Lecture #1

An Introduction to Bio-Inspired Artificial Intelligence

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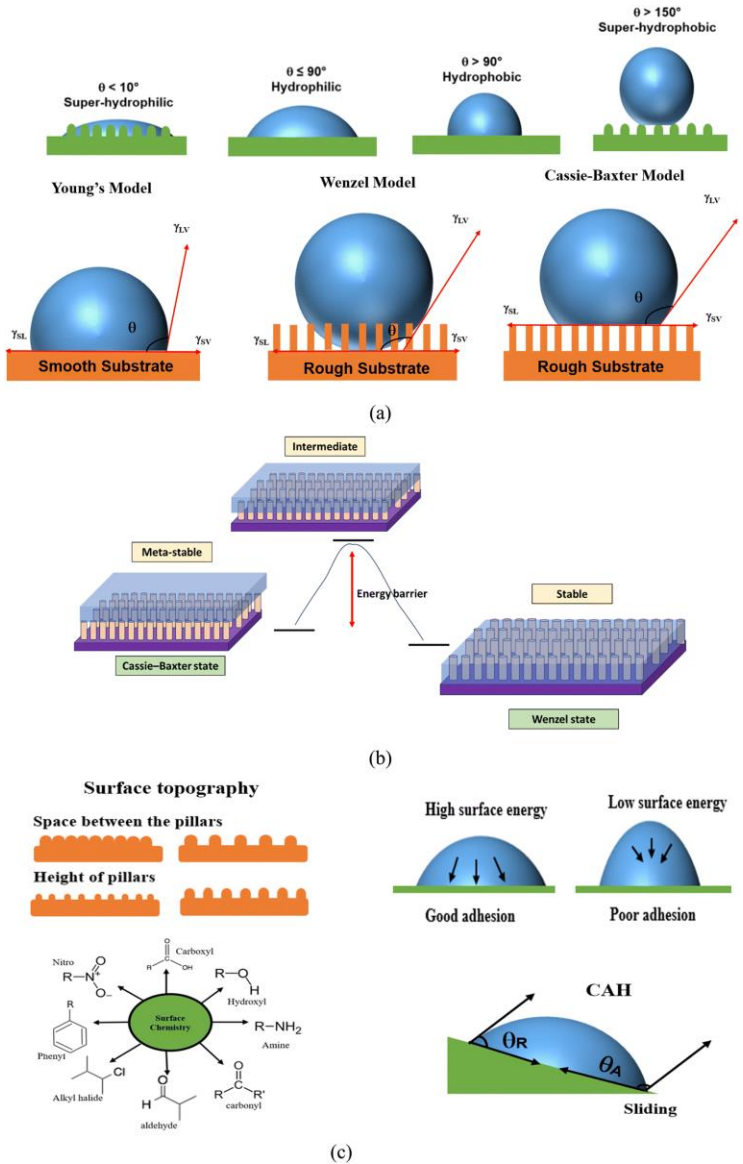
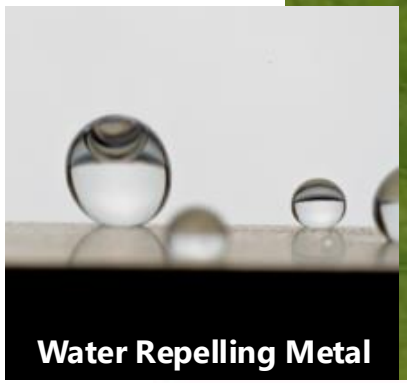
Inspiration from Nature

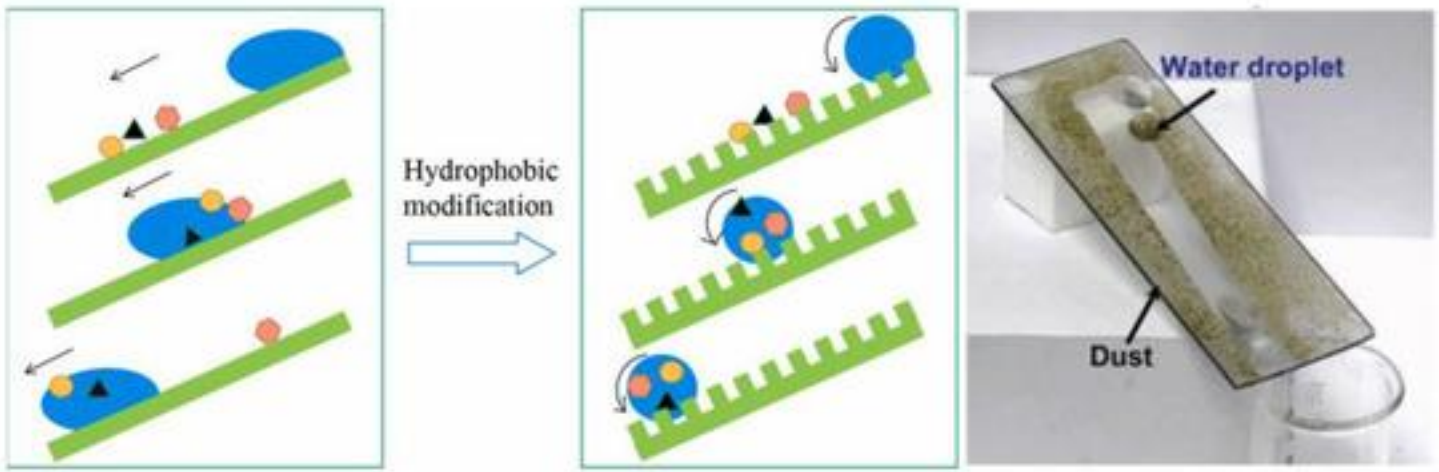
"Human ingenuity may make various inventions, but it will never devise any inventions more beautiful, nor more simple, nor more to the purpose than Nature does; because in her inventions nothing is wanting and nothing is superfluous".

