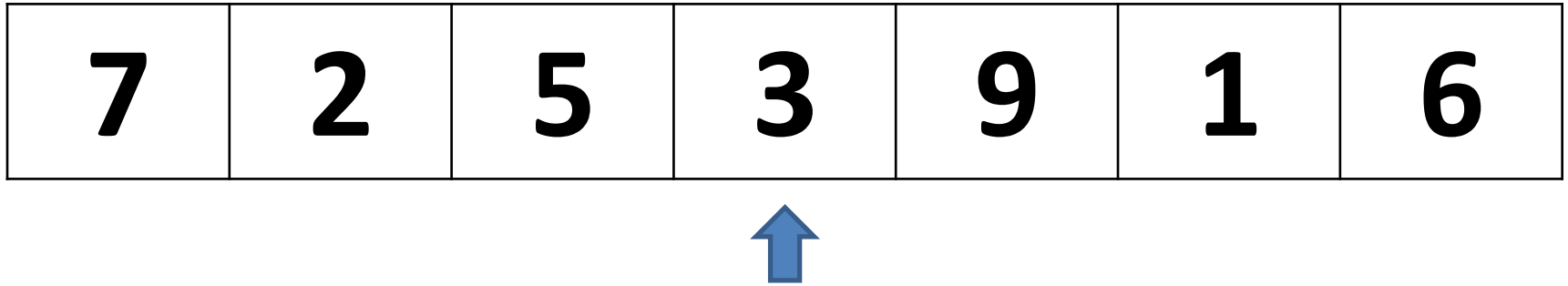
start

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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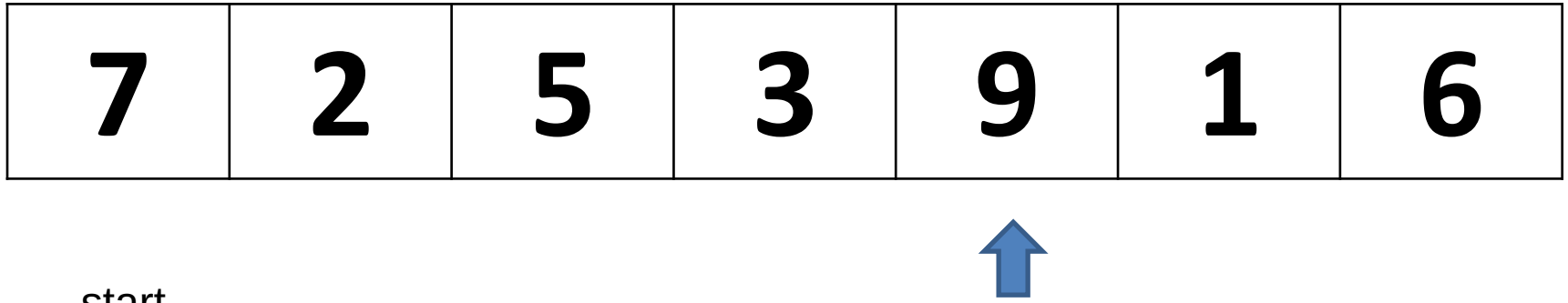

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Goal: Find the minimum element

`minimum_so_far` = 2

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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` = 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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start

