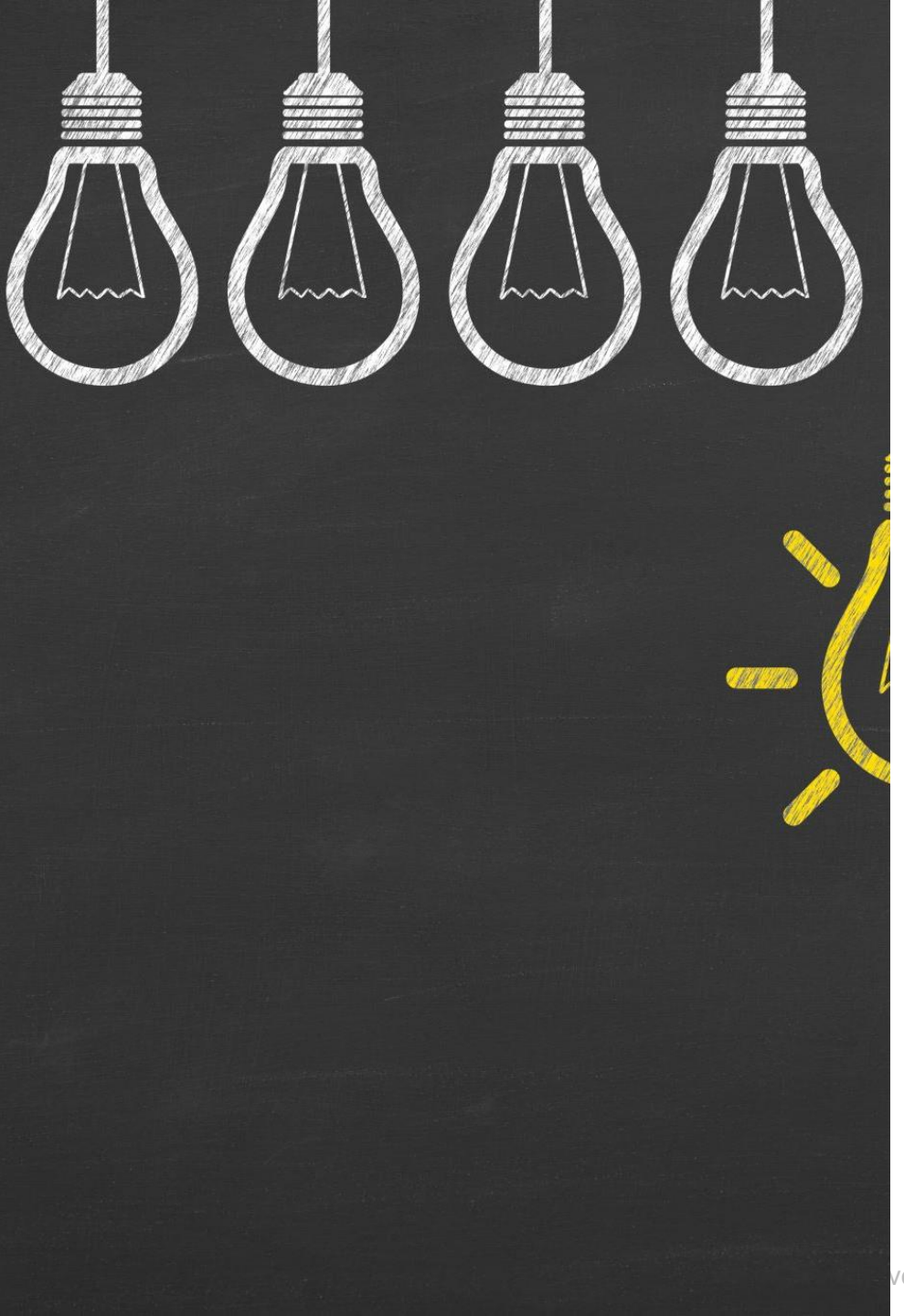
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Module 01: Computational Thinking Problem Solving Techniques (Biology)



Computational Thinking Competencies (4 main)

- Computational: Involving the calculation of answers, amounts, results(e.g., calculations, order)
- Thinking: The activity of using your mind to consider something (e.g., reasoning, questioning)
- Competencies: Important skills that are needed to do a job (e.g., managerial competencies)

Abstraction | Algorithms | Decomposition | Pattern Recognition

Abstraction: Biology

- Abstraction: Identifying and utilizing the structure of concepts / main ideas
- Simplifies things
  - Identifies what is important without worrying too much about the detail
- Allows us to manage the complexity of the context or content

The abstraction process – *deciding what details we need to highlight and what details we can ignore* – underlies computational thinking.

- Jeannette Wing

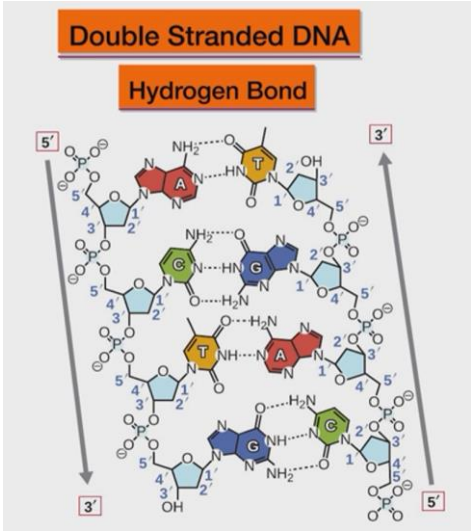
Bioinformatics

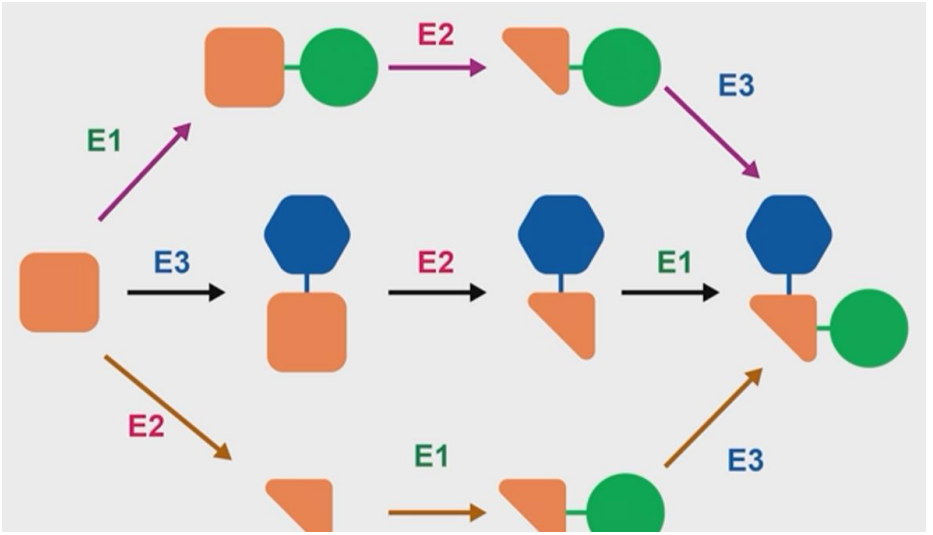
- Combines different fields of study, including computer sciences, molecular biology, biotechnology, statistics and engineering
- Large amount of data: Genomics, Proteomics

