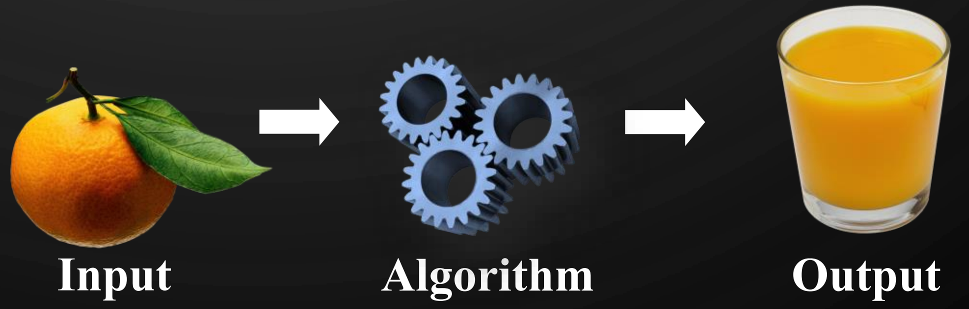
CH 4
ALGORITHM ANALYSIS

ACKNOWLEDGEMENT: THESE SLIDES ARE ADAPTED FROM SLIDES PROVIDED WITH DATA STRUCTURES AND ALGORITHMS IN JAVA, GOODRICH, TAMASSIA AND GOLDWASSER (WILEY 2016)

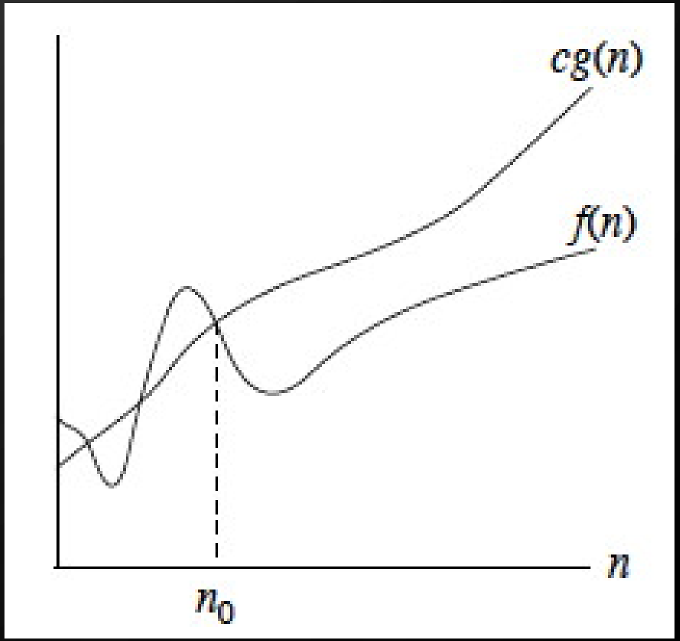
ANALYSIS OF ALGORITHMS (CH 4.2-4.3)


Input → Algorithm → Output

RUNTIME ANALYSIS

BIG-OH

- Given functions $f(n)$ and $g(n)$, we say that $f(n)$ is $O\big(g(n)\big)$ if there are positive constants c and n_0 such that $f(n) \leq cg(n)$ for $n \geq n_0$
  - $f(n)$ is the real (measured) time
- We need to know how to determine $f(n)$, c, and n_0
  - This is all done through experiments



DETERMINING $f(n)$

- Vary the size of the input and then determine runtime using System.nanoTime()

```
for(int n = 2; n < MAX; n*=2) {
  int r = max(10, MAX/n); //number of repetitions
  long start = System.nanoTime();
  for(int k = 0; k < r; ++k)
    executeFunction();
  long stop = System.nanoTime();
  double elapsed = (stop - start)/1.e9/r;
}
```

DETERMINE c AND n_0

- First plot $f(n)$ – time vs size
- Second plot $\frac{f(n)}{g(n)}$ or $\frac{\text{time}}{\text{theoretical time}}$ vs size
- Look for where the data levels off. This will be n_0
- Look for the largest value to the right of n_0, this will be c

TOGETHER – TIME LINEAR SEARCH

- We will download and modify Timing.java for this activity (see Programming Assignment 3)

WHY GO THROUGH THIS ANALYSIS?

- If two algorithms have the same theoretical analysis, we must compare them experimentally!
  - The algorithm with a smaller c value is more efficient
- Determining the n_0 informs us:
  - When the theoretical complexity begins holding true
- If you reach the memory limit of the machine, you will see "odd" effects…

ACTIVITY

- Determine big-oh constants for Arrays.sort();
- Theoretical complexity will be $O(n \log n)$