SORTING

COP 3502

Sorting a List

- Let's say we have a list of the names of people in the class and we want to sort alphabetically
  - We are going to describe an algorithm (or systematic methods) for putting these names in order
  - The algorithms we will cover today:
    - **Selection Sort   Insertion Sort   Bubble Sort**

Sorting a List

- **<u>Selection Sort</u>**
  - Finds the smallest element (alphabetically the closest to a)
    - Swaps it with the element in the first position
  - Then finds the second smallest element
    - Swaps it with the element in the second position
  - Etc. until we get to the last position, and then we're done!

BOB

JOE

ABE

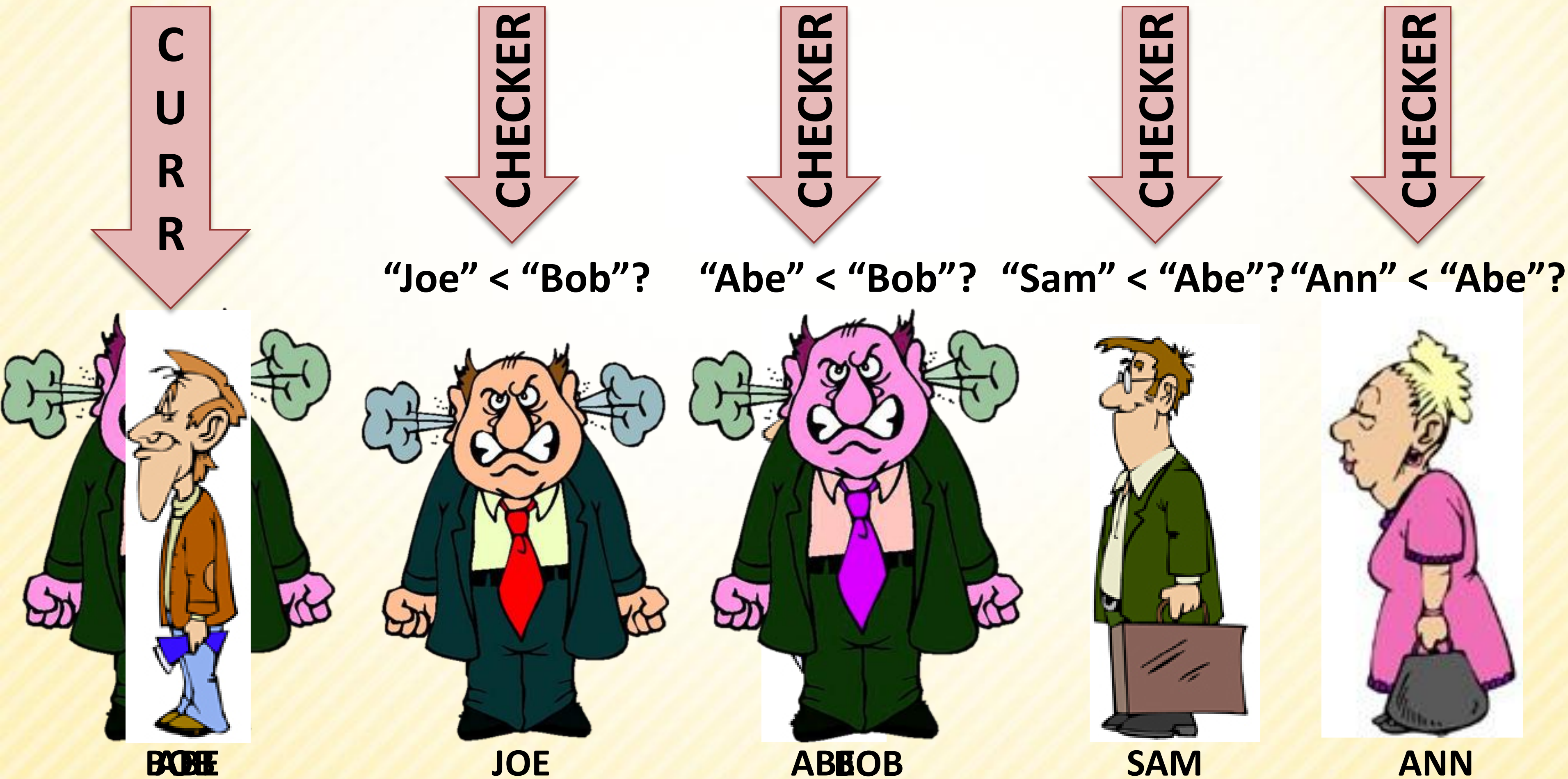
SAM

ANN

Sorting a List

- **Selection Sort**

Min = “Abe”