Goal: Find the minimum element

`minimum_so_far` = 1

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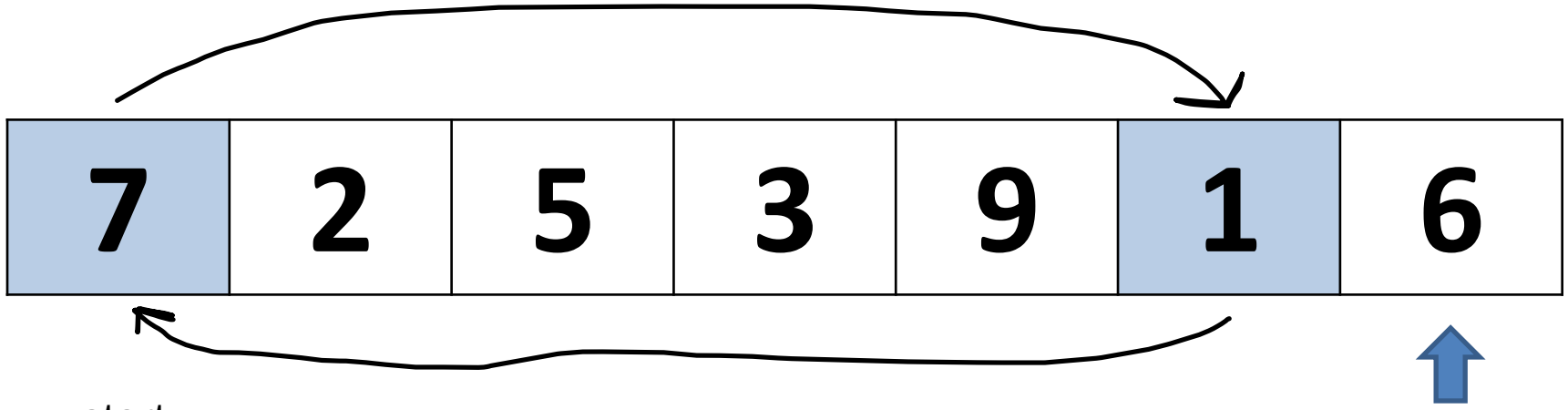

Goal: Find the minimum element

`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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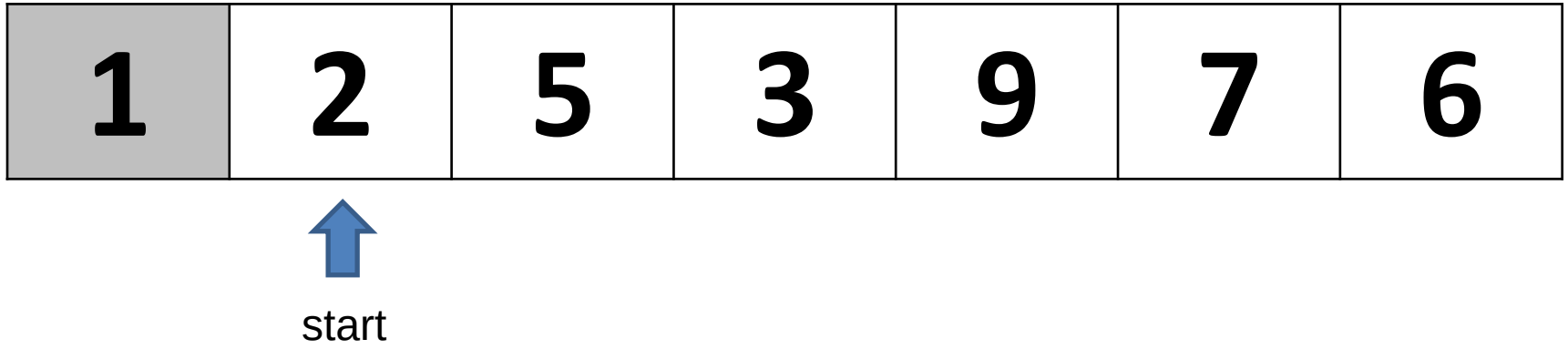