Pseudocode: An informal description of the steps involved in executing a computer program, often written in something similar to plain [in designed language]

Human Genomes (Abstraction)

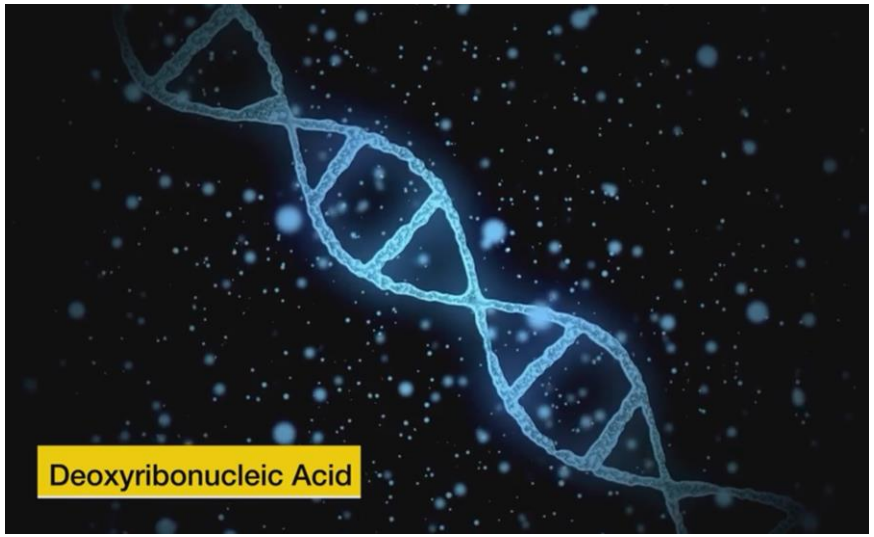
- Structure of cell:
  - Incredibly crowded
  - Incomprehensible for humans
- Question:
  - How to simplify the representation of cells?
  - How to make it readable?
- Answer:
  - By abstraction: labelling, lettering, shaping, colouring, etc.

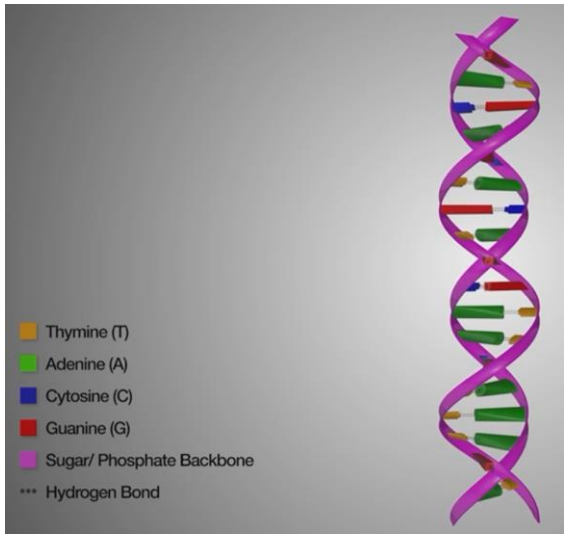




Human Genomes (Abstraction)

- Formulating in pseudo level can enable us to understand concepts more clearly.
- Abstraction simplifies complex life phenomenon to something readable and understandable.