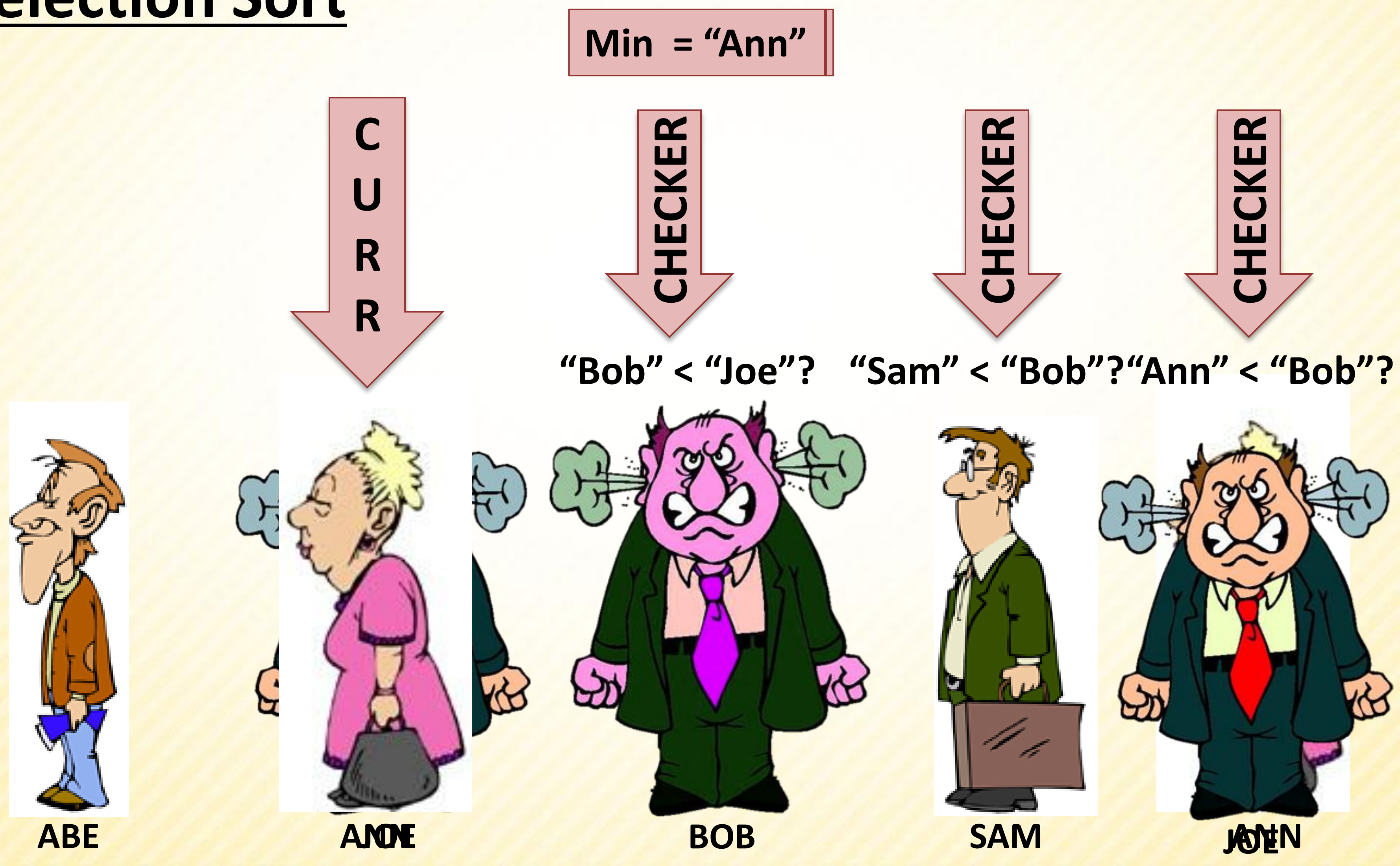
Sorting a List

- **<u>Selection Sort</u>**
  - Finds the smallest element (alphabetically the closest to a)
    - Swaps it with the element in the first position
  - Then finds the second smallest element
    - Swaps it with the element in the second position
  - Etc. until we get to the last position, and then we’re done!

ABE **JOE** **BOB** **SAM** **ANN**

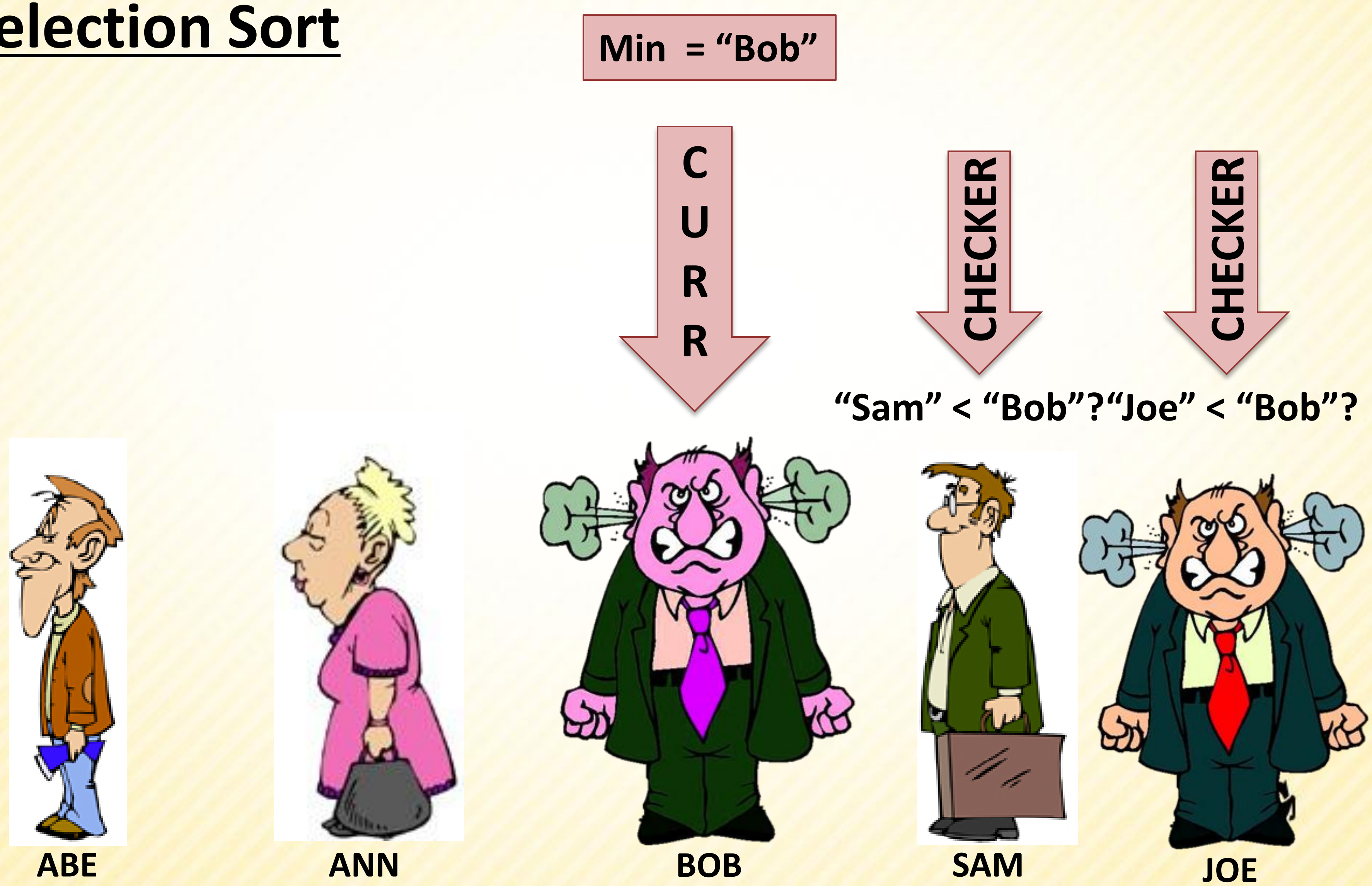
Sorting a List

- <u>Selection Sort</u>



Sorting a List

- **<u>Selection Sort</u>**



Sorting a List

- **Selection Sort**

Min = “Joe”

