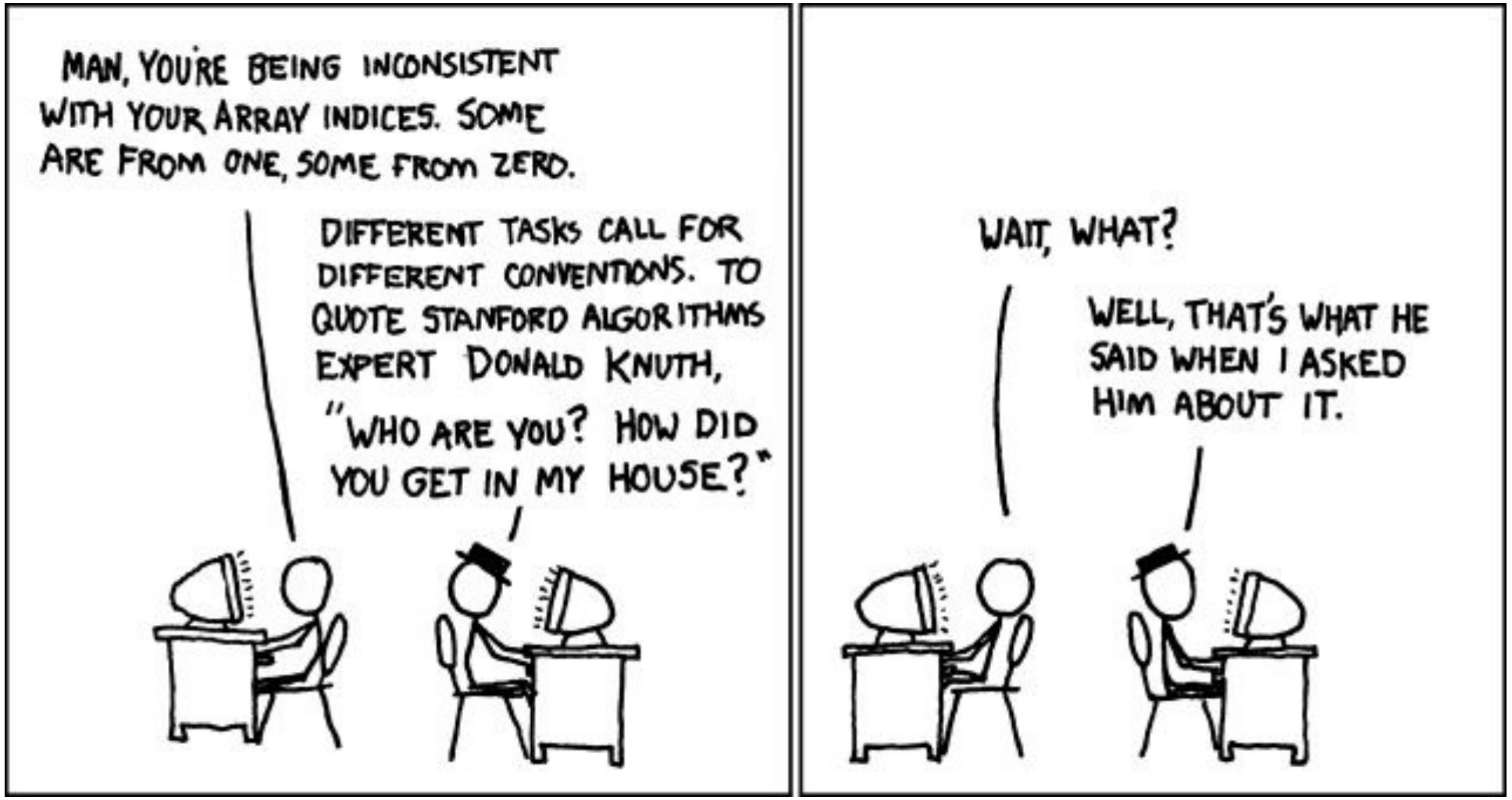