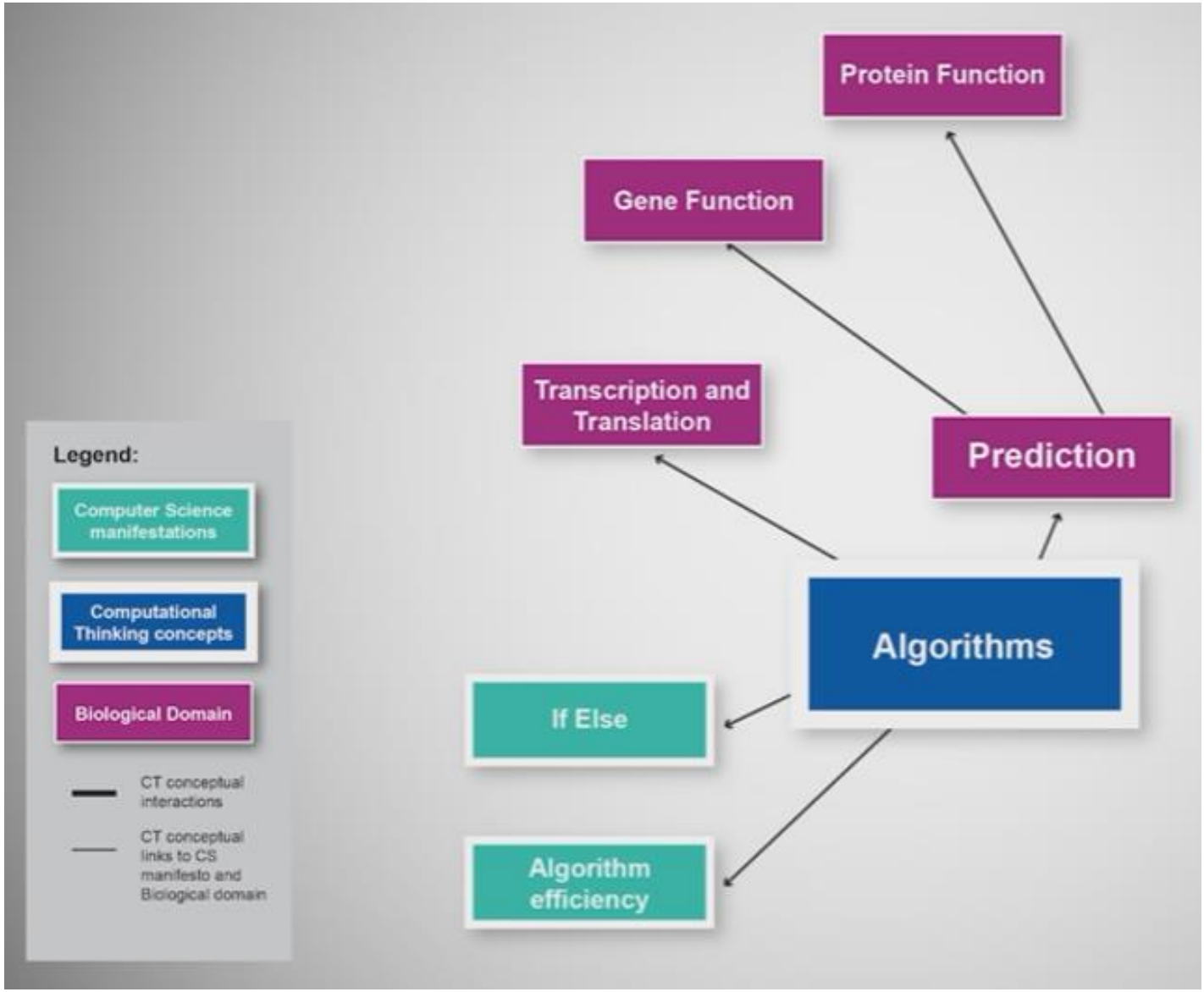


Algorithms in Biology

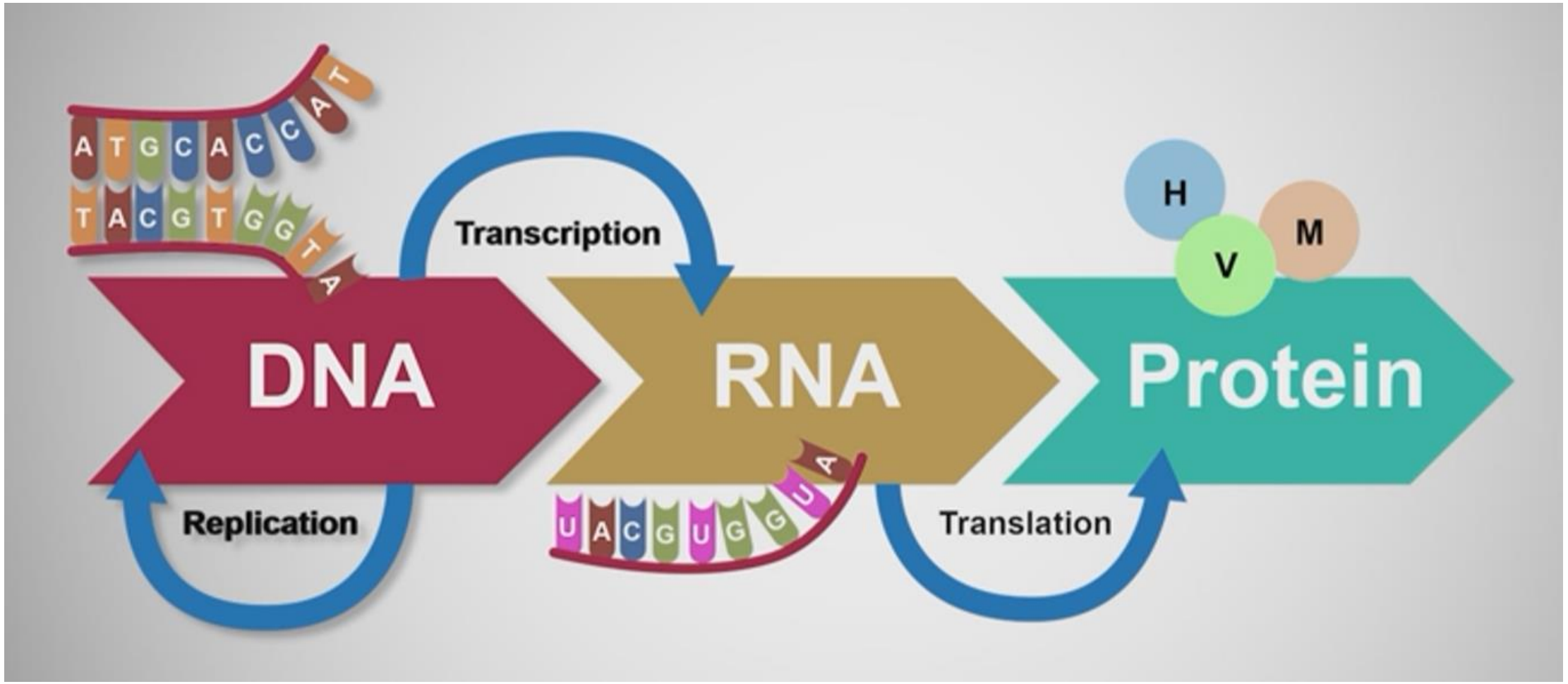
Algorithm

- is about following, identifying, using, and creating an ordered set of instructions
- ordering things
  - ascending order (e.g., from 1 to 5, or from A B C to X Y Z)
  - descending order (e.g., from 5 to 1, or from Z Y X to C B A)
- Allows us to order the complexity of the context or content

Algorithms Biology (overview)



Algorithms Biology (overview)

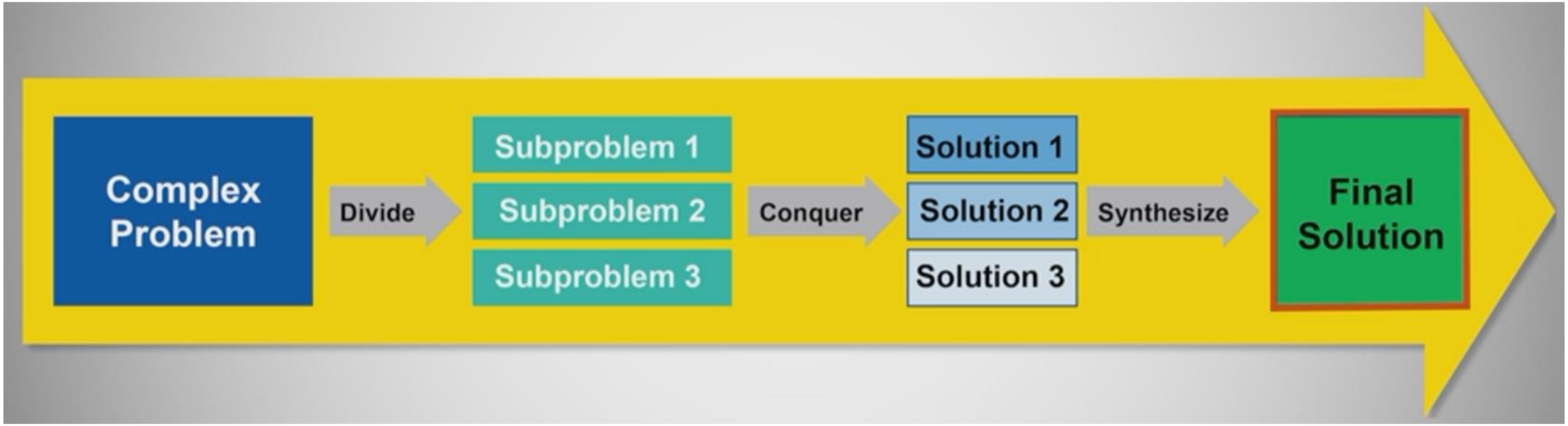


Decomposition in Biology

Decomposition is about:

- Breaking down data, processes or problems into smaller and more manageable components to solve a problem
- Each subproblem can then be examined or solved individually, as they are simpler to work with
- Natural way to solve problems
- Also known as divide-and-conquer

Decomposition (divide and conquer)