... Leonardo Da Vinci
15th Century

Inspiration from Nature







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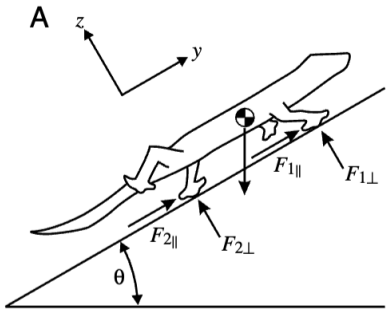

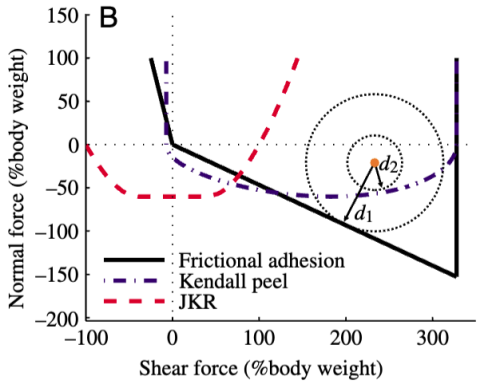

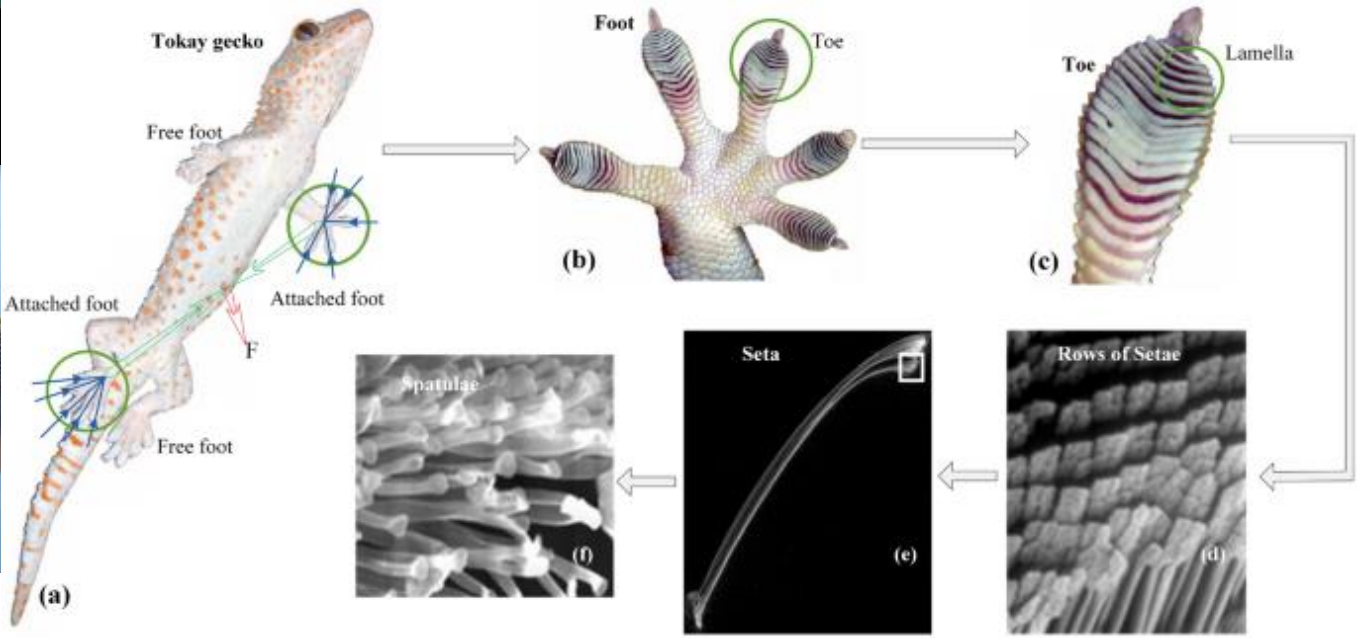

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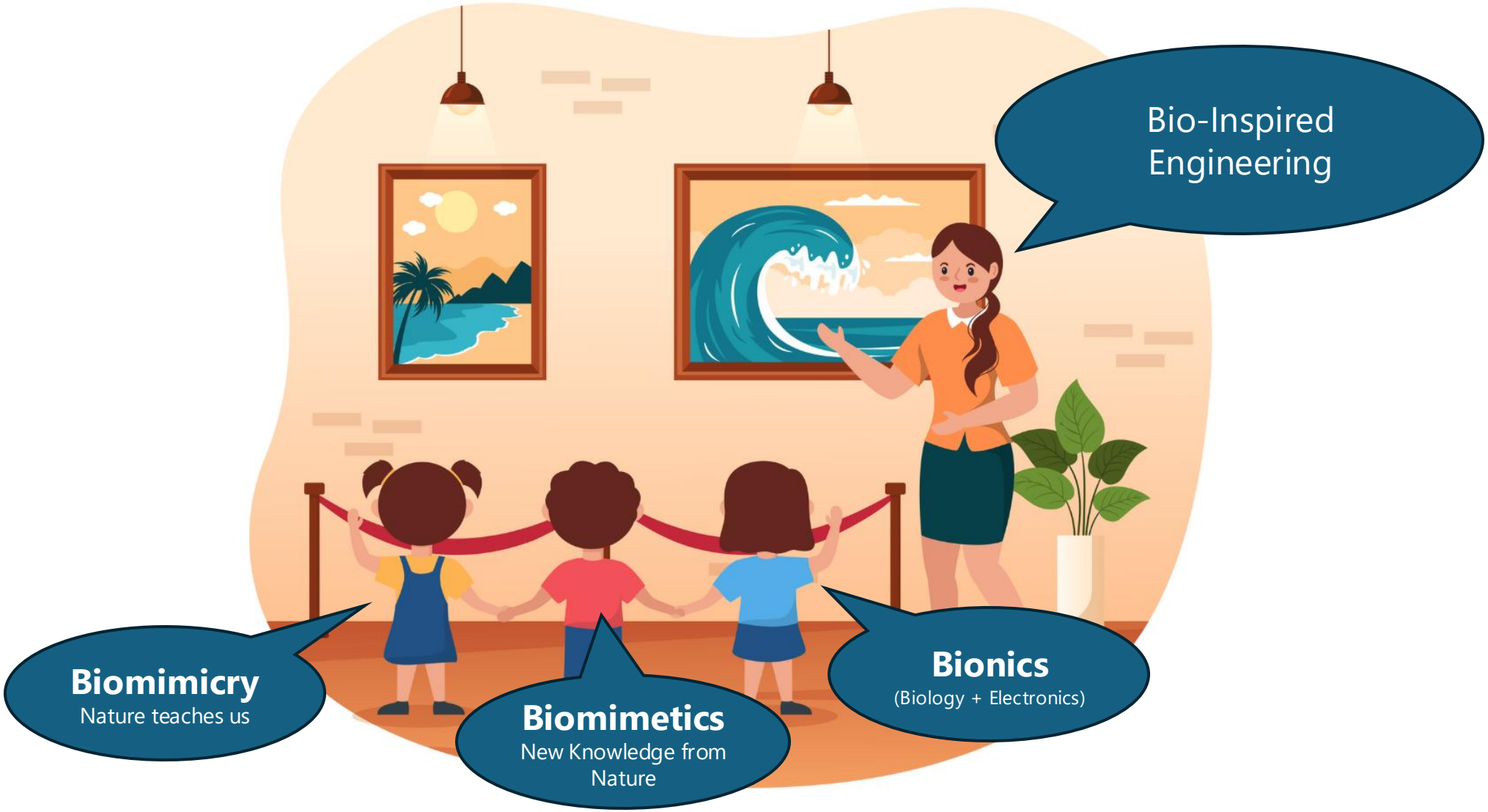
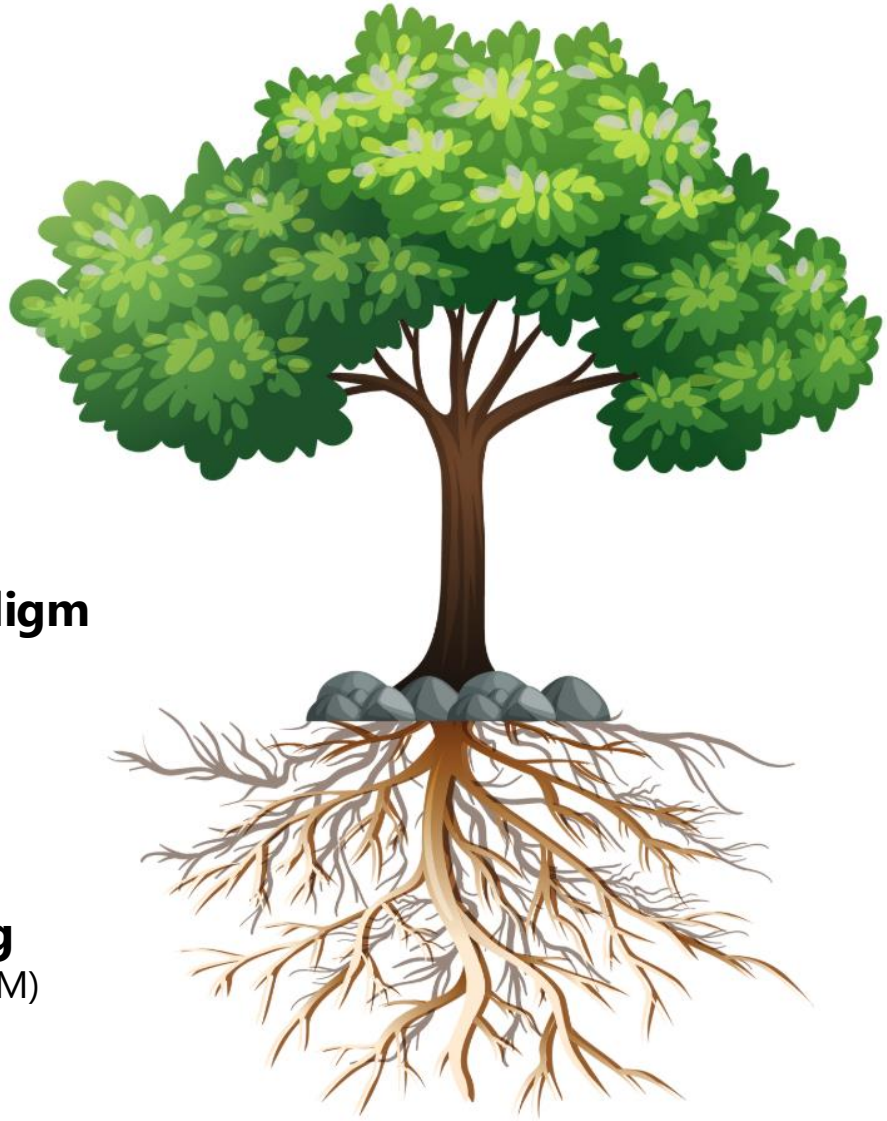


Artificial Intelligence



Classical AI Paradigm
(e.g., expert systems)

Computational Intelligence
(e.g., GA, SI, AIS)

Machine Learning
(e.g., random forest, SVM)

Modern AI Paradigm
(e.g., LLM, NLP)

An Introduction to Computational Intelligence

The study of adaptive mechanisms to enable or facilitate intelligent behavior in complex and in complex and changing environments

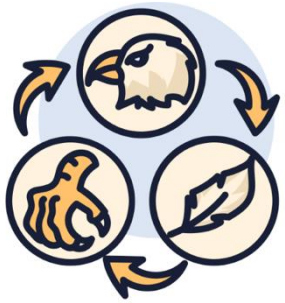
… from A.P. . Engelbrecht, “Computational Intelligence: An Introduction”, Second Edition, 2007

“Adaptation”

Learning Versus Adaptation

Learning

The ability to **acquire knowledge**, **understanding**, or **skills** through study, instruction, or experience.



