Chapter 1
The Role of the Algorithms in Computing

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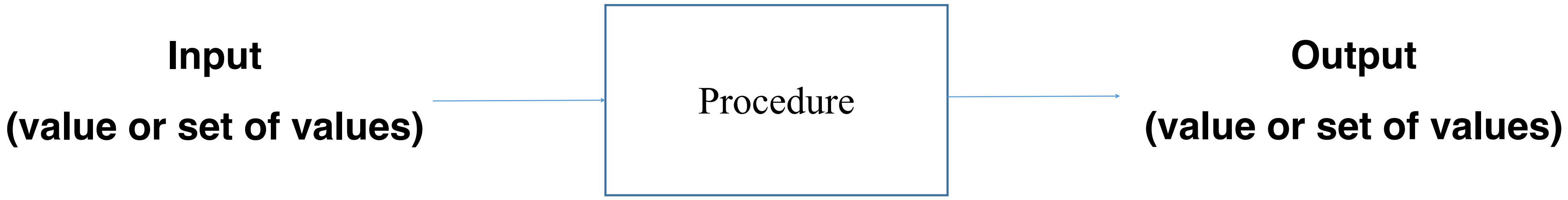
Algorithms

- **Algorithm:** Any well-defined computation procedure that takes some value, or set of values, as input and produces some value, or set of values, as output.



Algorithms

- **Example:** Sorting problem
  - Input: A sequence of *n* numbers $\langle a_1, a_2, \ldots, a_n \rangle$
  - Output: A permutation $\langle a_1', a_2', \ldots, a_n' \rangle$ of the input sequence such that $a_1' \leq a_2' \leq \ldots \leq a_n'$

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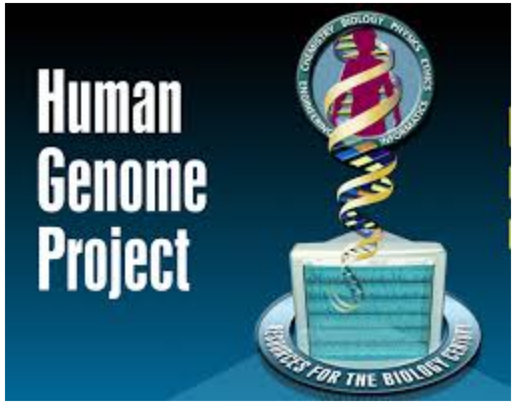
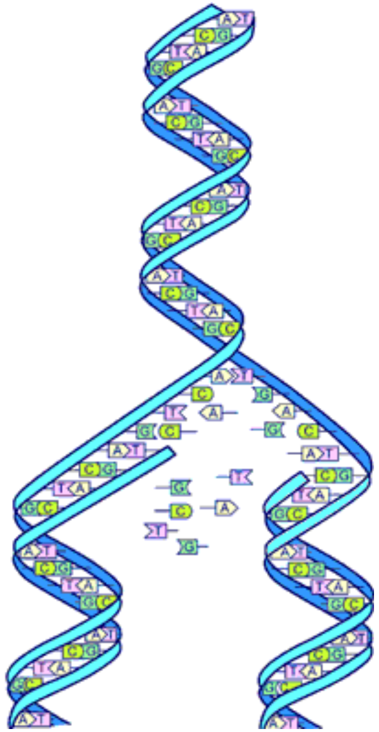
- An ***instance of a problem*** consists of the input needed to compute a solution to the problem.
- An algorithm is said to be ***correct*** if for every input instance, it halts with the correct output.
- A correct algorithm ***solves*** the given computational problem. An incorrect algorithm might not halt at all on some input instance, or it might halt with other than the desired answer.

What kind of problem can be solved by algorithm?

