Objectives:

- Learn various sorting algorithms
- Understand asymptotic complexity
- Think of ways of improving computer programs

You will be divided into groups for this activity. Each group is provided with twenty Styrofoam cubes. Each cube has a number marked on it. Today, you will be sorting your twenty cubes using various algorithms. Your twenty cubes represent elements in an array. These algorithms assume that the positions of your cubes are marked with indices that run from 0 to n-1 for n elements. In this particular case, your position numbers will run from 0 through 19 inclusive.
**Activity 1: Insertion Sort**

Initial state: The first element is sorted.
Start at index $p = 1$

Final state: All elements are sorted.

Iterative steps:
1. At index $p$ we know that all elements in positions 0 through $p-1$ are sorted.
2. Look at the element in index $p$. We need to add this to the sorted part of the array.
3. Slide all elements larger than this one to the right.
4. Repeat steps 1,2 and 3 with $p = p+1$

This means that everything before where you are now is already sorted. You are looking at a new element. You need to insert this into a sorted list. Then you need to move on to the next element.

**Q.** *What is the loop invariant? That is, what remains true every time you repeat the iterative steps?*

**Q.** *How many steps did you have to go through to sort the array? How is this related to $n$, the number of elements you had to sort?*

**Q.** *In which cases would this algorithm take the longest time? In which cases would it run really quickly?*