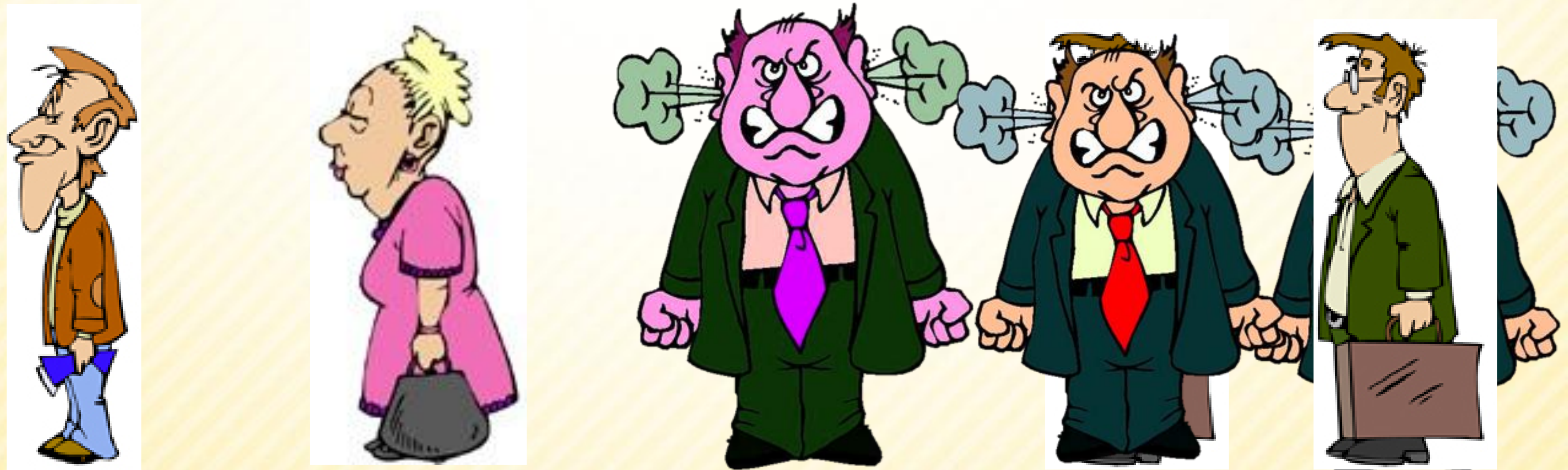
Notice that now the list is ***sorted***!

So we can stop when **Curr** is on the 2nd to last element.

CURR

CHECKER

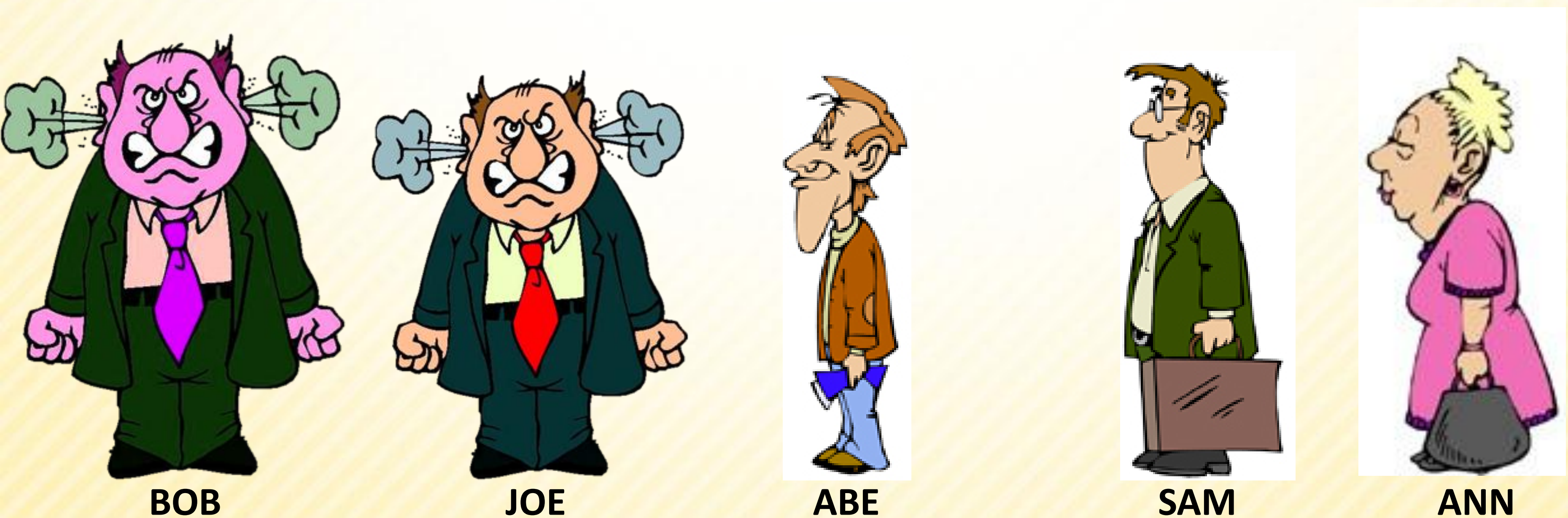
“Joe” < “Sam”?



ABE **ANN** **BOB** **JOE SAM** **SAM JOE**

Sorting a List

- **<u>Insertion Sort</u>**
  - Take each element one by one, starting with the second and "insert" it into the already sorted list to its left in the correct order.