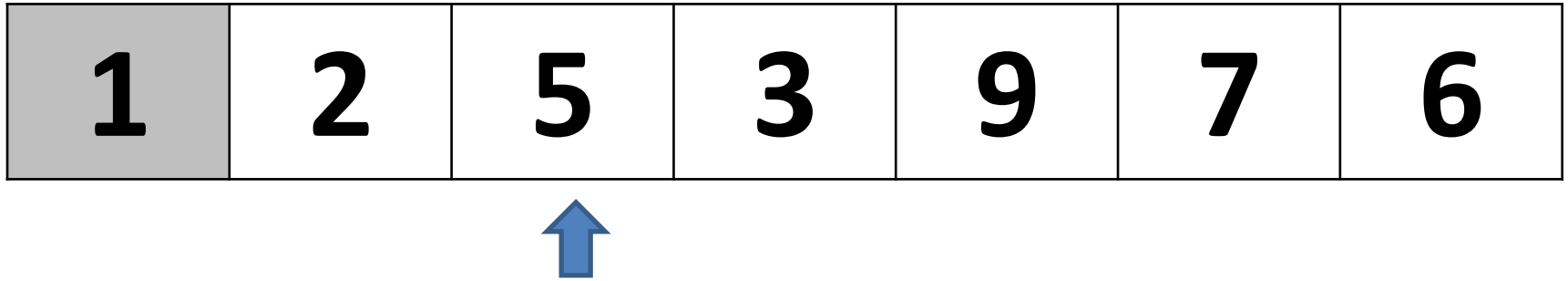
Goal: Find the minimum element

`minimum_so_far` = 2

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

Selection Sort

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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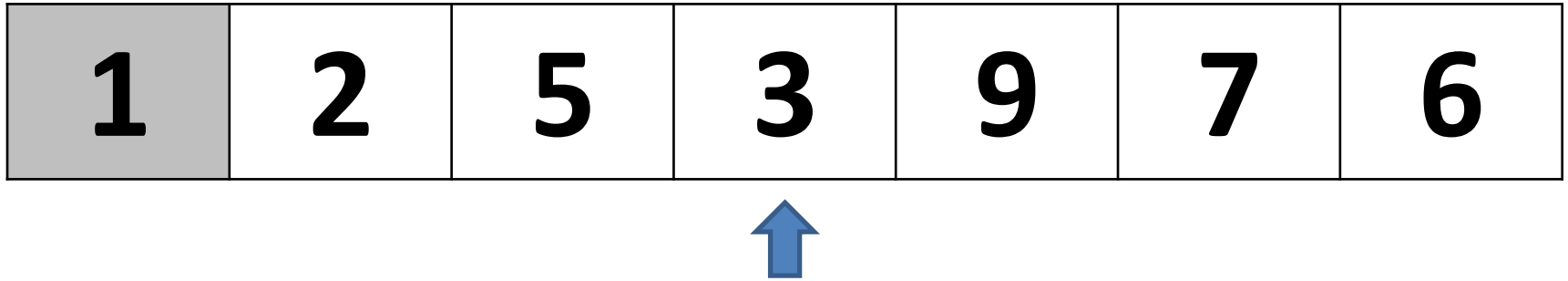

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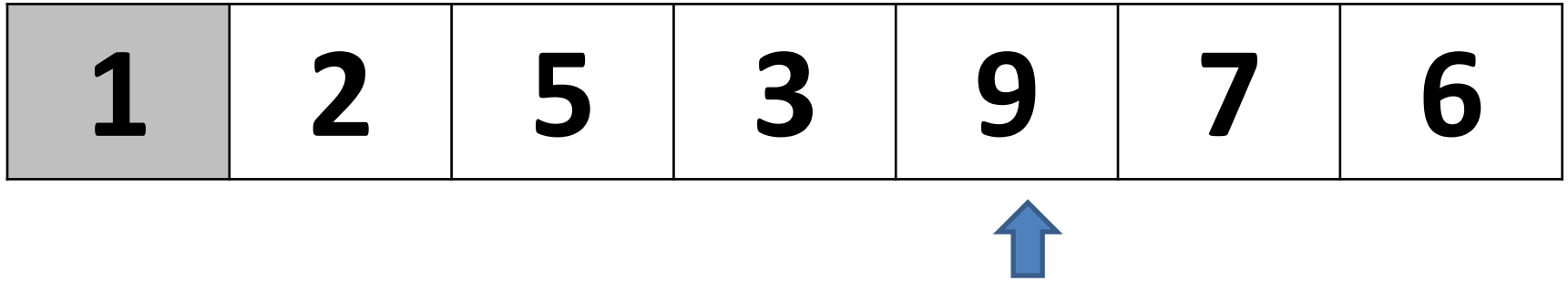

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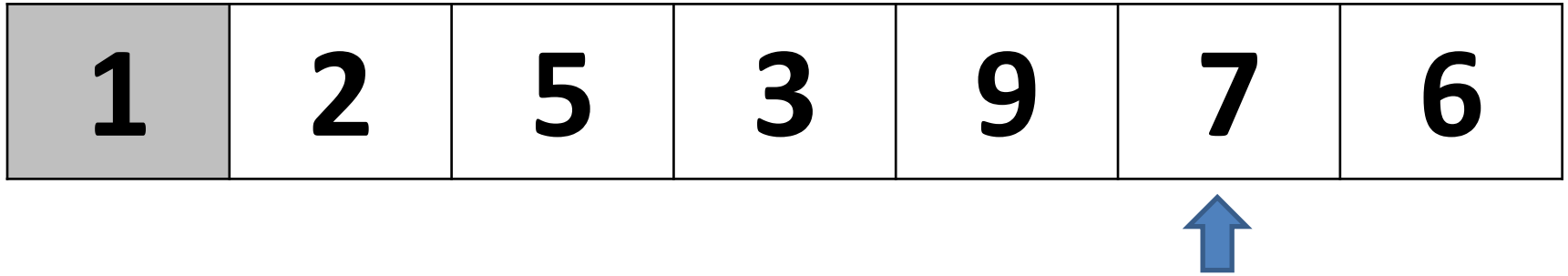
Selection Sort