- The Human Genome Project
  - Identifying all the 100,000 genes in human DNA
  - Determining the sequence of 3 billion chemical base pairs that make up human DNA
  - Storing information in human DNA databases
  - Developing tools for human DNA data analysis

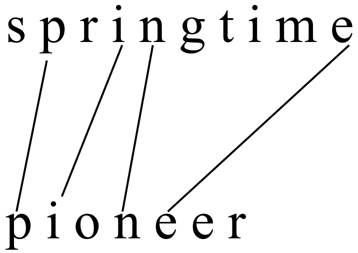




Longest common subsequence

- **Promblem**: Given 2 sequences, $X = \langle x_1, \ldots, x_m \rangle$ and $Y = \langle y_1, \ldots, y_n \rangle$,find a subsequence common to both whose length is longest. A subsequence doesn’t have to be consecutive, but it has to be in order.

- **Examples:**



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What kind of problem can be solved by algorithm?

- The Internet Applications
  - Internet enables people to quickly access and retrieve large amounts of information
  - Finding good routes on which the data will travel (CH24 Shortest Paths)
  - Using a search engine to quickly find pages on which particular information resides (CH11 Hash tables, 32 String Matching)

What kind of problem can be solved by algorithm?

- Electronic Commerce with Public-key Cryptography and Digital Signatures (CH31 Number-Theoretic Algorithms)
    - ***Electronic commerce*** enables goods and services to be negotiated and exchanged electronically
    - ***Credit card numbers***
    - ***Passwords***
    - ***Bank statements private***

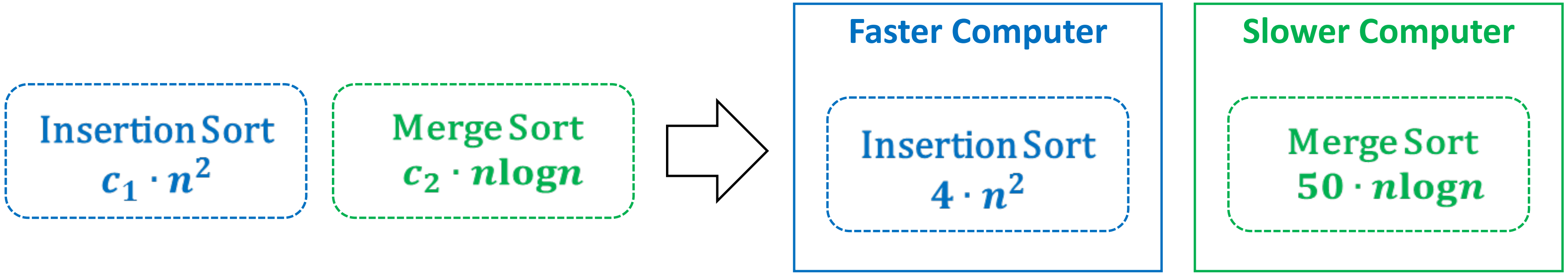
What kind of problem can be solved by algorithm?

- **Manufacturing and Other Commercial Settings**
    - Allocating scarce resources in the ***most beneficial way***

- ***How to assign crews to flights for an airline company***?
- Where to place its wells for an oil company?
- Where to spend money buying advertising?
- Where to place more resources for an Internet service provider?

What kind of problem can be solved by algorithm?

- **Efficiency**
  - Algorithms devised to solve the same problem often differ dramatically in their efficiency
  - *These difference can be significant than differences due to hardware and software*
  - ***E.g.,*** Sorting *n* items



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What kind of problem can be solved by algorithm?

- Efficiency
  - *These difference can be significant than differences due to hardware and software*

When $n = 10$

Faster Computer	Slower Computer
Insertion Sort $4 \cdot n^2$	Merge Sort $50 \cdot nlogn$

Insertion sort takes: $4 \cdot 10^2 = 400$ **(s)**
Merge sort takes: $50 \cdot 10\log10 = 500$ **(s)**

When $n = 10^6$

Faster Computer	Slower Computer
Insertion Sort $4 \cdot n^2$	Merge Sort $50 \cdot nlogn$

Insertion sort takes: $4 \cdot 10^{12} = 4 \times 10^{12}$ **(s)**
Merge sort takes: $50 \cdot 10^6\log10^6 = 3 \times 10^8$ **(s)**

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