Sorting a List

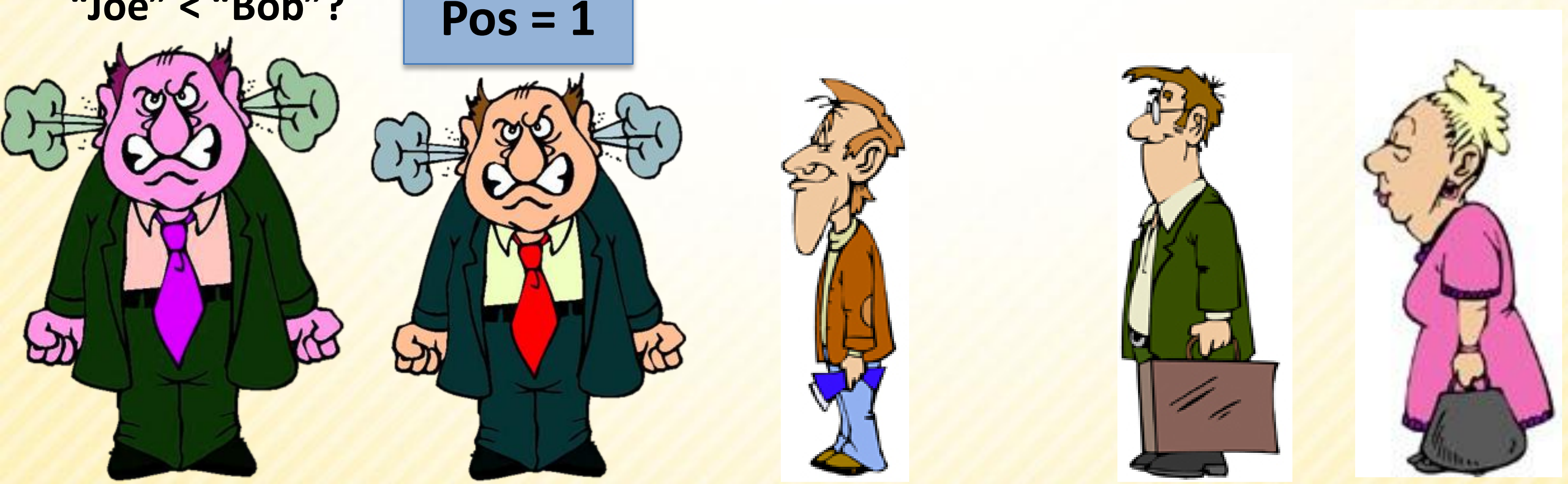
- **Insertion Sort**

PREV

CURR

"Joe" < "Bob"?

Pos = 1



BOB JOE ABE SAM ANN

Sorting a List

- **<u>Insertion Sort</u>**

P R E V

C U R R

C U R R

"Abe" < "Bob"?

"Abe" < "Joe"?