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



start

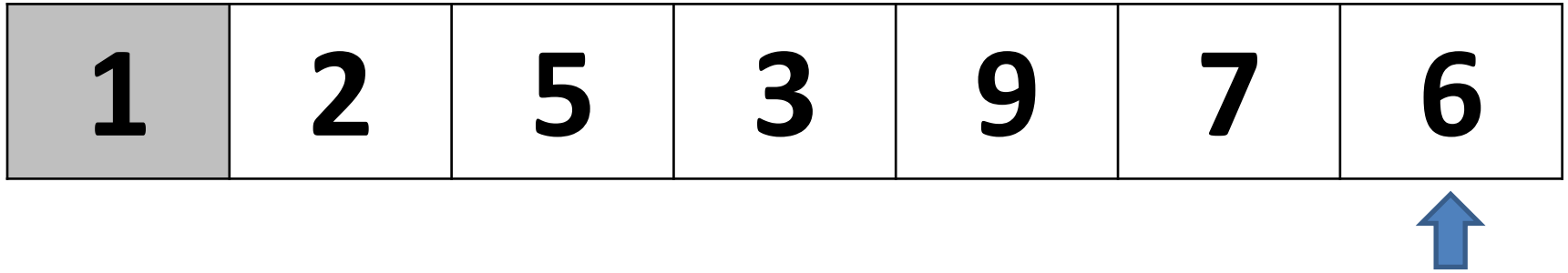
Goal: Find the minimum element

`minimum_so_far` = 2

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



start

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

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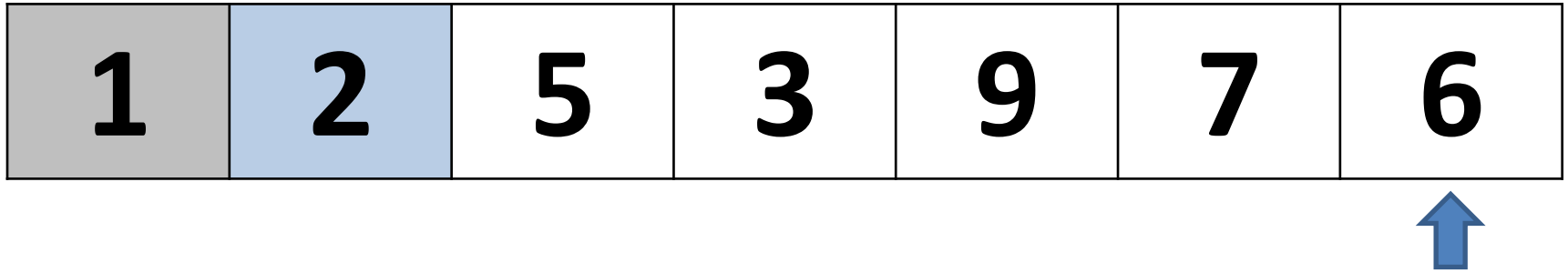