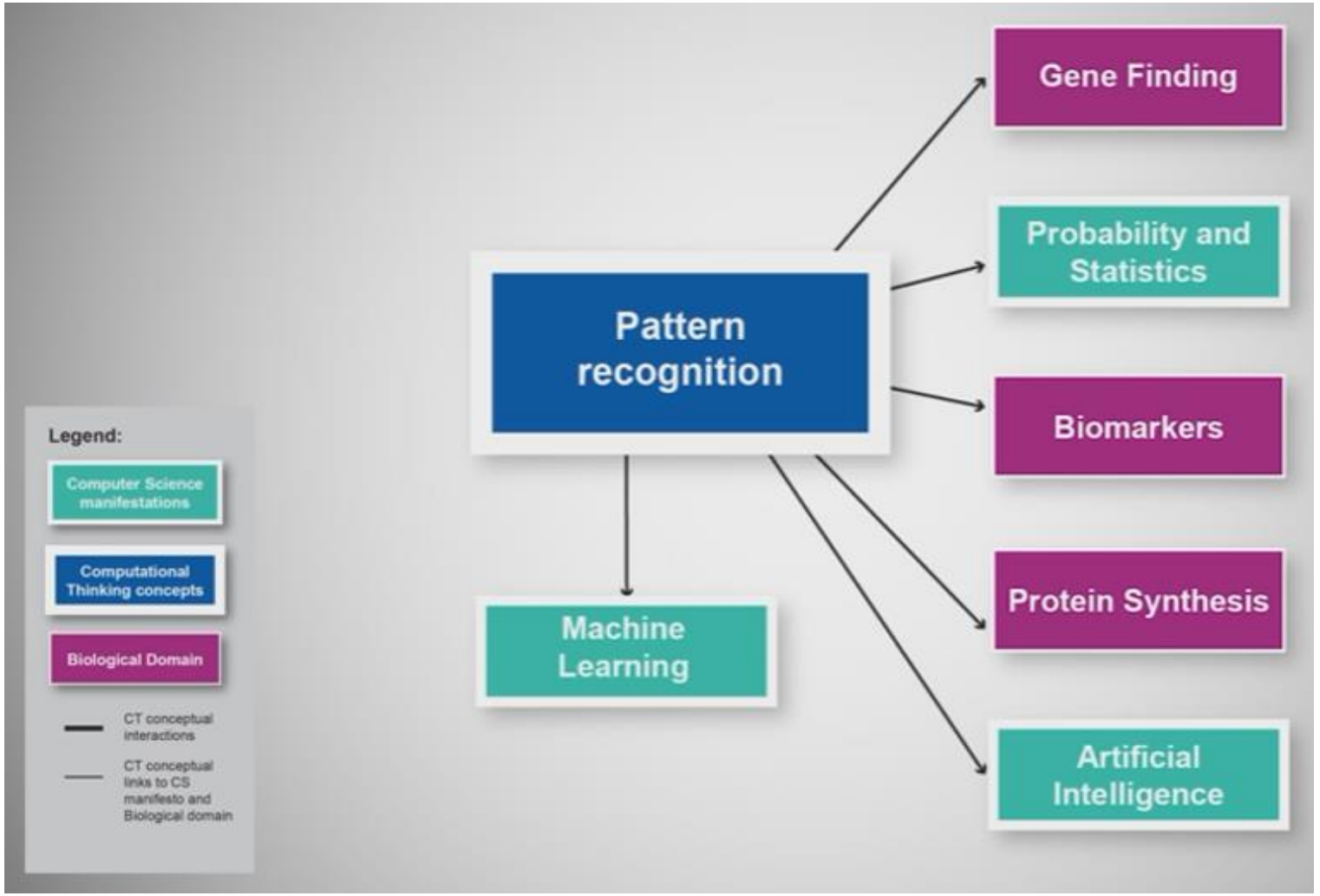
Decomposition

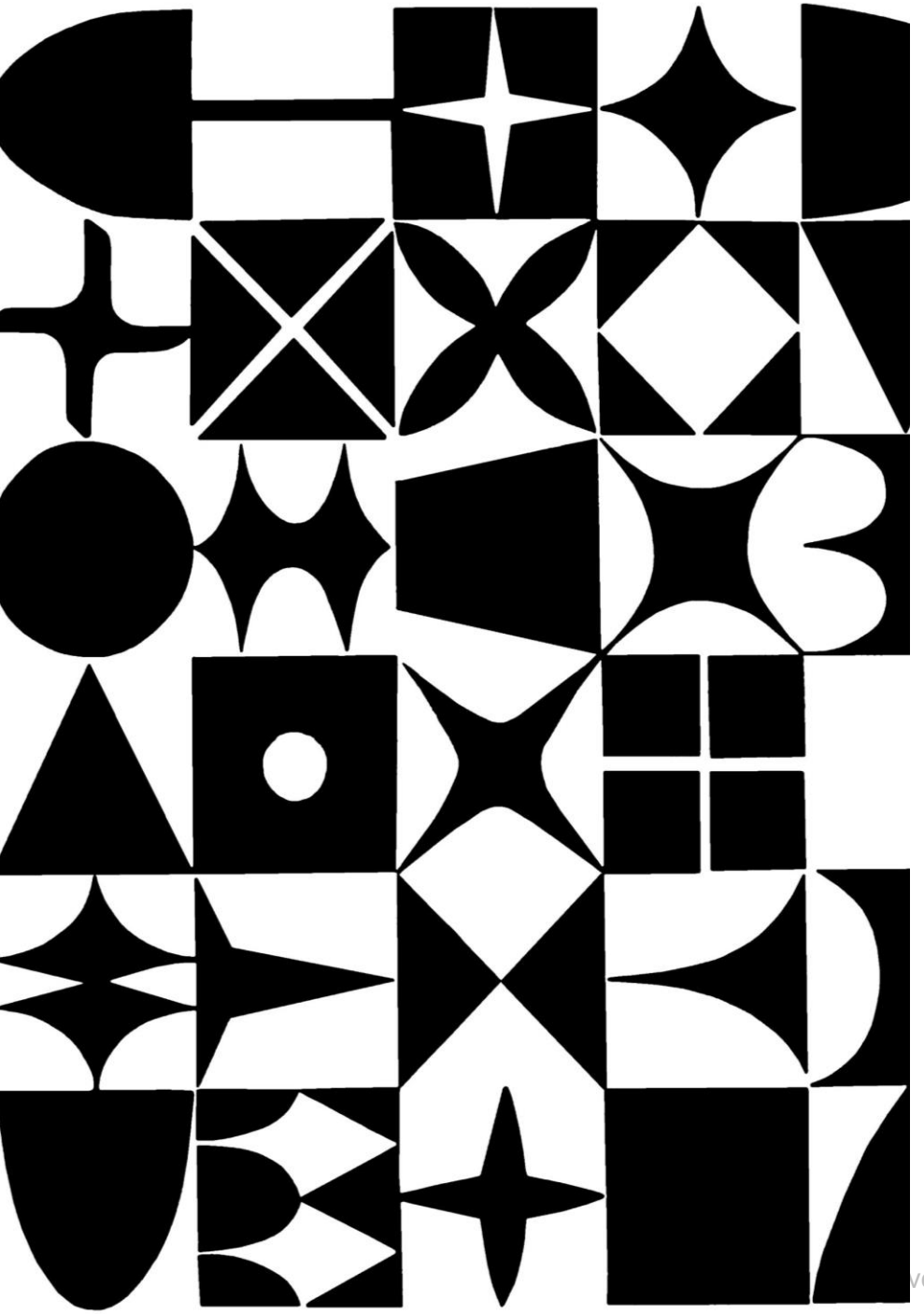
- Solve complex problems
  - If a complex problem is not decomposed, it is much harder to solve at once. Subproblems are usually easy to tackle
- Each subproblem can be solved by different parties of analysis
- Decomposition forces you to analyze your problem from different aspects

Pattern Recognition

- is about observing patterns, trends and regularities in data
- A pattern is a discernible regularity
  - The elements of a pattern repeat in a predictable manner
- In computational thinking, a pattern is the spotted similarities and common differences between problems
- It involves finding the similarities or patterns among small, decomposed problems, which can help us solve complex problems more efficiently