Adaptation

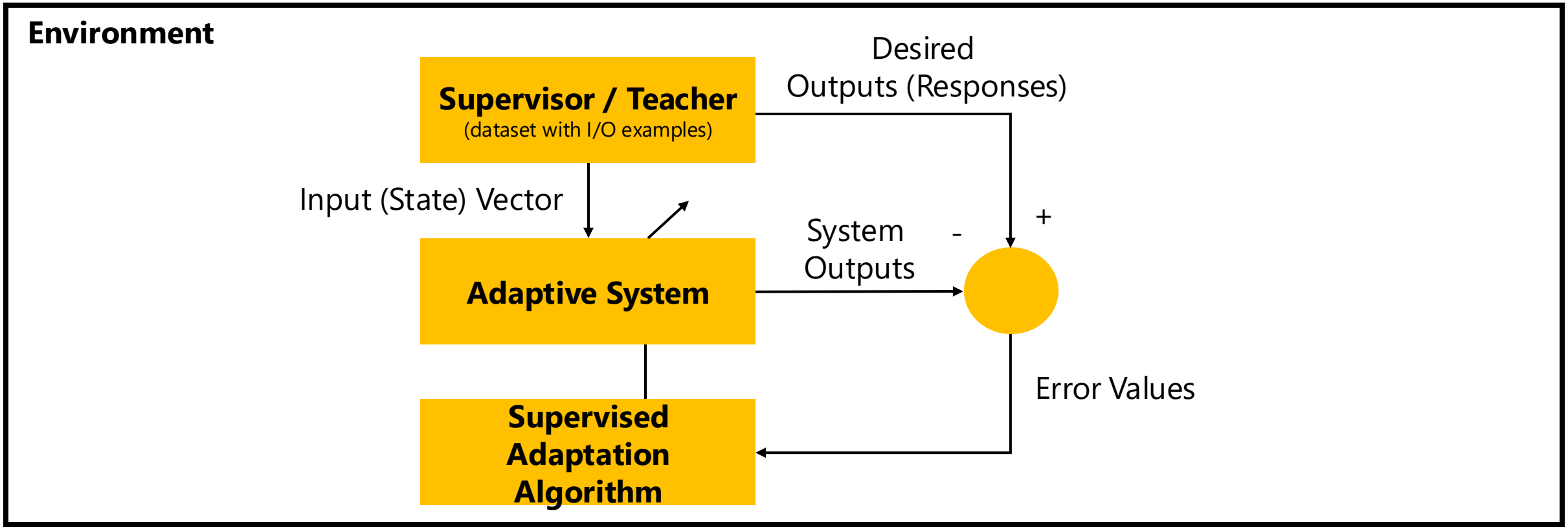
The ability of a system to **adjust** or **evolve** its parameters in order to **better achieve** its **goal**.

Learning applies to the entire intelligent system, while adaptation mainly applies to the portion of the system where computational intelligence exists.

Source: R. C. Eberhart and Y. Shi, Computational intelligence: concepts to implementations, 2007.

Three Types of Adaptation

Supervised Adaptation | **Reinforcement Adaptation** | **Unsupervised Adaptation**



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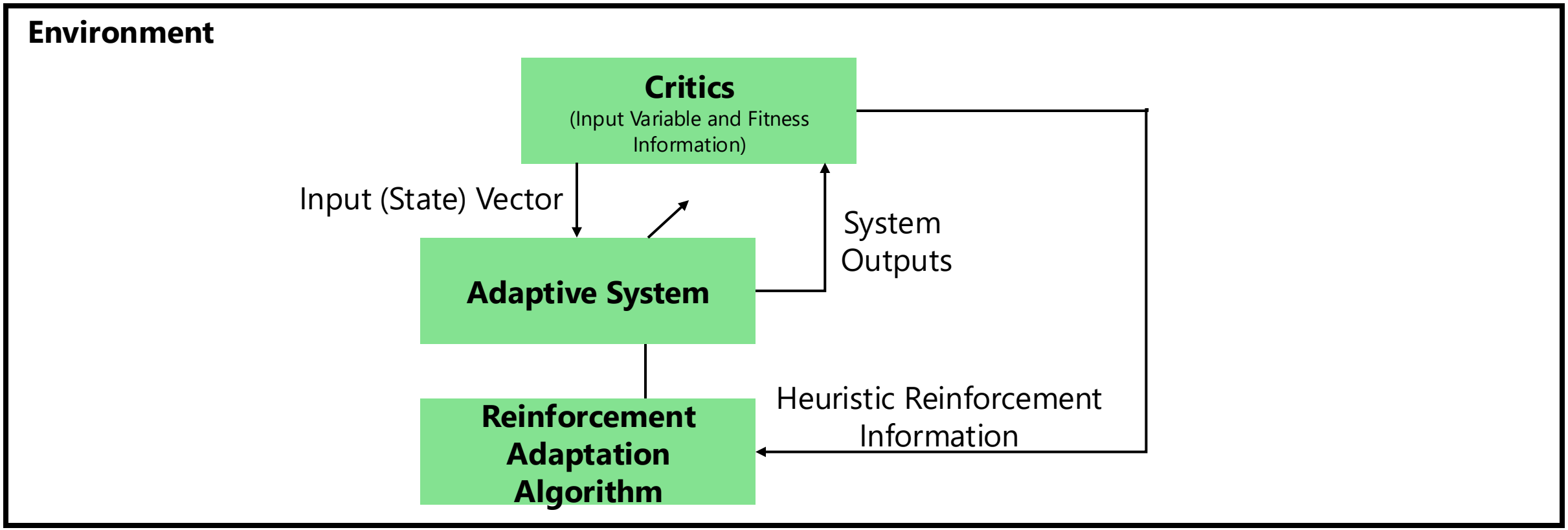
Three Types of Adaptation