Pos = 2

ABE BOB

JOE ABE BOB

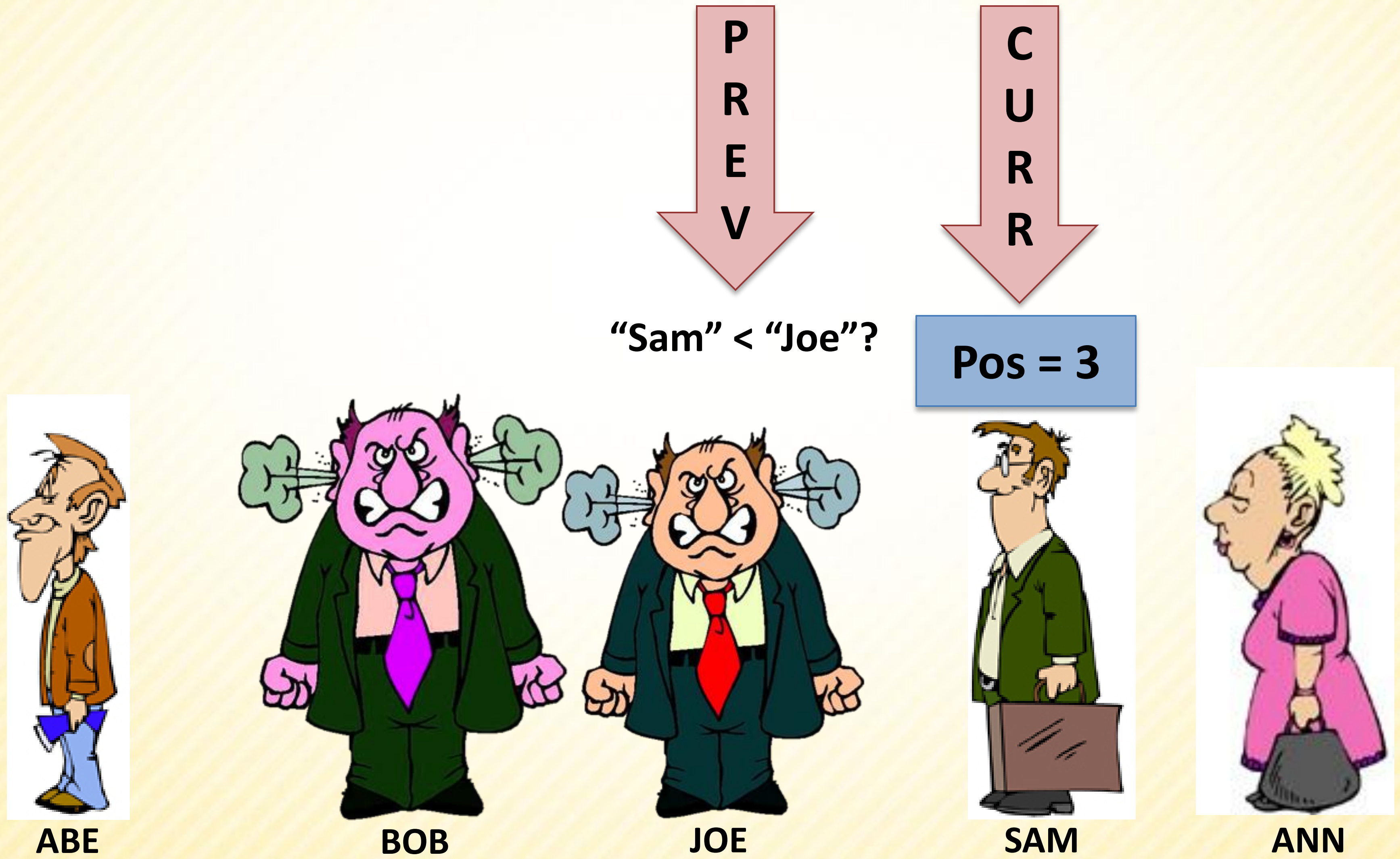
ABE JOE

SAM

ANN

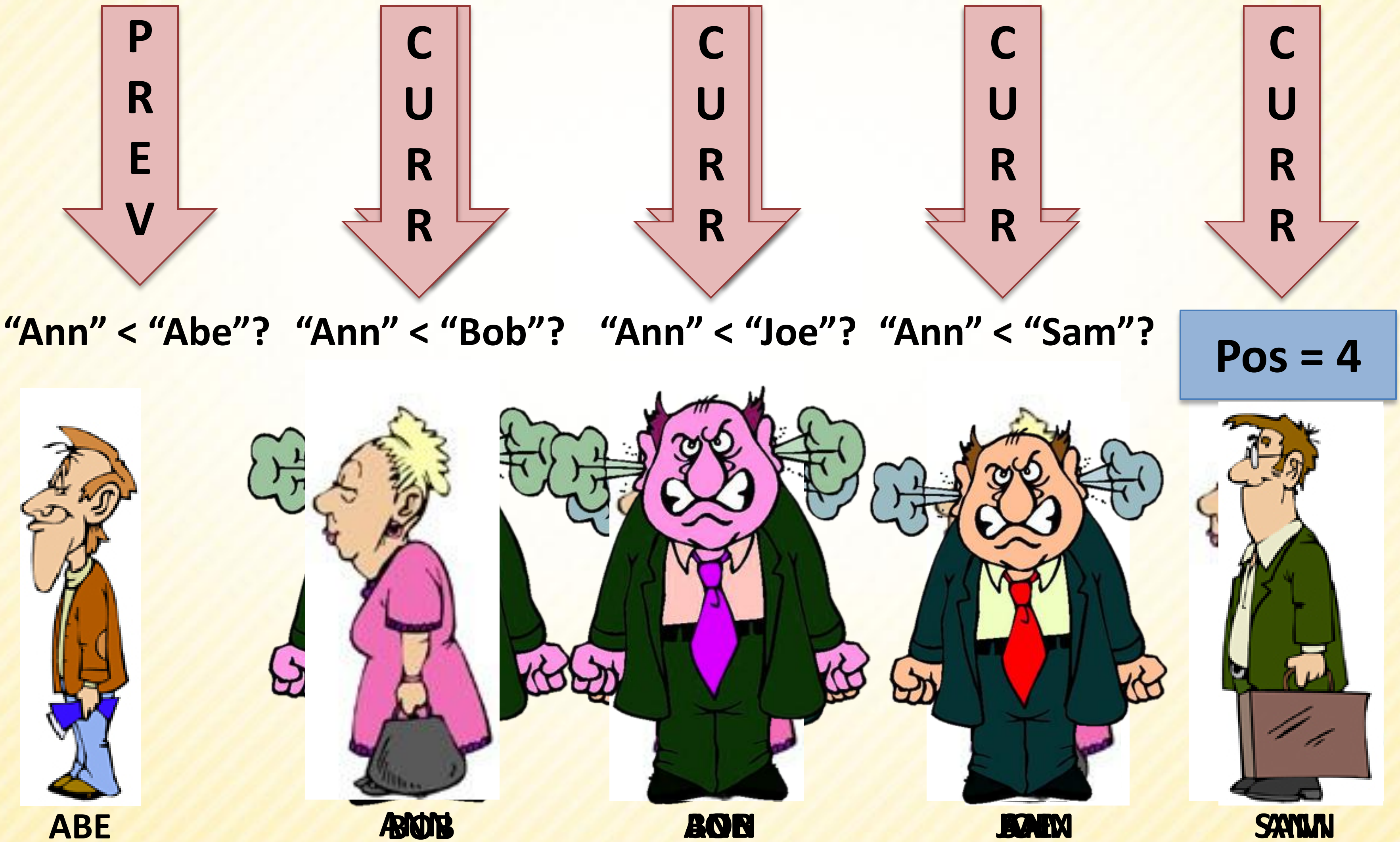
Sorting a List

- **<u>Insertion Sort</u>**



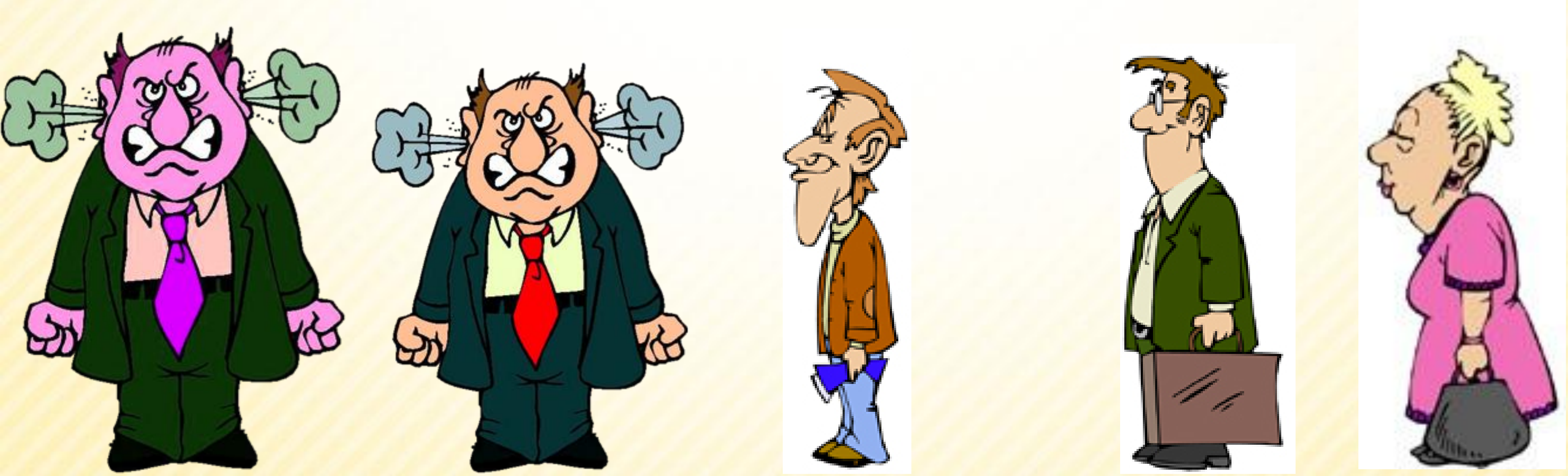
Sorting a List

- **Insertion Sort**



Sorting a List

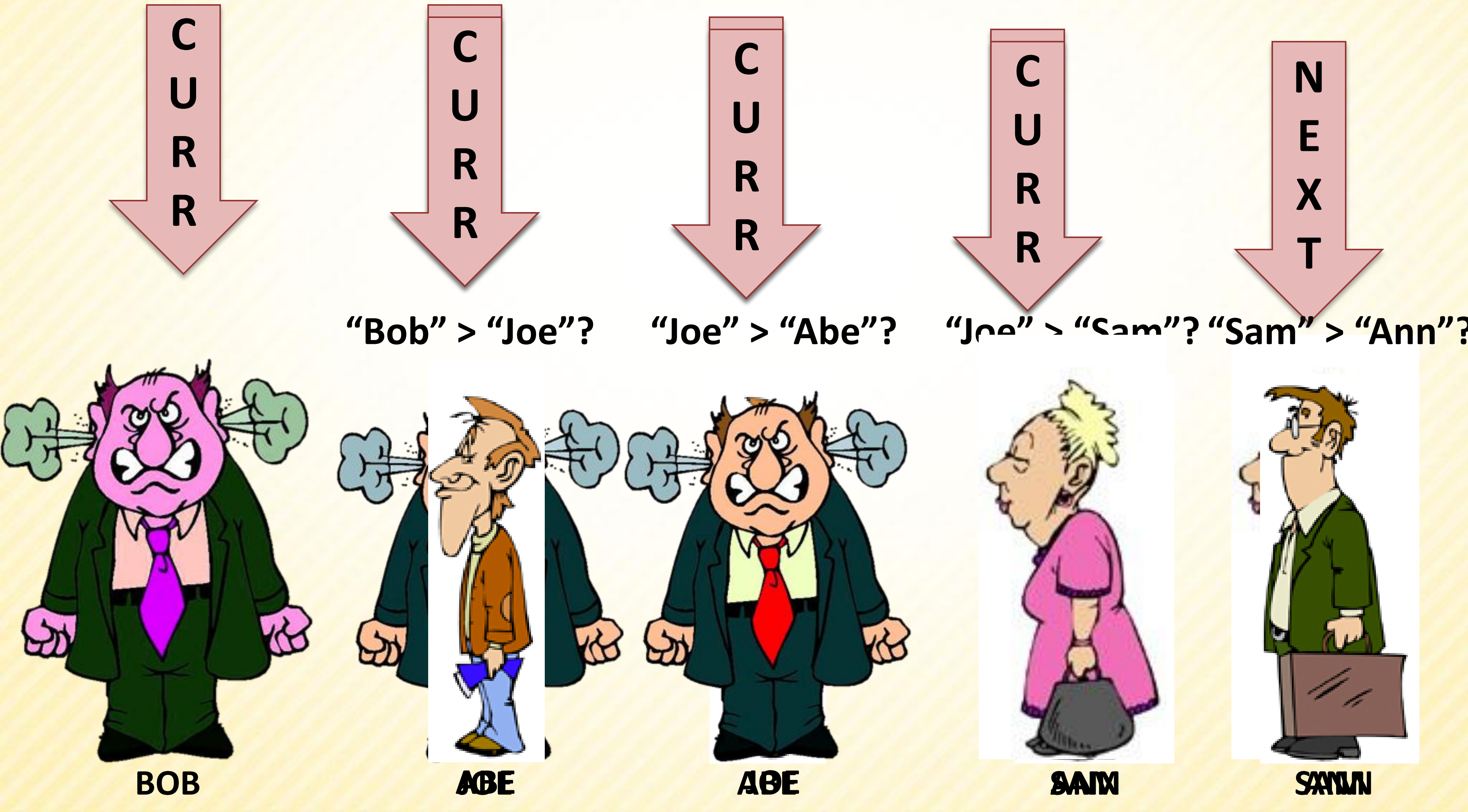
- **Bubble Sort**
  - The basic idea behind bubble sort is that you always compare consecutive elements, going left to right.
    - Whenever two elements are out of place, swap them.
    - At the end of a single iteration, the max element will be in the last spot.
  - Now, just repeat this n times
  - On each pass, one more maximal element will be put in place.
  - As if the maximum elements are slowly ***"bubbling"*** up to the top.