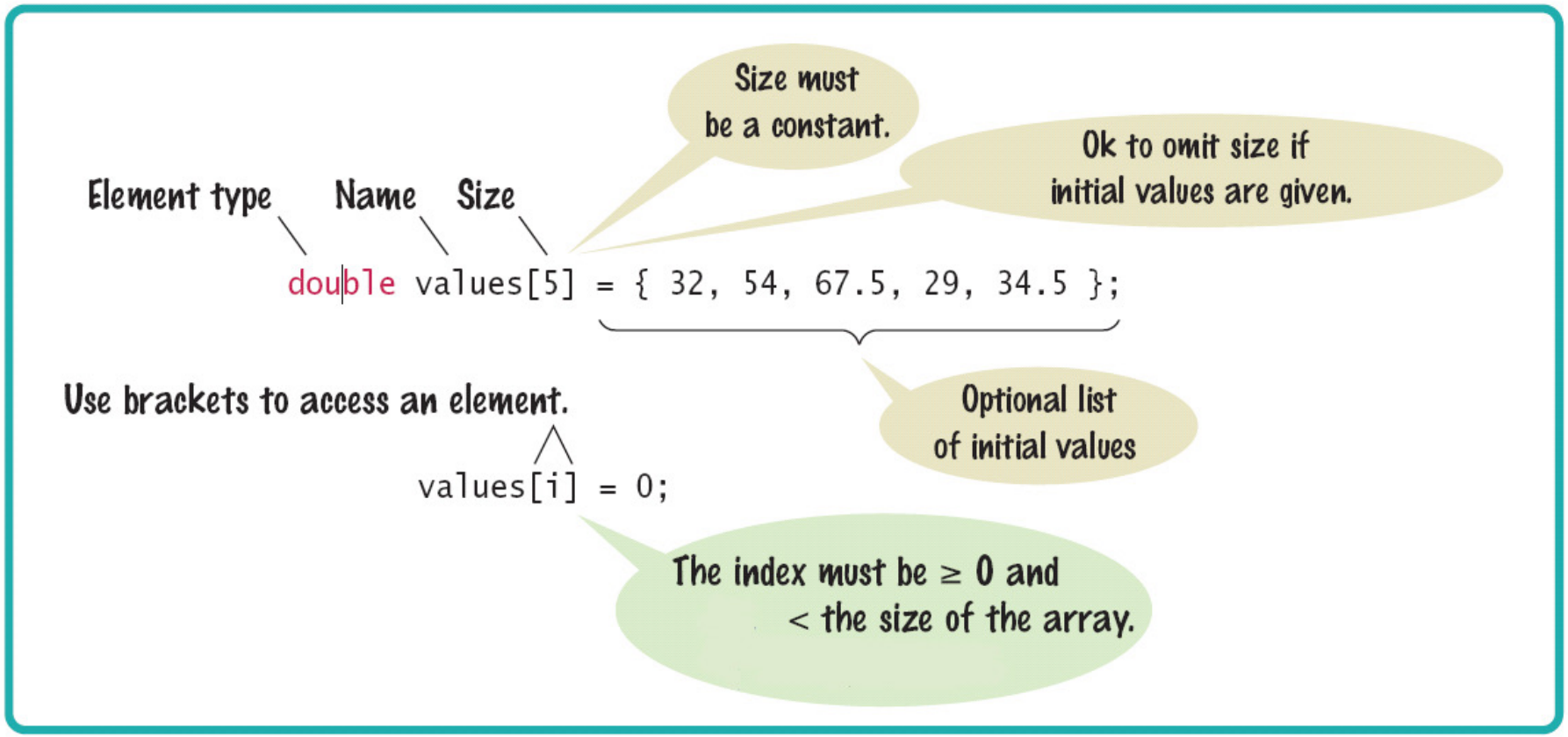