start

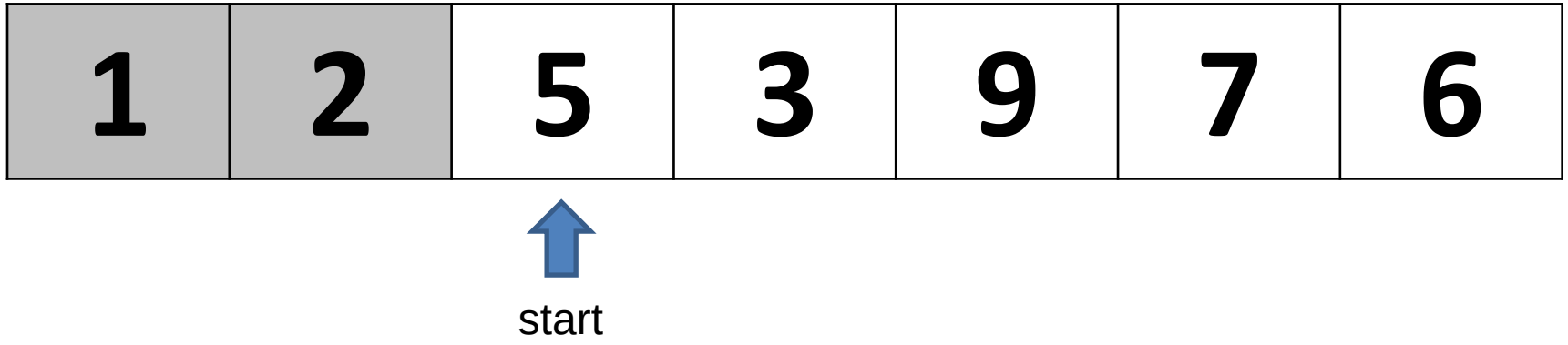
Goal: Find the minimum element

`minimum_so_far` = 2

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

Selection Sort

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



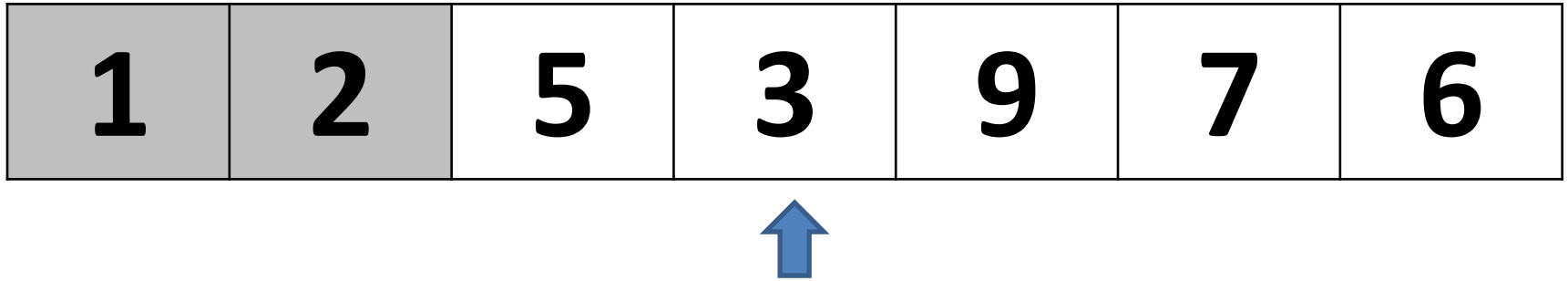
Goal: Find the minimum element

`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

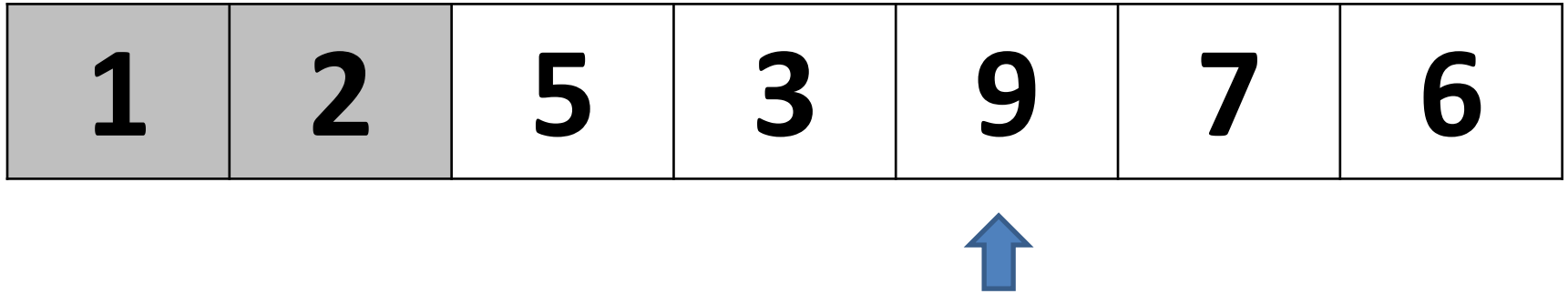