Supervised Adaptation

Reinforcement Adaptation

Unsupervised Adaptation



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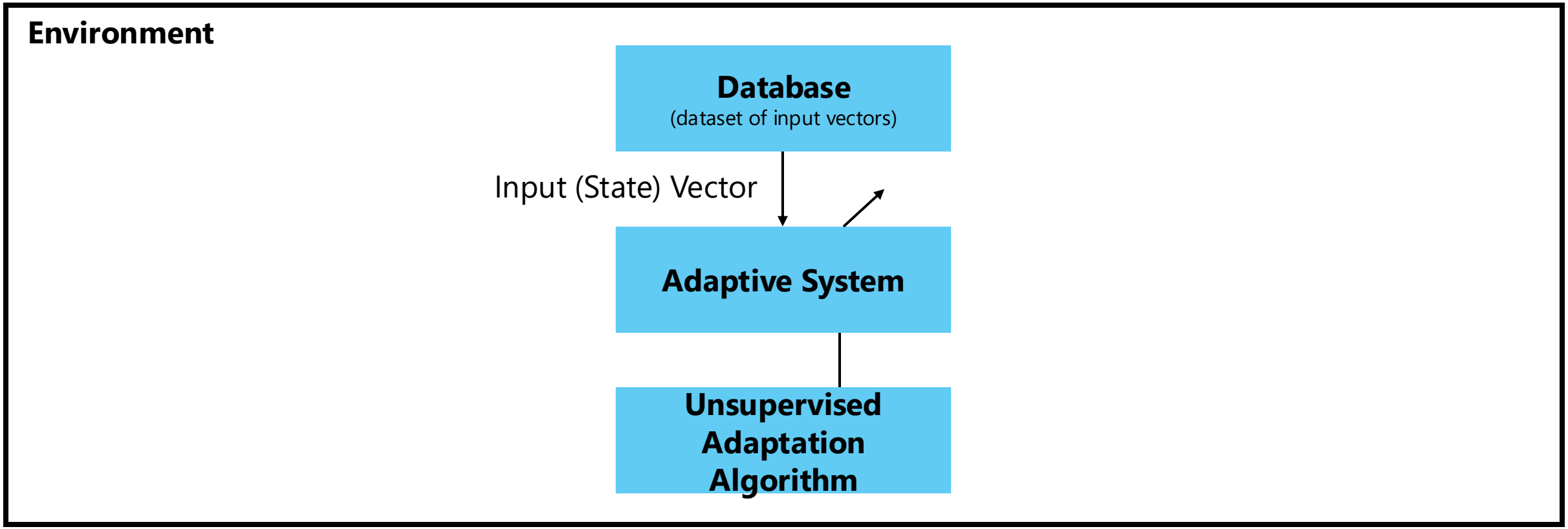
Three Types of Adaptation

Supervised Adaptation

Reinforcement Adaptation

Unsupervised Adaptation



Source: R. C. Eberhart and Y. Shi, Computational intelligence: concepts to implementations, 2007.

Computational Intelligence Definition

- A methodology involving computing that provides a system with **an ability to learn and/or to deal with new situations**, such that the system is perceived to possess one or more attributes of reason, such as **generalization**, **generalization**, **discovery**, **association** and **abstraction**.

- Computational intelligence comprises practical **adaptation** and **self-organization** concepts, paradigms, algorithms and implementations that enable or facilitate appropriate actions (intelligent behavior) in complex and changing environments.

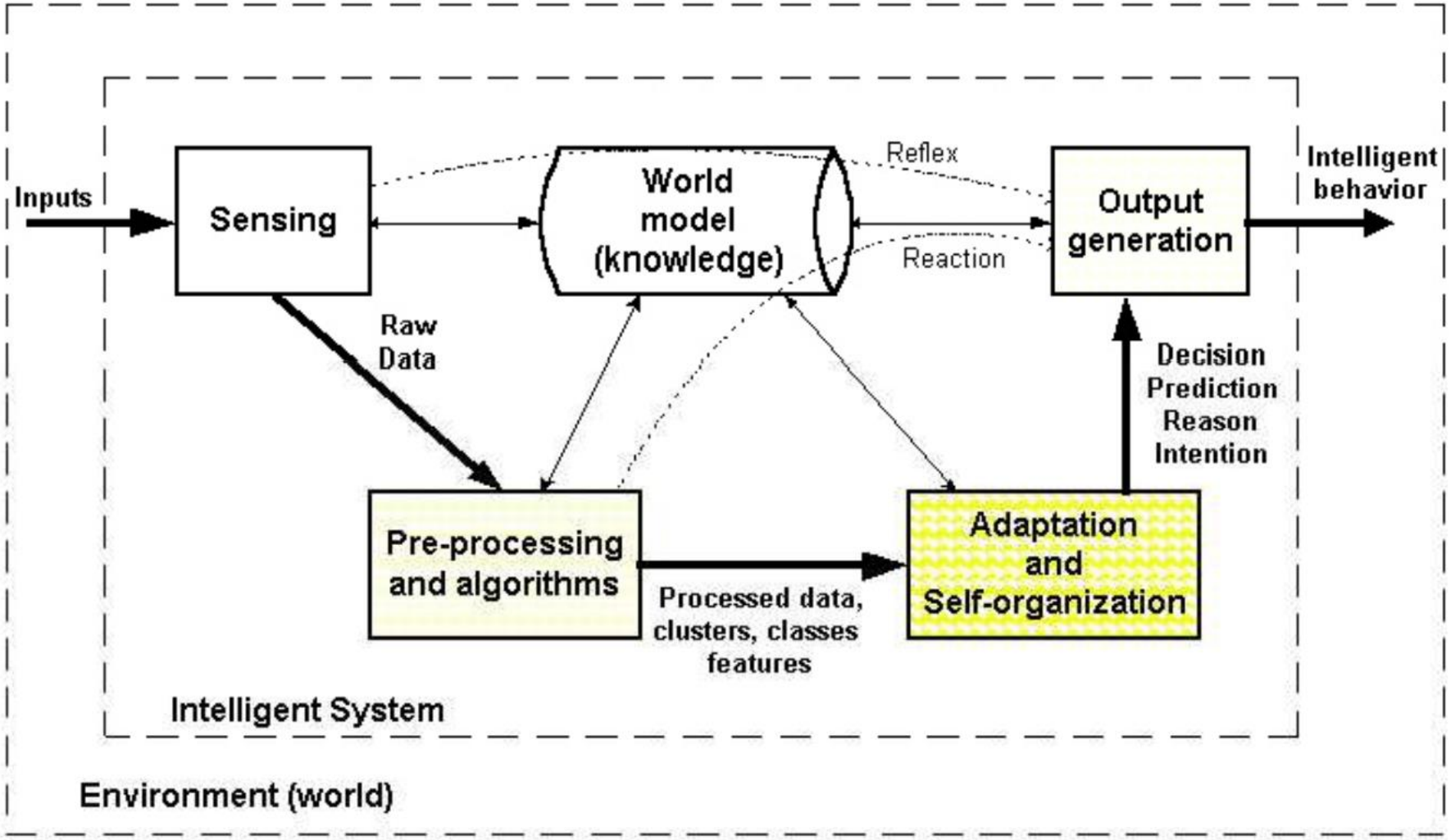
Source: R. C. Eberhart and Y. Shi, Computational intelligence: concepts to implementations, 2007.