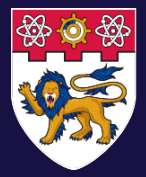
Pattern Recognition in Biology





Pattern Recognition

- Patterns make problems simpler and easy to solve
- Problems are easier to solve when they share patterns, we can use the same problem-solving solution wherever the pattern exists
- The more patterns we can find, the easier and quicker our problem solving will be



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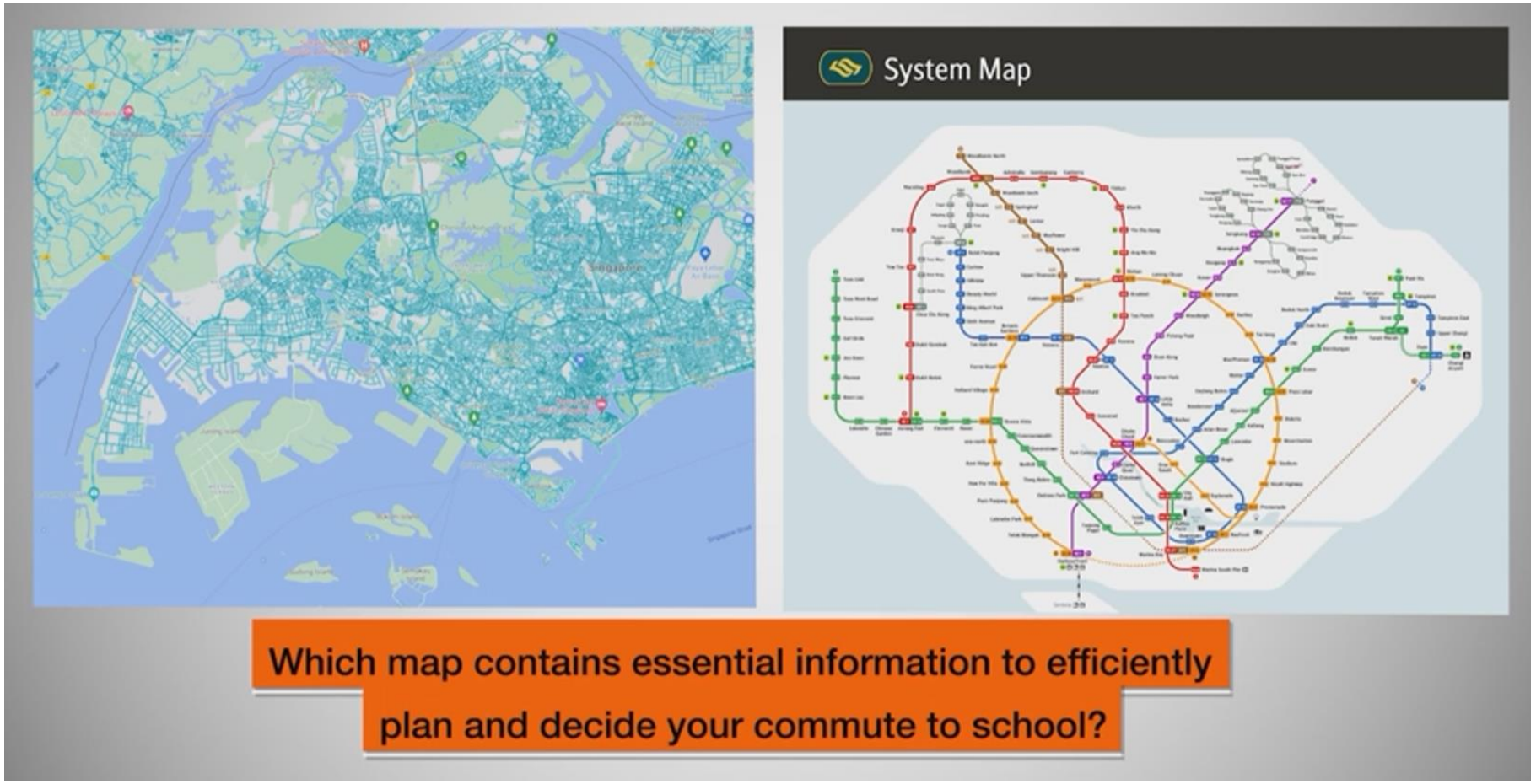
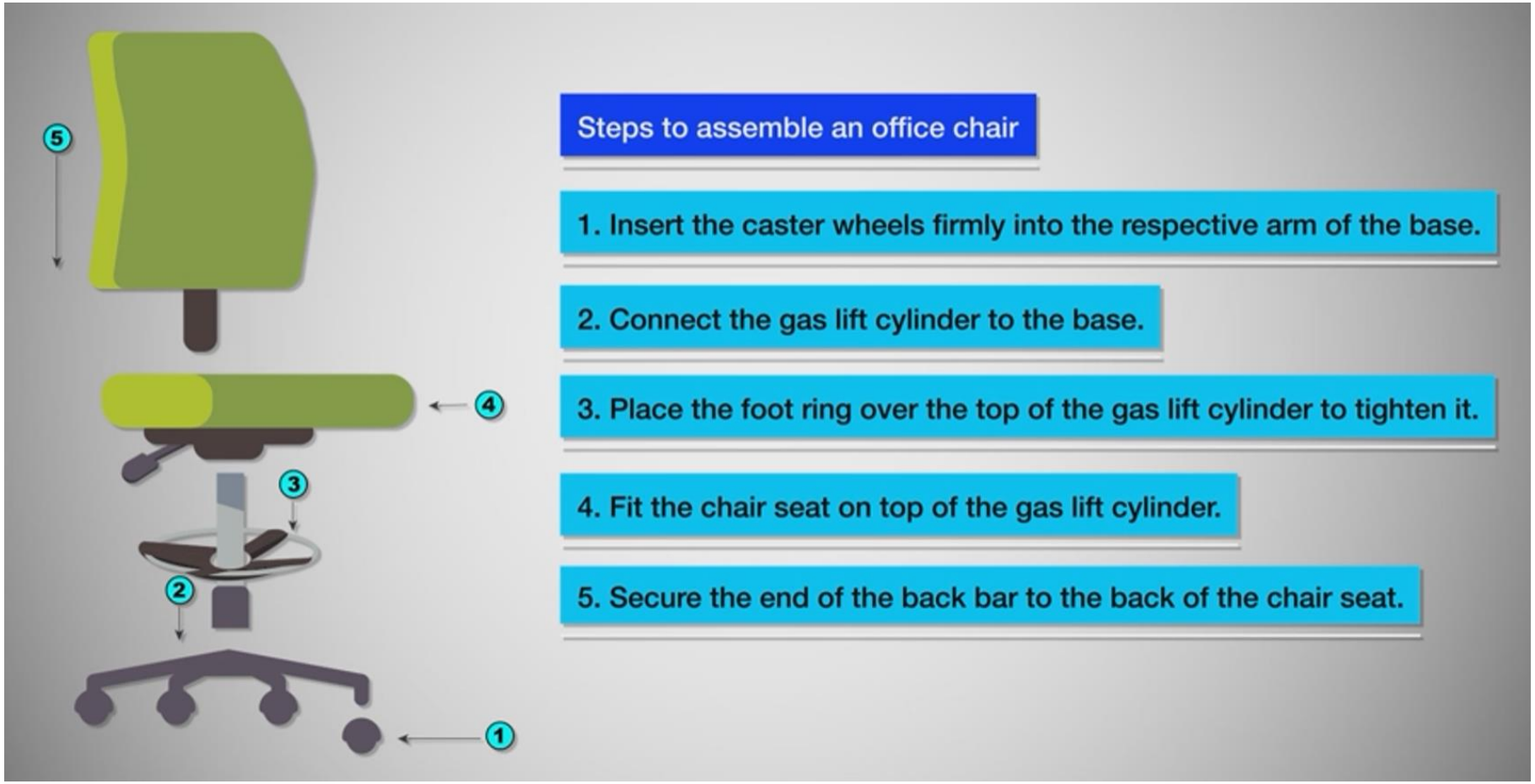
Module 01: Computational Thinking Problem Solving Techniques (Real Life Examples)