MAN, YOU'RE BEING INCONSISTENT WITH YOUR ARRAY INDICES. SOME ARE FROM ONE, SOME FROM ZERO.
DIFFERENT TASKS CALL FOR DIFFERENT CONVENTIONS. TO QUOTE STANFORD ALGORITHMS EXPERT DONALD KNUTH, "WHO ARE YOU? HOW DID YOU GET IN MY HOUSE?"
WAIT, WHAT?
WELL, THAT'S WHAT HE SAID WHEN I ASKED HIM ABOUT IT.

More Arrays

Recap: Array

Defining an Array



Common Error – Copying

- Consider these two arrays:

```
int squares[5] = { 0, 1, 4, 9, 16 };
int lucky_numbers[5];
```

- How can we copy the values from squares to lucky_numbers?
- Let's try what seems right and easy…
  - `squares = lucky_numbers;`
    …and wrong!
  - *You cannot assign arrays!*
  - *The compiler will report a syntax error.*

Common Algorithms – Copying Requires a Loop

```
/* you must copy each element individually using a loop! */

int squares[5] = { 0, 1, 4, 9, 16 };
int lucky_numbers[5];

for (int i = 0; i < 5; i++)
{
   lucky_numbers[i] = squares[i];
}
```

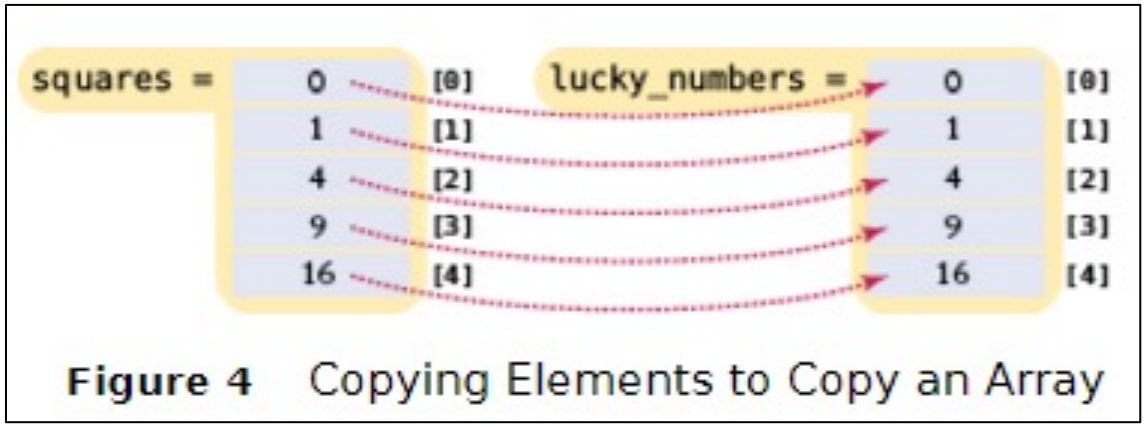
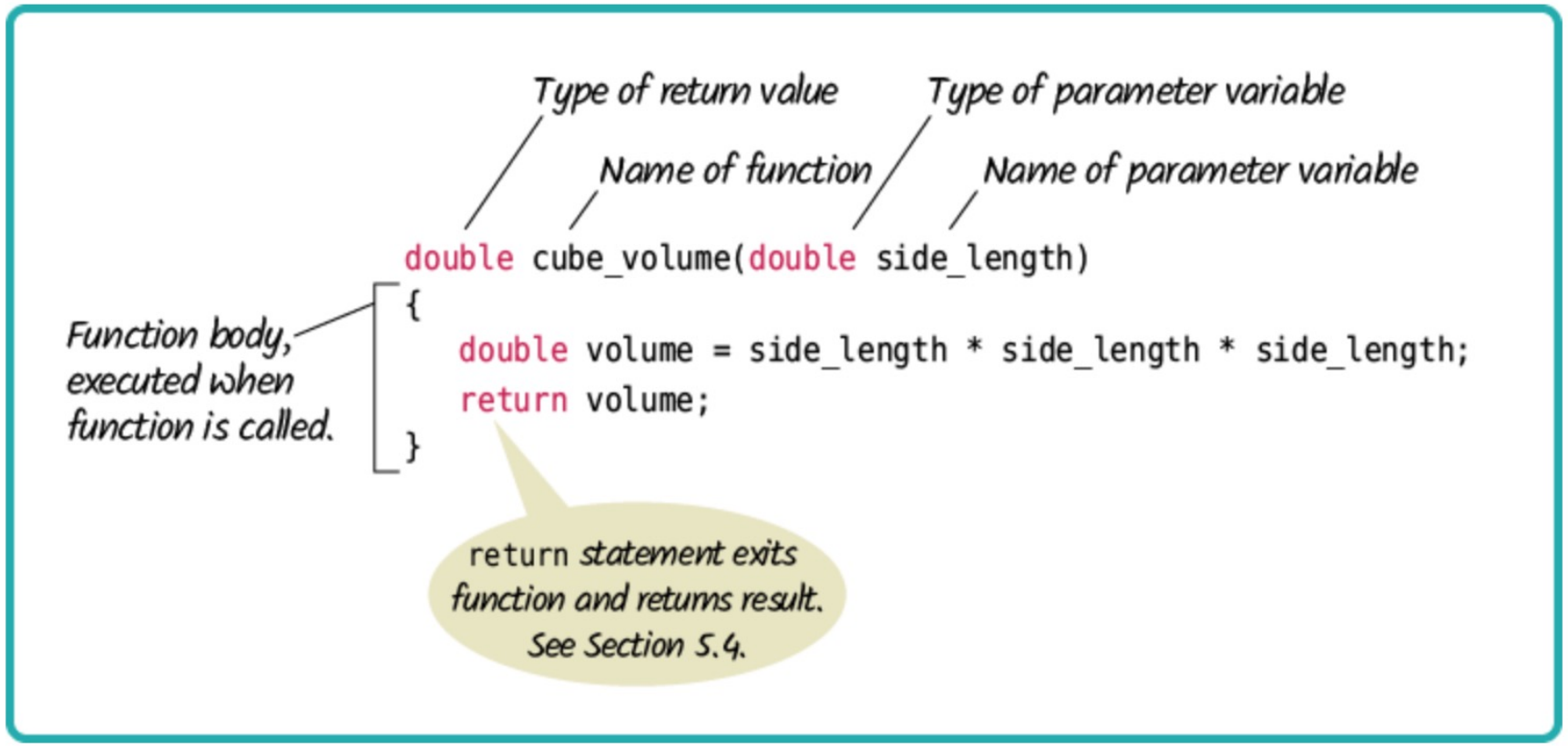