Self-Organization

- A self-organizing system functions without central control and through contextual local interactions.
- Components achieve a simple task individually, but a complex collective behavior emerges from their mutual interactions.
- Nature provides examples of self-organization, such as ants food foraging, molecule formation, or antibody detection.
- Self-organizing applications include
  - Multi-Agent Systems
  - Grid
  - Web Communities
  - Networking
  - Network Security
  - Manufacturing Control
  - Business Process Infrastructure

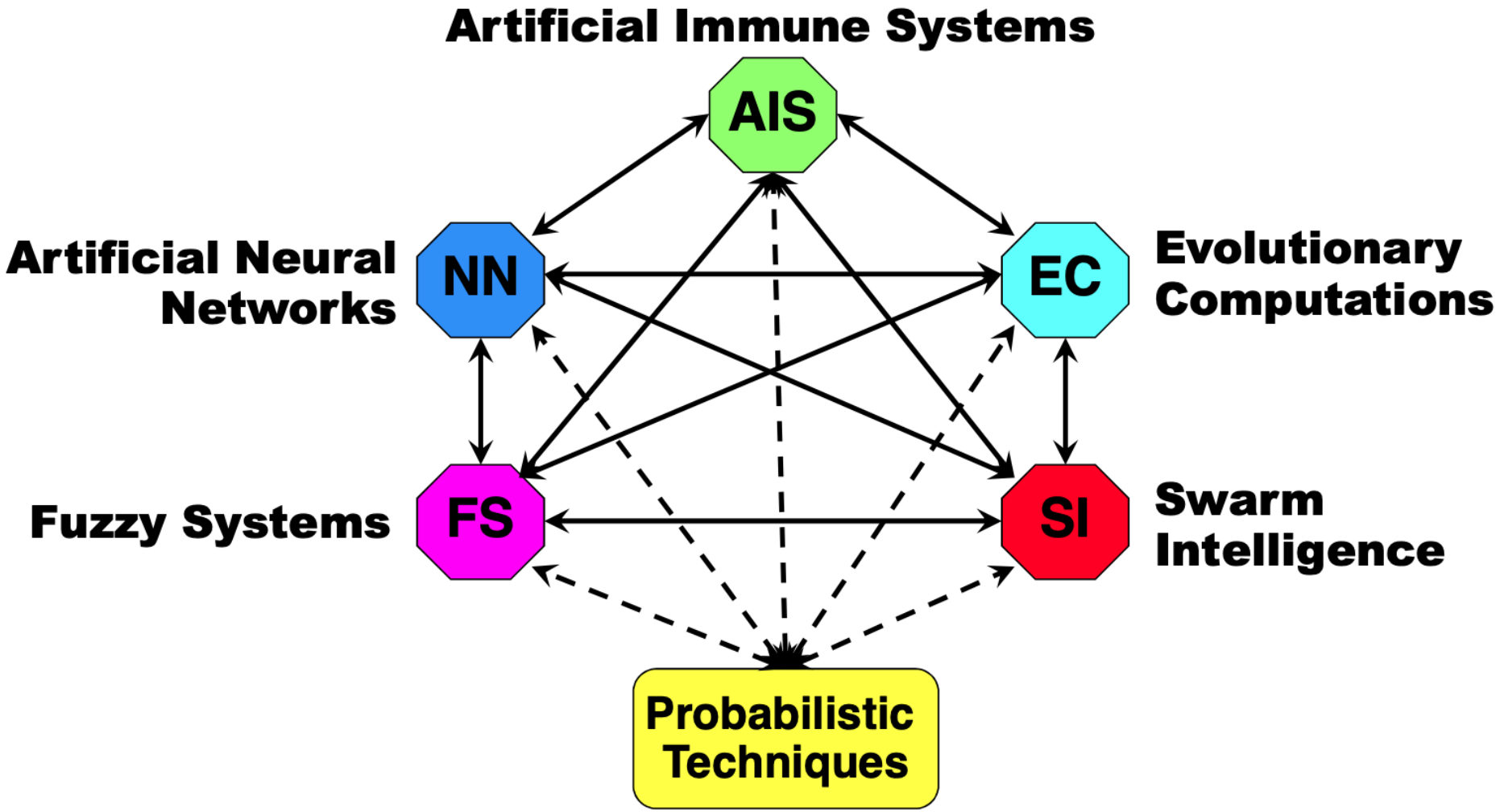
Source: G. Di Marzo Serugendo et al., (Eds.) AAMAS 2003 Ws ESOA, LNAI 2977, pp. 1-19, 2004

Relationships Among Components of Intelligent Systems



Source: R. C. Eberhart and Y. Shi, Computational intelligence: concepts to implementations, 2007.