BOB JOE ABE SAM ANN

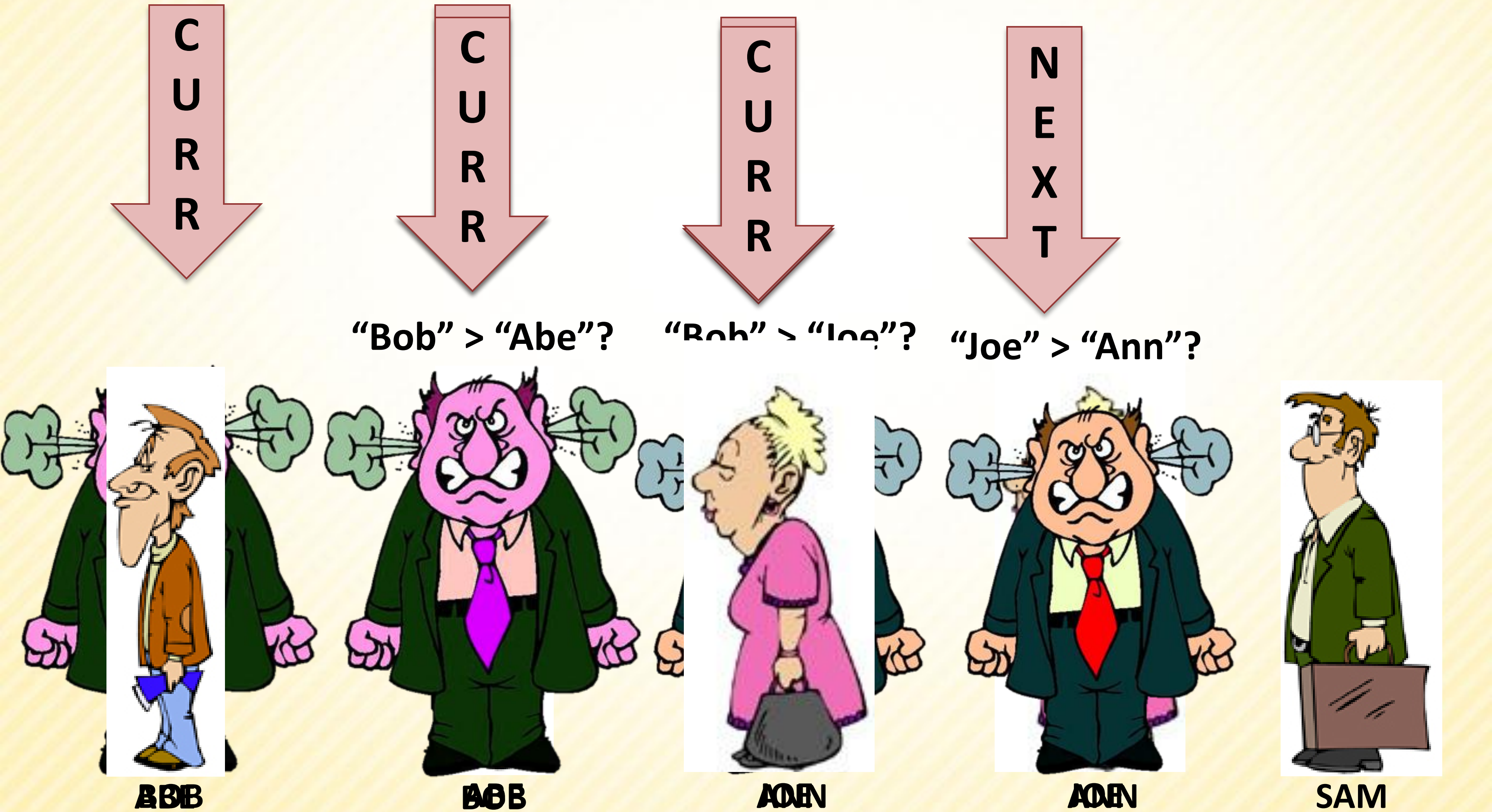
Sorting a List

- **<u>Bubble Sort</u>**



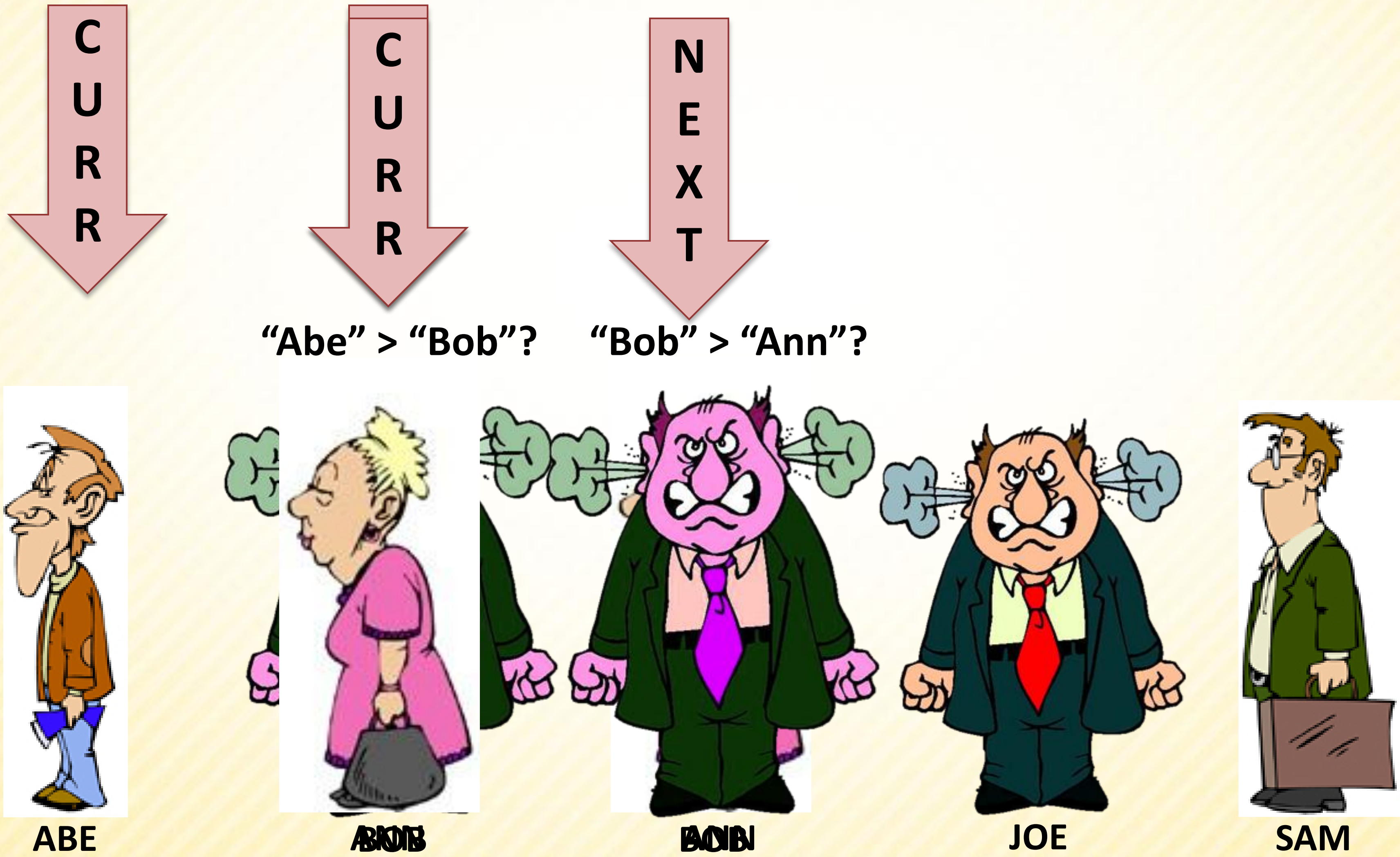
Sorting a List

- <u>**Bubble Sort**</u>



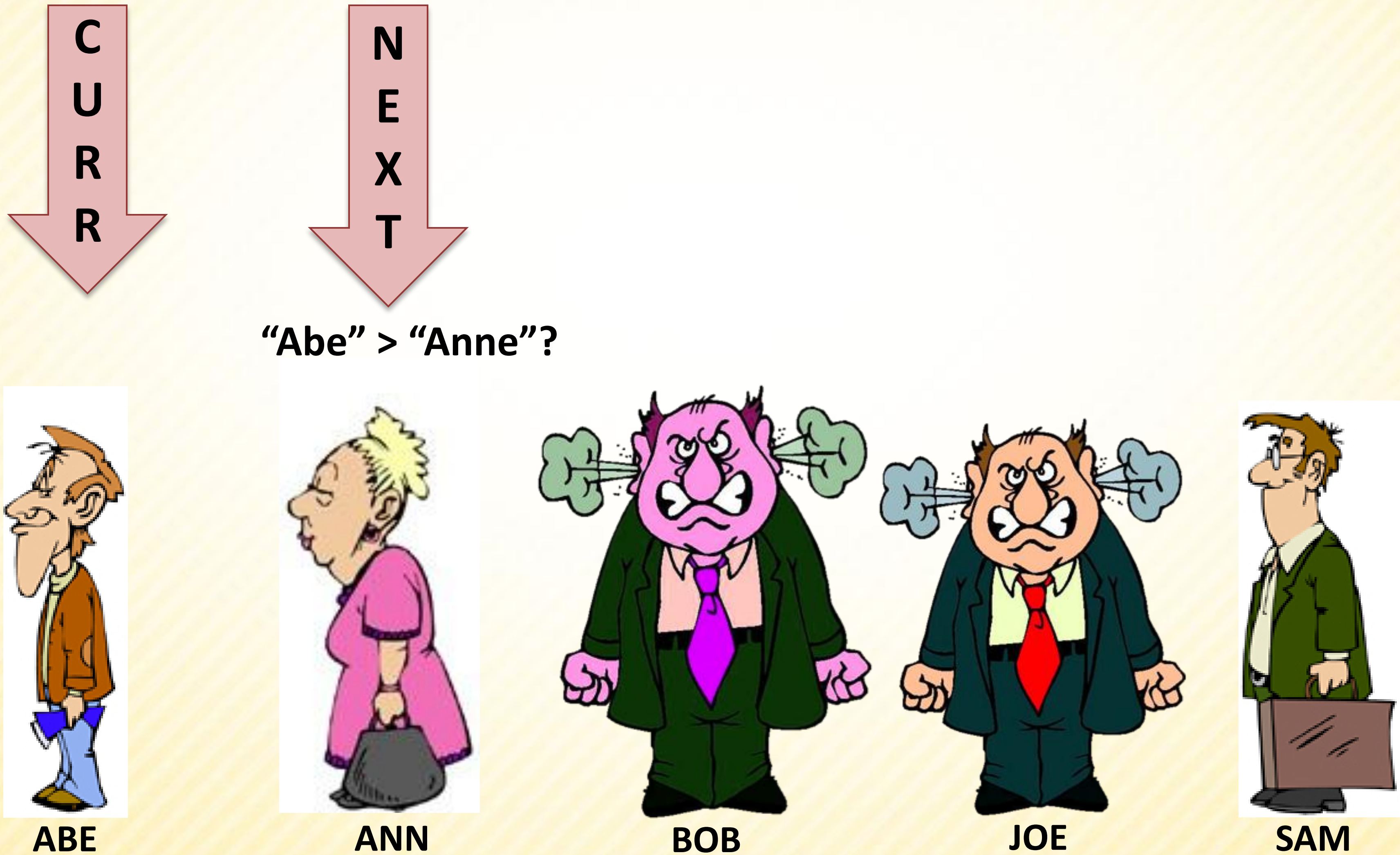
Sorting a List

- **Bubble Sort**



Sorting a List

- **<u>Bubble Sort</u>**



Limitation of Sorts that only swap adjacent elements

- A sorting algorithm that only swaps adjacent elements can only run so fast.
  - In order to see this, we must first define an inversion:
    - An inversion is a pair of numbers in a list that is out of order.
    - In the following list: 3, 1, 8, 4, 5
    - the inversions are the following pairs of numbers: (3, 1), (8, 4), and (8, 5).
  - When we swap adjacent elements in an array, we can remove at most one inversion from that array.

Limitation of Sorts that only swap adjacent elements

- Note that if we swap non-adjacent elements in an array, we can remove multiple inversions. Consider the following:
  - 8 2 3 4 5 6 7 1
    - Swapping 1 and 8 in this situation removes every inversion in this array (there are 13 of them total).
- Thus, the run-time of an algorithm that swaps adjacent elements only is constrained by the total number of inversions in an array.

Limitation of Sorts that only swap adjacent elements

- Let's consider the average case.
  - There are $\binom{n}{2} = \frac{(n-1)n}{2}$ pairs of numbers in a list of ***n*** numbers.
    - Of these pairs, on average, half of them will be inverted.
  - Thus, on average, an unsorted array will have $\frac{(n-1)n}{4} = \Omega(n^2)$ number of inversions,
    - and any sorting algorithm that swaps adjacent elements only will have a $\Omega(n^2)$ run-time.