Goal: Find the minimum element

`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

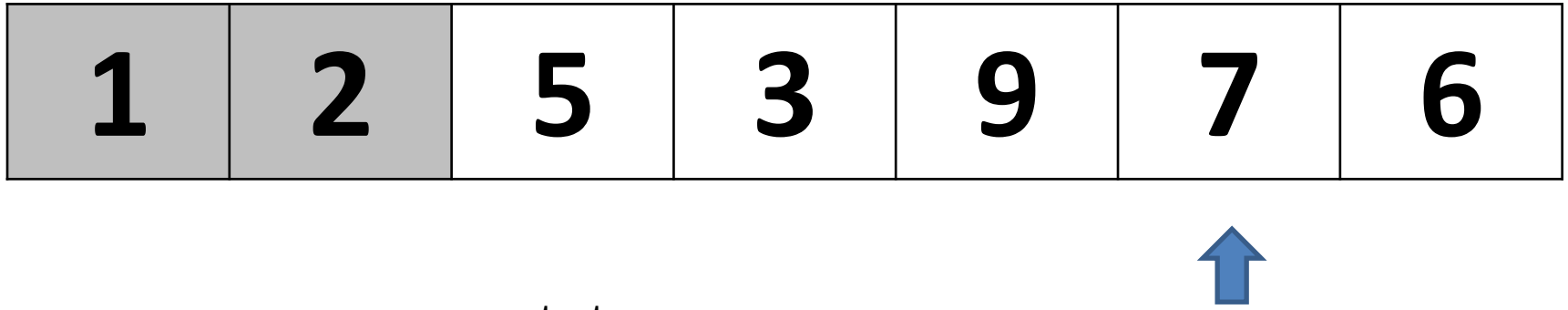
Goal: Find the minimum element

`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

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Selection Sort

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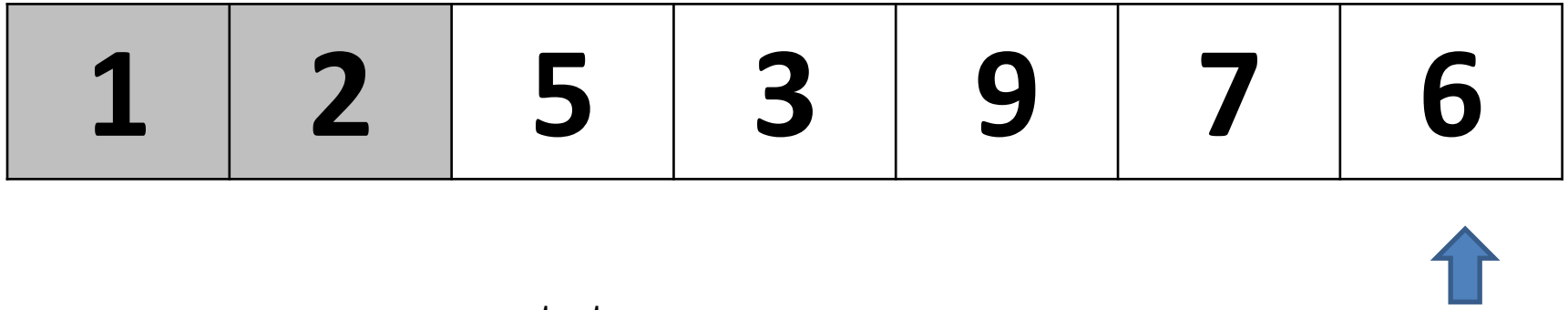