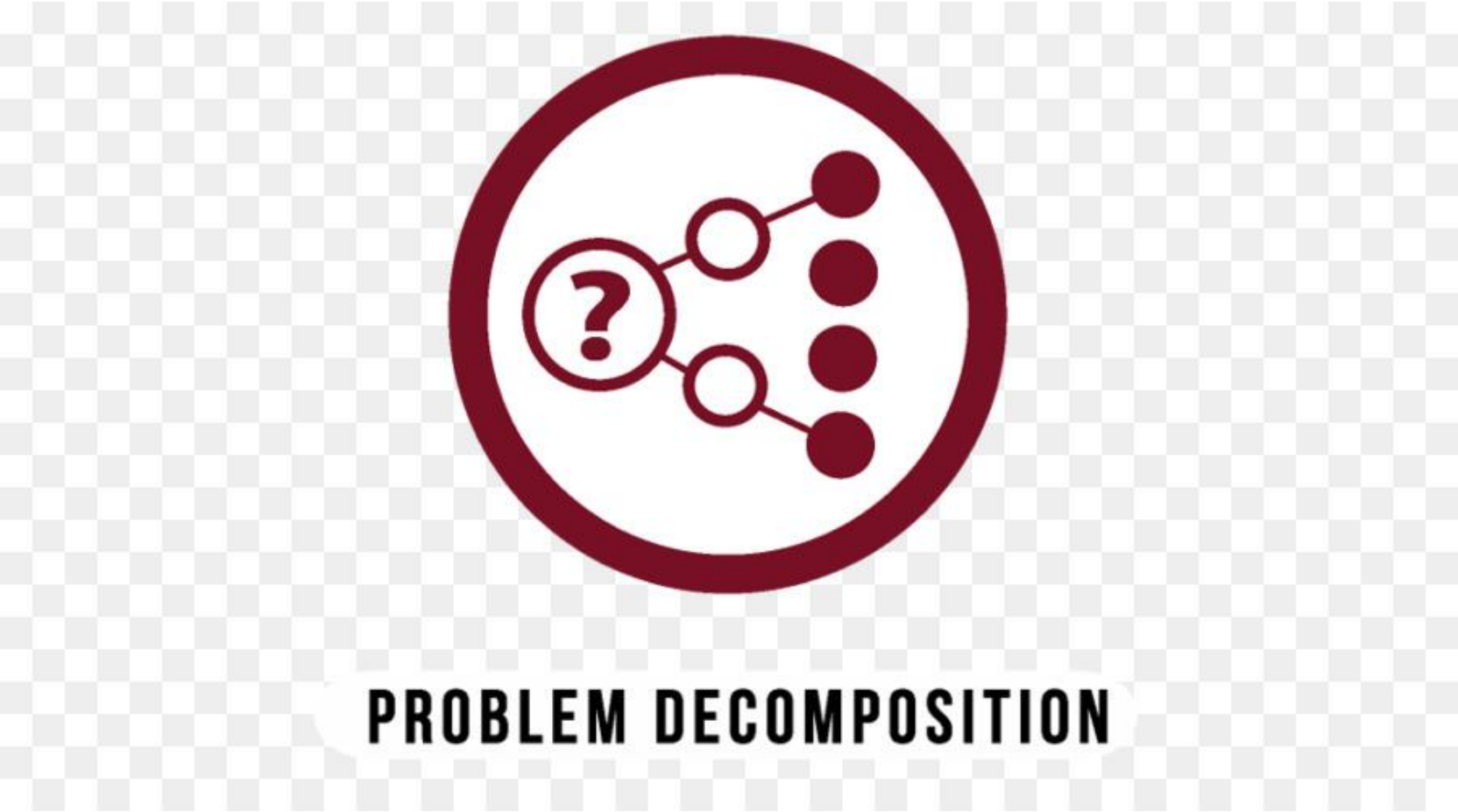
Abstraction - Example



Algorithm - Example



Decomposition - Example



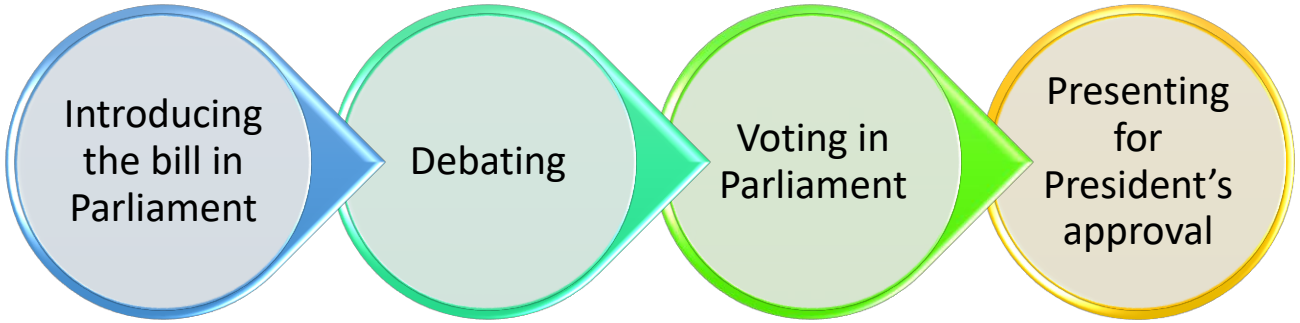
Pattern Recognition - Example

Abstraction in Arts

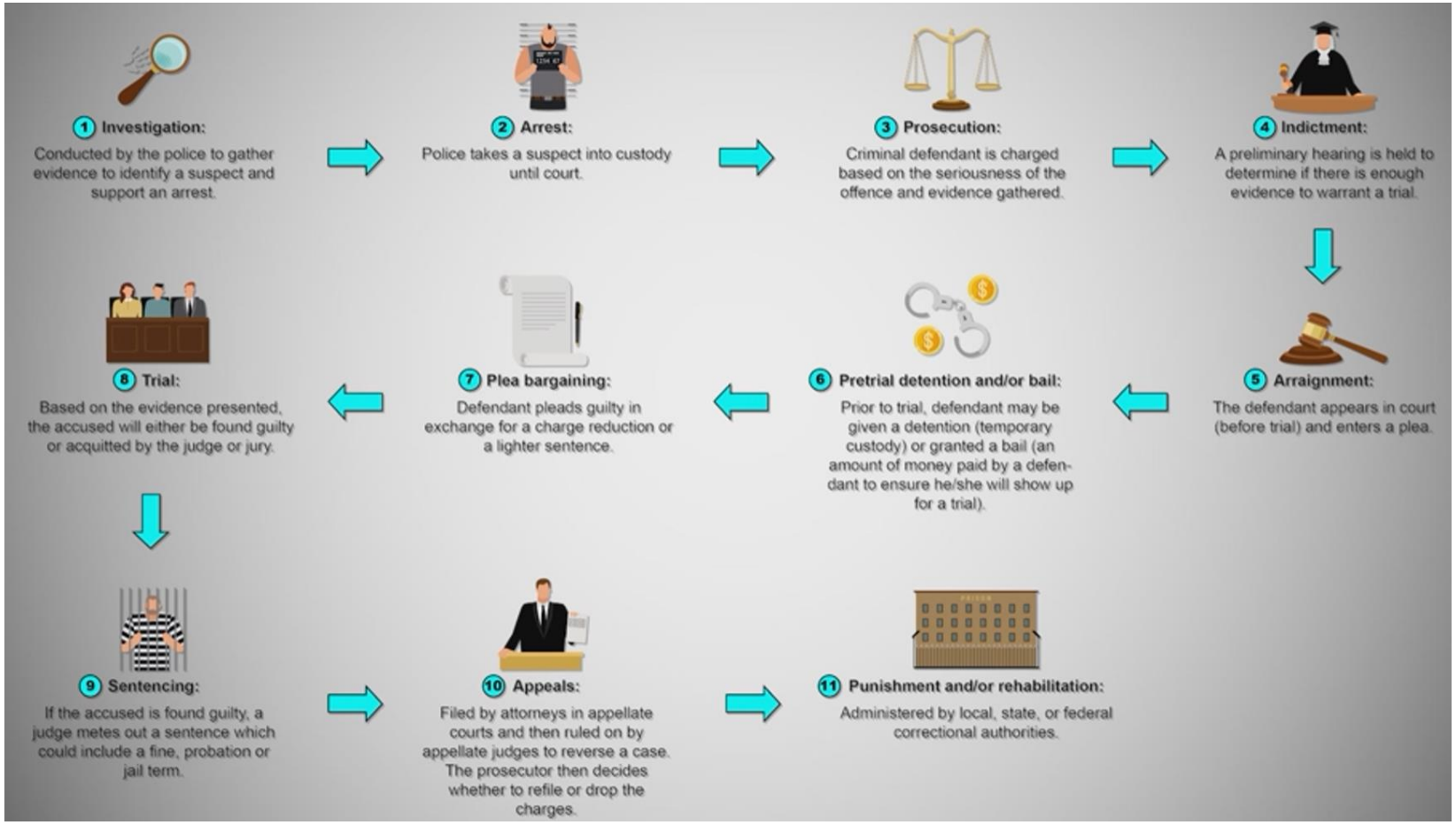
- Art, when viewed as a form of abstractions of real world, has been created since stone age
- Symbols have been used a form of communication between past and present

Algorithms in Legal Settings

- Official processes in legislative system with usages including
  - Assist in maintaining consistency
  - Reducing bias
- E.g., Process of creating a law:



Prosecution Process viewed as an Algorithm

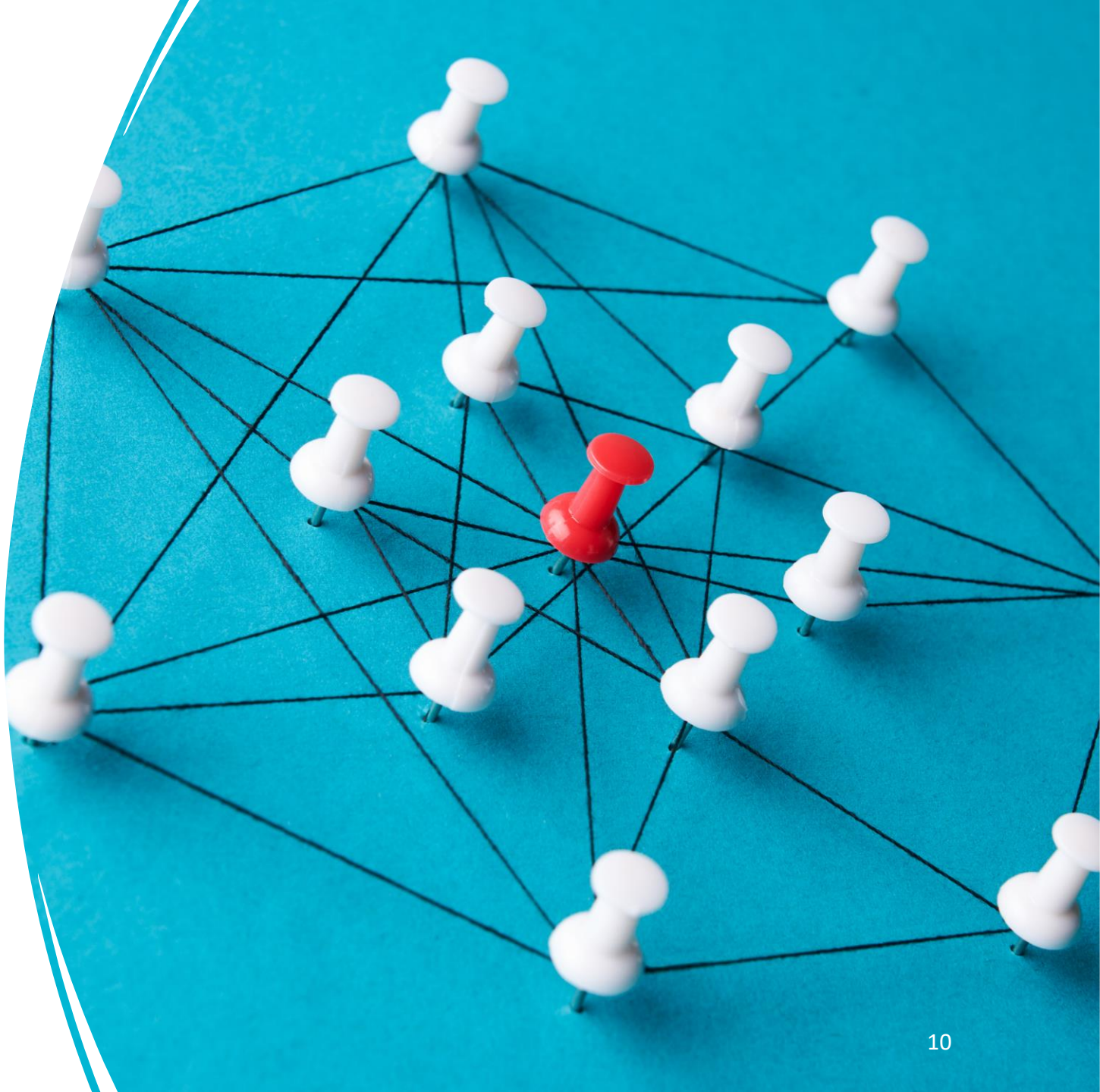


Decomposition – Piggy Bank Example

- How to count coins efficiently?
  - Sort them first, then count

Decomposition – Company Example

Companies have departments and teams, with different functions and power



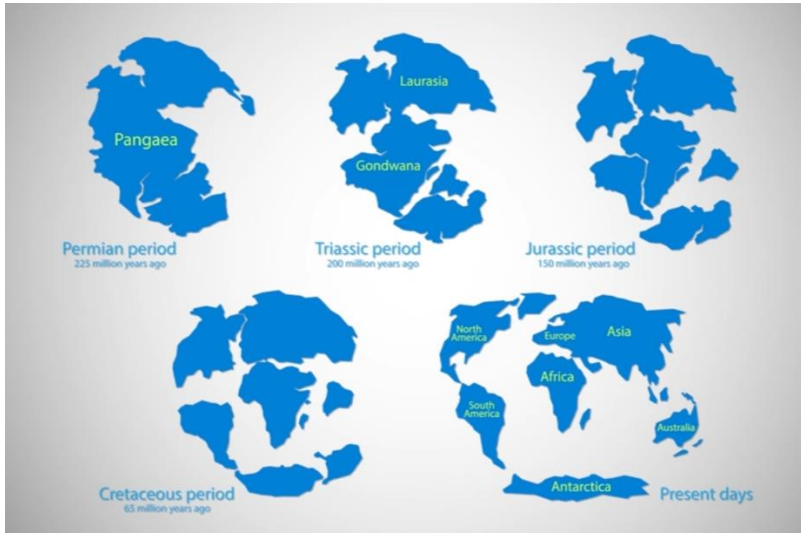
Pattern Recognition – Geology Example

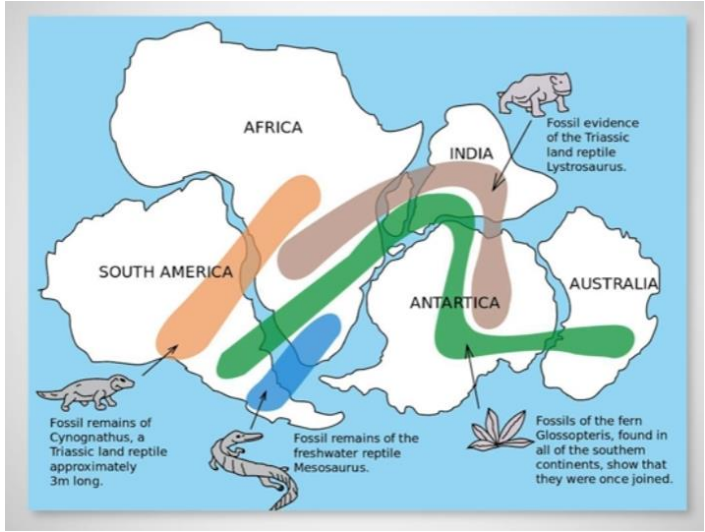
Geology:

- The study of structure, evolution, and dynamics of the Earth and its natural mineral and energy resources.

Pangaea:

- A supercontinent made up of the current 7 continents.