Figure 4 Copying Elements to Copy an Array

Recap: Functions

Syntax 5.1 Function Definition



Arrays as Parameters in Functions

Pass by value

```
double cubeVolume(double side_length)
{
  if (side_length >= 0)
  {
     return side_length * side_length * side_length;
  }
}

int main()
{
   int len = 3;
   double result1 = cubeVolume(len); // Calling cubeVolume
   cout << "A cube with side length 2 has volume "<< result1<< endl;
   return 0;
}
```

Arrays as Parameters in Functions

- Recall that when we work with arrays we use a companion variable.
- The same concept applies when using arrays as parameters:
- You must pass the size to the function so it will know how many elements to work with.

Array as function argument

- What does the computer know about an array?
  - The base type
  - The address of the first indexed variable
  - The number of indexed variables

- What does a function know about an array argument?
  - The base type
  - The address of the first indexed variable

Entire Arrays as Arguments

- Formal input parameter argument can be an entire array!
  – argument passed in function using array name
  – called array parameter

- Send size of array as well
  – typically done as second parameter
  – simple int type formal parameter

Arrays as function argument

In some main() function definition, consider this call:

```
int score[5], numberOfScores = 5;
fillup(score, numberOfScores);
```

- 1st argument is entire array
- 2nd argument is integer value
- **No brackets on the array argument**
- Passing in score → provides fillup() with the data type (int) and address of score[0]
  - knowing the type helps us retrieve the 2nd-last elements
- Passing in numberOfScores → provides size of array

Arrays as function argument

In some main() function definition, consider this call:

```
int score[5], numberOfScores = 5;
fillup(score, numberOfScores);
```

- Must send in size of array separately
- **Fun fact:** This means we can use the **same function** to fill any sized array!
  - Exemplifies nice “re-use” properties of functions

```
int score[5], time[10];
fillup(score, 5);
fillup(time, 10);
```

Array as function argument: How?

- What's really passed?
- Think of array as 3 "pieces"
  - Address of first indexed variable (`arr_name[0]`)
  - Array base type (`int` or `double` or `float` or …)
  - Size of array
- Only 1st piece is passed!
  - Just the beginning address of array (the 1st element)
  - Knowing the type helps us retrieve the (2nd – last) elements

Array Parameters in Functions Require [ ] in the Header

- You use an empty pair of square brackets *after* the parameter variable's name to indicate you are passing an array.

```
double sum(double data[], int size)
```