start

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

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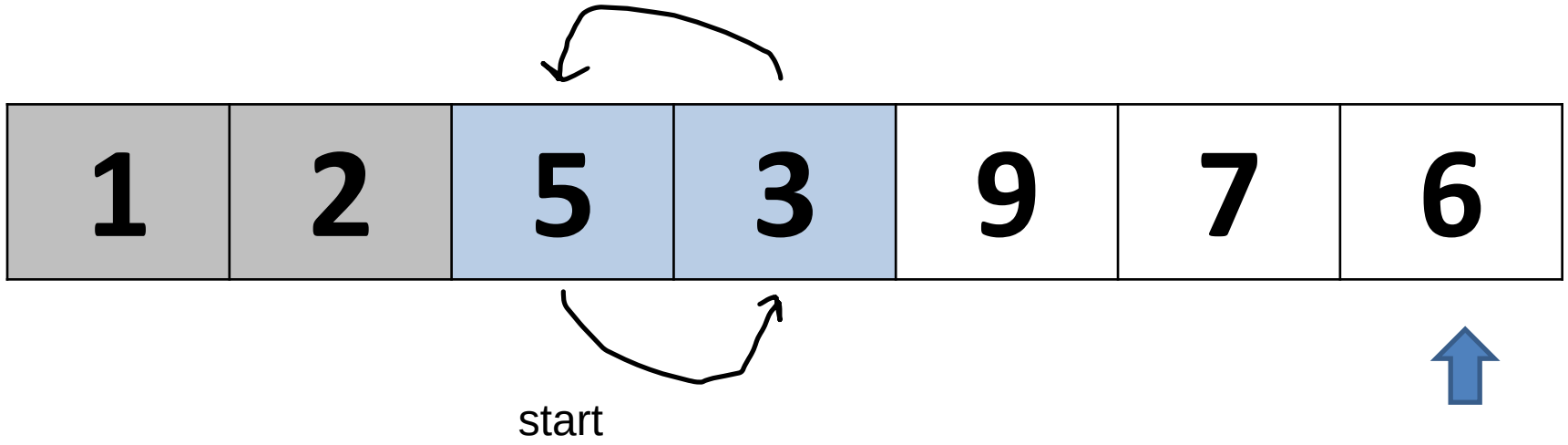

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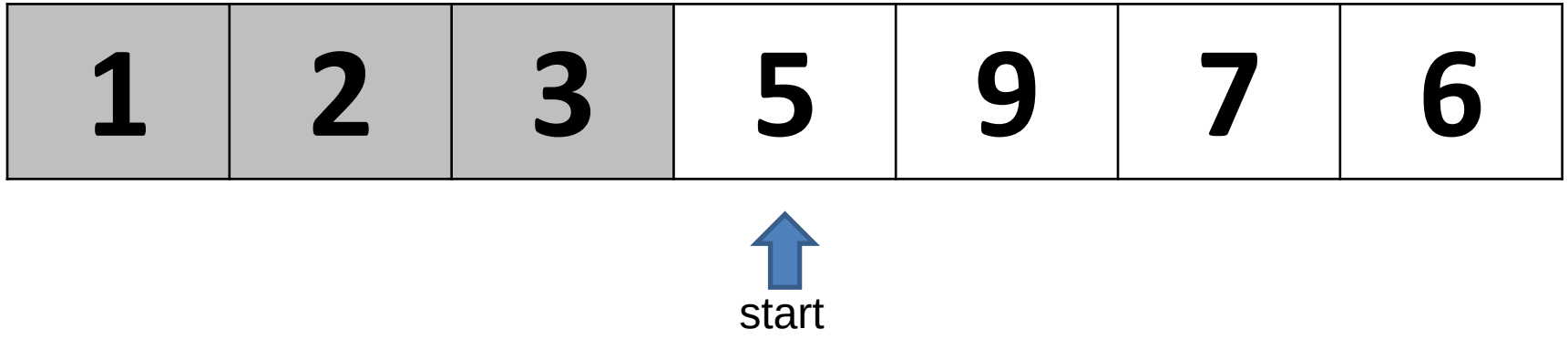

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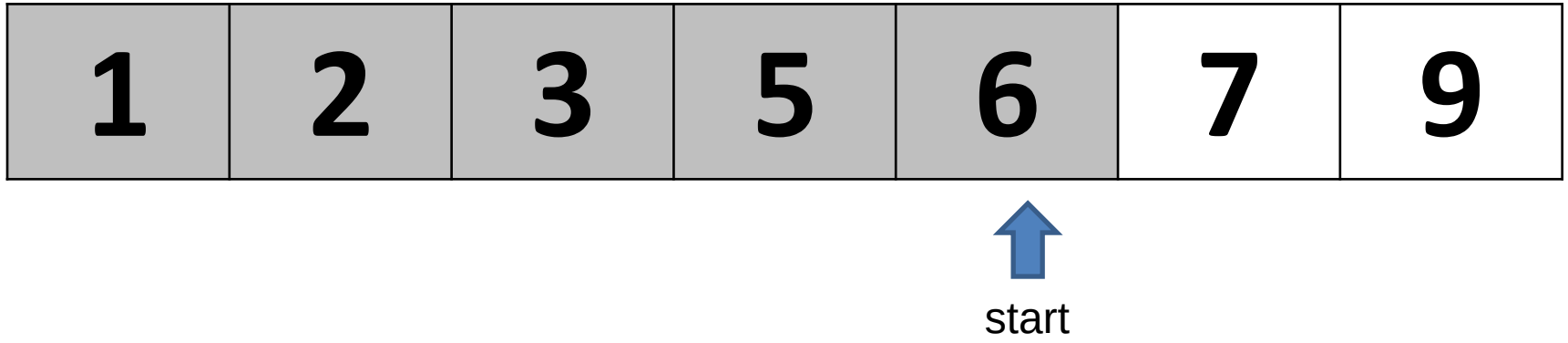