Abstraction in English Language Arts (ELA)

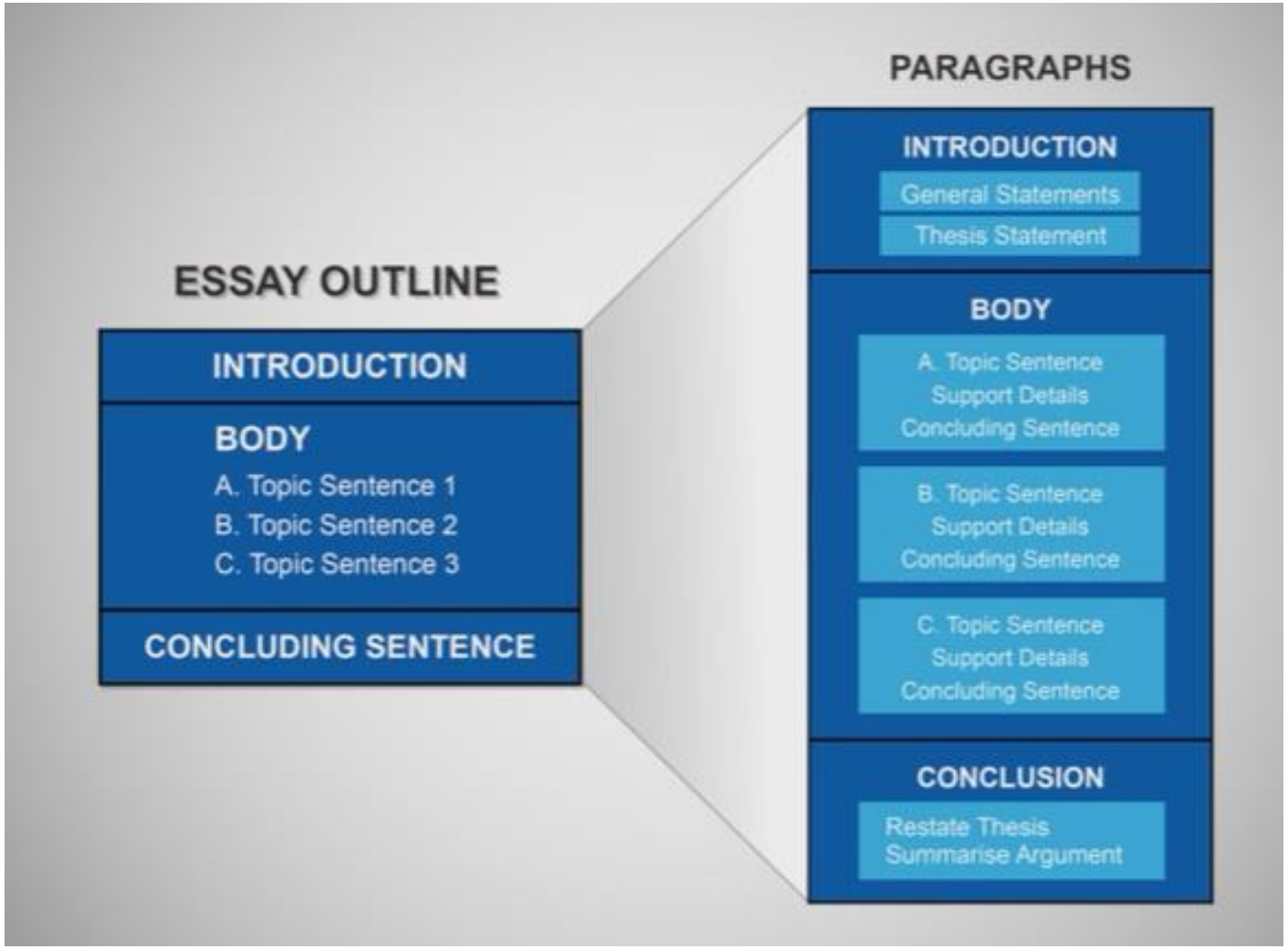
- Abstraction involves the induction of ideas or the synthesis of particular facts into one general theory.
- To provide a book synopsis: sieve out the main plotline of the book; omit small details describing the appearance of characters

Algorithms in ELA

Traditional Poetry defined due to its regular rhythm, verse structure and rhyme scheme.

https://sites.research.google/versebyverse/

Decomposition in ELA



Pattern Recognition in ELA

- Phonics is used to learn to pronounce new words by children
- Patterns and rules can be derived from spellings