Array Function Call Does NOT Use the Brackets

When you call the function, supply both the name of the array and the size, BUT NO SQUARE BRACKETS!!

```
double NUMBER_OF_SCORES = 10;
double scores[NUMBER_OF_SCORES] = { 32, 54, 67.5, 29, 34.5, 80, 115, 44.5, 100, 65 };
double total_score = sum(scores, NUMBER_OF_SCORES);
```

You can also pass a smaller size to the function:

```
double partial_score = sum(scores, 5);
```

This will sum over only the first five doubles in the array.

```
//function to scale all elements in array by a factor

void multiply(double values[], int size, double factor)
{
   for (int i = 0; i < size; i++)
   {
      values[i] = values[i] * factor;
   }
}

. . . .

multiply(values, size, factor)
```

Arrays as Parameters but No Array Returns

- You can pass an array into a function but you cannot return an array.

- However, the function can modify an input array, so the function definition must include the result array in the parentheses if one is desired.

Array Parameters Always are Reference Parameters

- When you pass an array into a function, the contents of the array can *always* be changed. An array name is actually a reference, that is, a memory address:

```
//function to scale all elements in array by a factor
void multiply(double values[], int size, double factor)
{
   for (int i = 0; i < size; i++)
   {
      values[i] = values[i] * factor;
   }
}
```

Array Parameter Function Example

- Here is the sum function with an array parameter:
  - Notice that to pass one array, it takes two parameters.

```
double sum(double data[], int size)
{
      double total = 0;
      for (int i = 0; i < size; i++)
      {
         total = total + data[i];
      }
      return total;
}
```

```
double sum(double data[], int size)
{
      double total = 0;
      for (int i = 0; i < size; i++)
      {
         total = total + data[i];
      }
      return total;
}

int main()

{

      const int CAPACITY = 5;

      int numbers[CAPACITY] = {1,2,3,4,5};

      cout << "Sum of array values: " << sum(numbers,CAPACITY) << endl;

      return 0;

}
```

Arrays as Parameters and Return Value

If a function can change the size of an array, it should let the caller know the new size by returning it:

```
int readInputs(double inputs[], int capacity)
{
   //returns the # of elements read, as int
   int current_size = 0;
   double input;
   while (cin >> input)
   {
      if (current_size < capacity)
      {
         inputs[current_size] = input;
         current_size++;
      }
   }
   return current_size;
}
```

Array Parameters in Functions: Calling the Function

- Here is a call to the `readInputs` function:

```
const int MAXIMUM_NUMBER = 1000;
double values[MAXIMUM_NUMBER];
int current_size = readInputs(values, MAXIMUM_NUMBER);
```

- After the call, the `current_size` variable specifies how many were added.

Function to Fill or Append to an Array

Or it can let the caller know by passing and returning the current size:

```
int appendInputs(double inputs[], int capacity, int current_size)
{
   double input;
   while (cin >> input)
   {
    if (current_size < capacity)
      {
         inputs[current_size] = input;
         current_size++;
      }
   }
        return current_size;
}
```

- *Note this function has the added benefit of either filling an empty array or appending to a partially-filled array*

Constant Array Parameters

- When a function doesn't modify an array parameter, it is considered good style to add the const reserved word, like this:

```
double sum(const double values[], int size)
```

- The `const` reserved word helps the reader of the code, making it clear that the function keeps the array elements unchanged.

- If the implementation of the function tries to modify the array, the compiler issues a warning.

The const Parameter Modifier

- Recall: array parameter actually passes address of 1st element
- Function can then modify array!
  - Often desirable, sometimes not!
- Protect array contents from modification
  - Use "const" modifier before array parameter
  - Called "constant array parameter"
  - Tells compiler to "not allow" modifications

Example – function definition

```
// Takes 2 arrays of the same size as input parameters and outputs an array
// whose elements are the sum of the corresponding elements in the 2 input arrays.

void addArray(int size,          // IN size of arrays
              const float A[],   // IN input array
              const float B[],   // IN input array
              float C[])         // OUT result array
 {
    int i;
    for (i = 0; i < size; i++)
         C[i] = A[i] + B[i];

  } // End of function addArray
```

Example – function call

The function `addArray` could be used as follows:

In main():

```
int one[50], two[50], three[50];
. . .
addArray(50, one, two, three);

// but also:
addArray(20, one, two, three);

// it will only do the addition on the first 20 elements of
each array
```