Computational Intelligence Paradigms



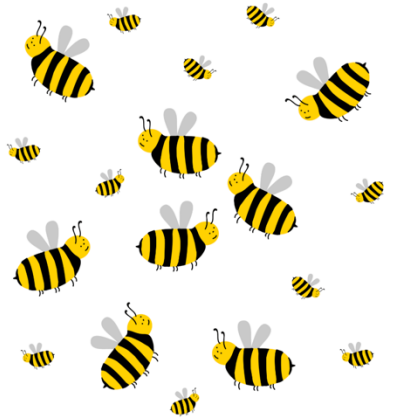
Source: A.P. . Engelbrecht, "Computational Intelligence: An Introduction", Second Edition, 2007.

Scope of this Competency

Evolutionary Computation

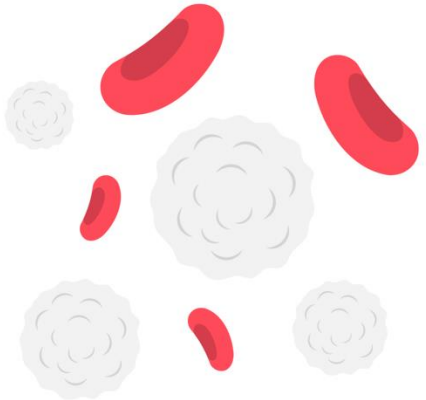
You will learn the basic concept of evolutionary computation, such as genetic algorithms and their variants.

Swarm Intelligence



You will learn about the core idea how agents are working together intelligently using the concept of swarm intelligence, such as particle swarm intelligence, or ant colony

Arificial Immune System

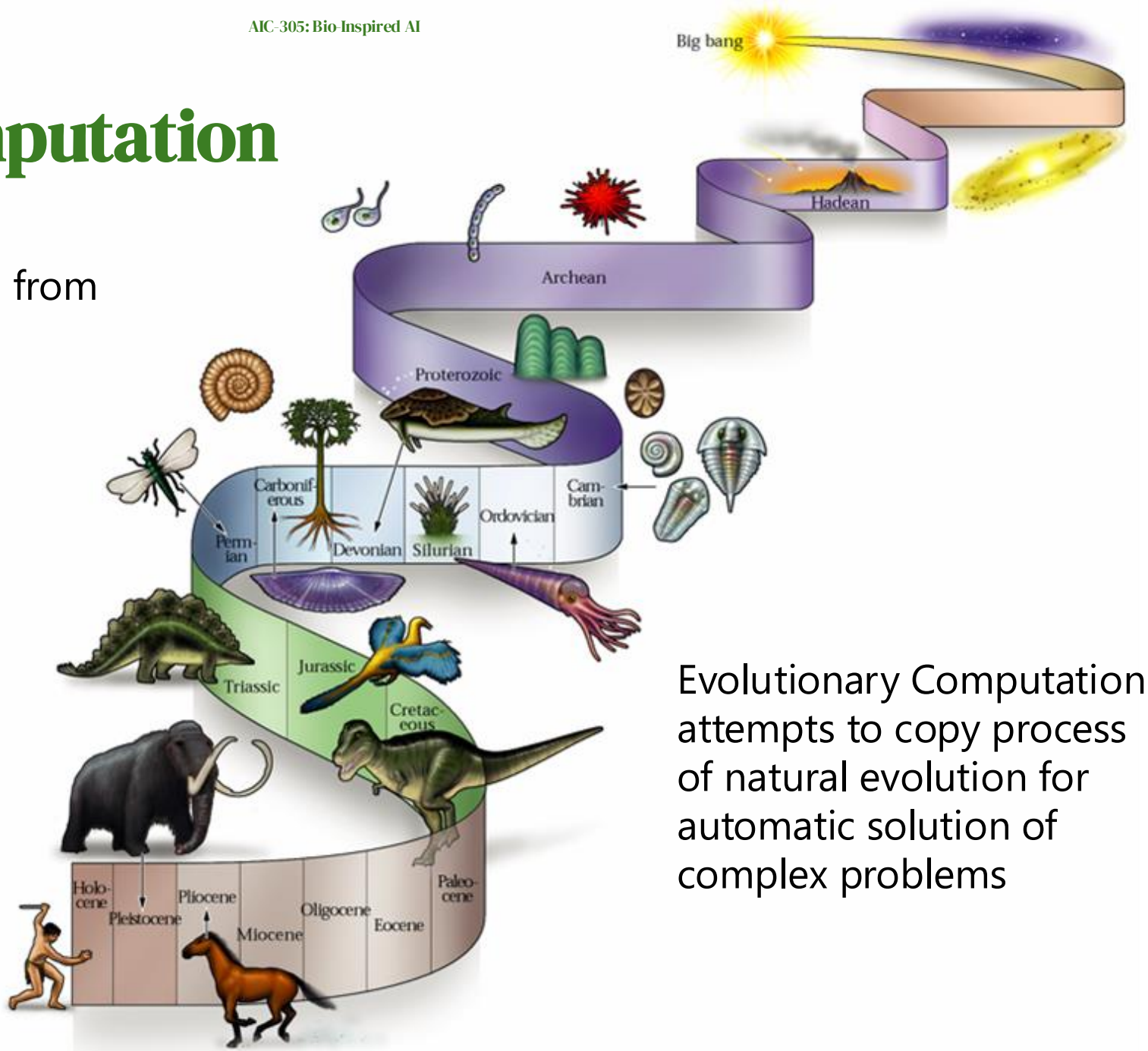


You will learn about how AI and computational systems could imitate the human immune system and make it possible to solve complex problems.