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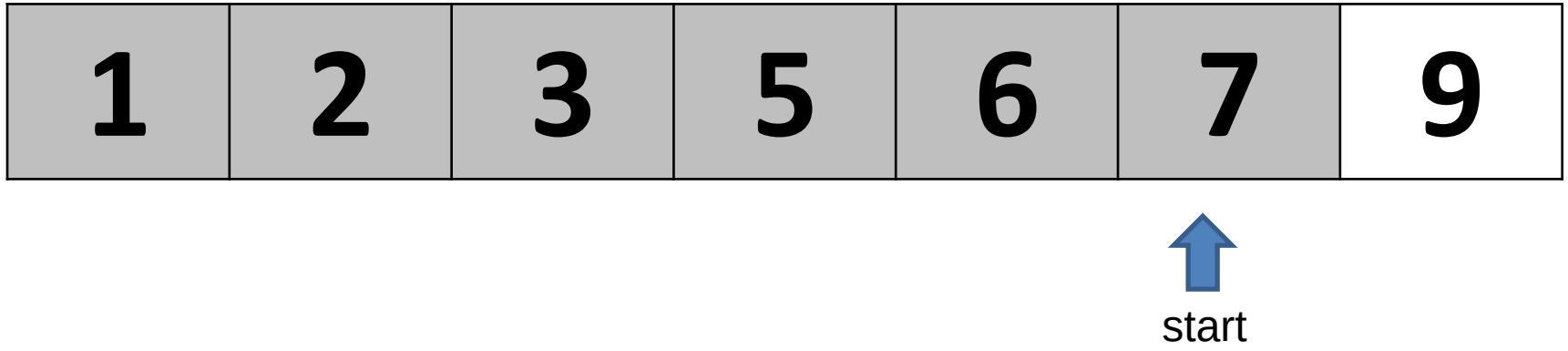

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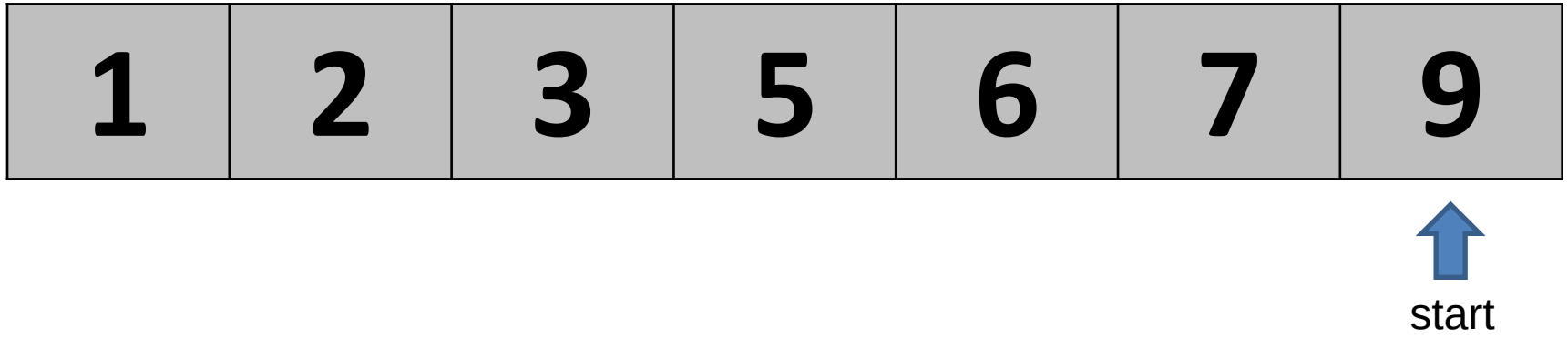

Selection Sort

Selection Sort Gif

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