Evolutionary Computation

Biological systems result from an evolutionary process

Biological systems are
- robust
- complex
- adaptive

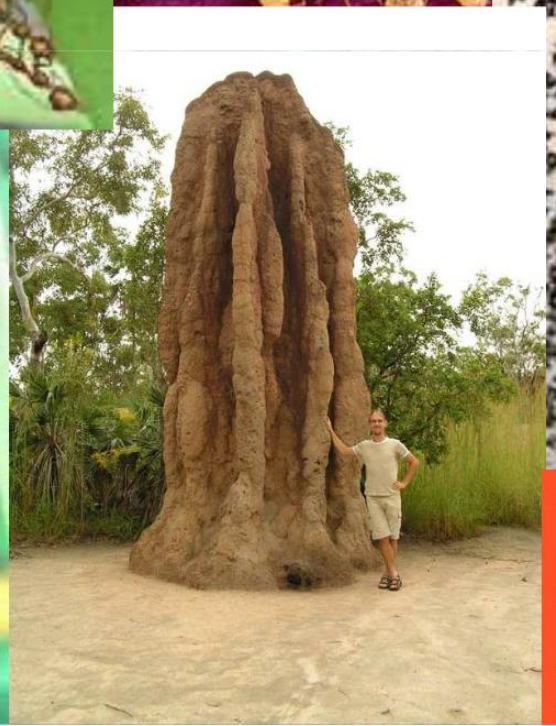


Evolutionary Computation attempts to copy process of natural evolution for automatic solution of complex problems

Source: D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, 2008

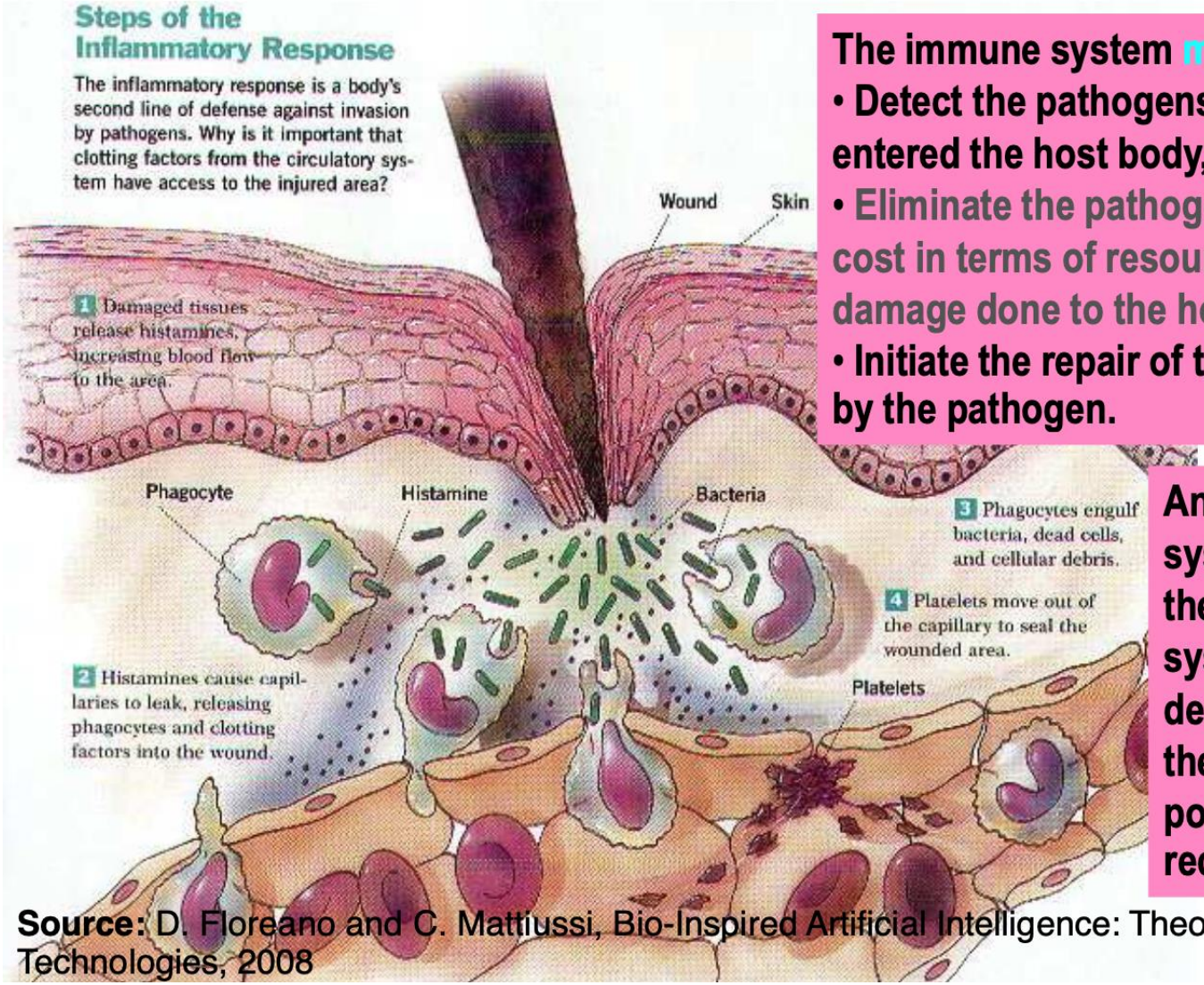
Swarm Intelligence

Swarm intelligence is inspired by collaborative behaviours in social animals such as birds, ants, fish and termites.



These social animals require no leader. Their collaborative behaviours emerge from interactions among individuals.

Artificial Immune System



The immune system must:

- **Detect the pathogens once they have entered the host body,**
- **Eliminate the pathogens with minimal cost in terms of resources employed and damage done to the host, and**
- **Initiate the repair of the damages done by the pathogen.**

An artificial immune system (AIS) models the natural immune system's ability to detect cells foreign to the body, which is powerful pattern recognition ability.

Source: D. Floreano and C. Mattiussi, Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies, 2008

Style of Learning

- Lecture + Discussion
- Problem-based Learning Through **3 Algorithms**, i.e., Evolutionary Computation, Swarm Intelligence, and Artificial Immune System
- For each algorthm,
  - **Week 1: I will conduct a lecture for the algorithm.**
    - At the end of the class, students will be separated into groups which will be responsible for each variation of the algorithm.
    - Each group will receive reading documents which serve as guidelines for the group assignment.
  - **Week 2: I will open the class for group discussion and presentation.**
    - The presentation must cover the explanation of the variant, programming code/pseudo code for implementing the variant, and a simple simulation for your choice of application.

End of the Lecture

Please don’t hesitate to raise your hand and ask questions if you're curious about anything!