Membrane system/ P system

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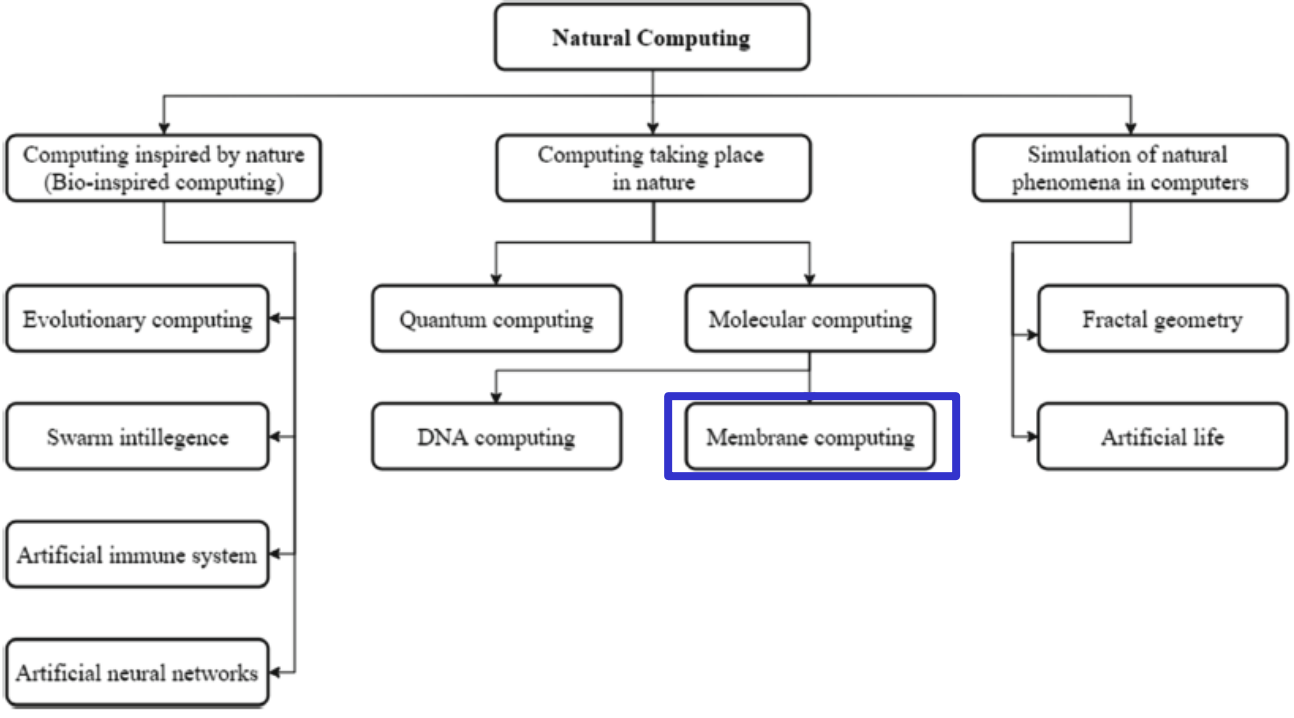
What is membrane system/p system?

- A branch of natural computing.
- Biologically-inspired computational model.
- Based upon the structure and functioning of biological cells.
- The obtained computing devices are called membrane system/ p system.
- First introduced by Gheorghe Păun in 1998.

What is membrane system/p system?



Types of membrane or p system:

- Cell-like p system:
- Tissue-like p system
- Neural p system

Types of membrane or p system:

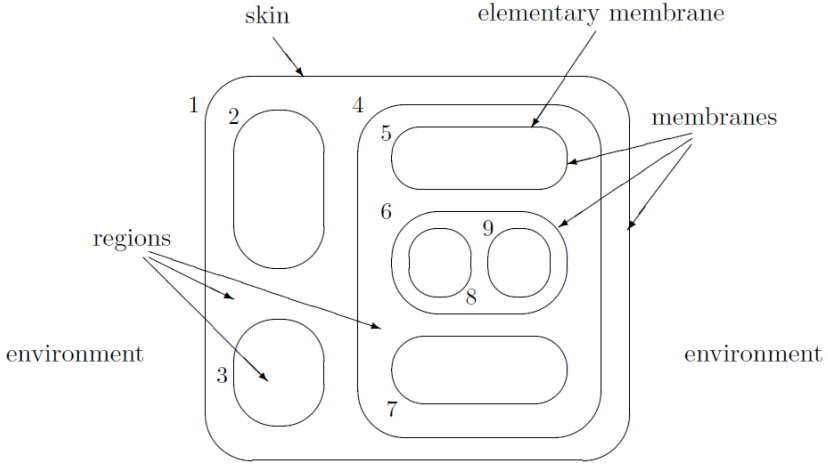
- Cell-like p system:
  - A single cell ; basic element- membrane structure
- Tissue-like p system
  - Several one-membrane cells in a common environment.
  - Communicate with each other through environment or by channels.
- Neural p system
  - Two type (i) tissue-like neural P system (ii) spiking neural P system
  - Spiking neural P system- inspired from the way that neurons process and communicate data by sending spikes.

Components of membrane system:

- Membranes
- Symbols/Objects
- Catalysts
- Rules
- Environment

Components of membrane system:

- Membranes
  - Main structures of a P system. It contain:
    - Set of objects: Chemicals/catalysts
    - Set of rules: Determine possible ways in which chemicals may react with one another to form products.
    - Set of other membranes
  - Elementary membrane: membrane without any other membrane inside is called.
  - Skin membrane: Outermost membrane.



A membrane structure

Components of membrane system:

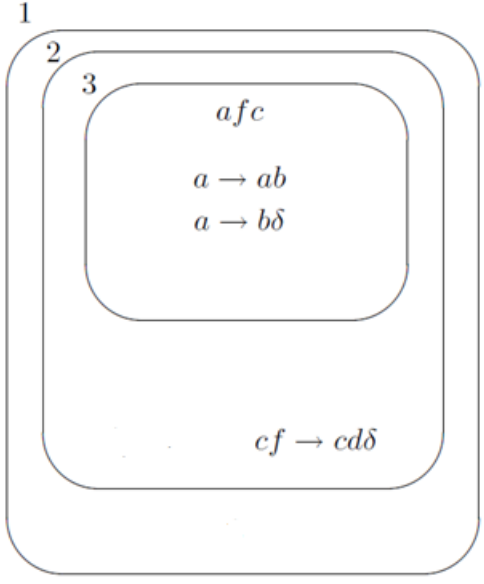
- Symbols
  - Represent chemicals which reacts with other chemicals.
  - Represented by different letter.
- Catalysts
  - Assists the object to evolve.
  - Not consumed during a reaction.

Components of membrane system:

- Rules
  - Represent possible chemical reaction.
  - Input objects are consumed and output objects are produced according to the rule.
  - Input objects needs to be present in order for it to be applied.

Components of membrane system:

- Rules
  - Different types of rules.
    - Evolution rules
    - Communication rules
    - Rules for handling membranes
    - Membrane dissolving rule-(denoted by delta (δ)) corresponding membrane disappears and its contents, object are left free in the surrounding membrane.

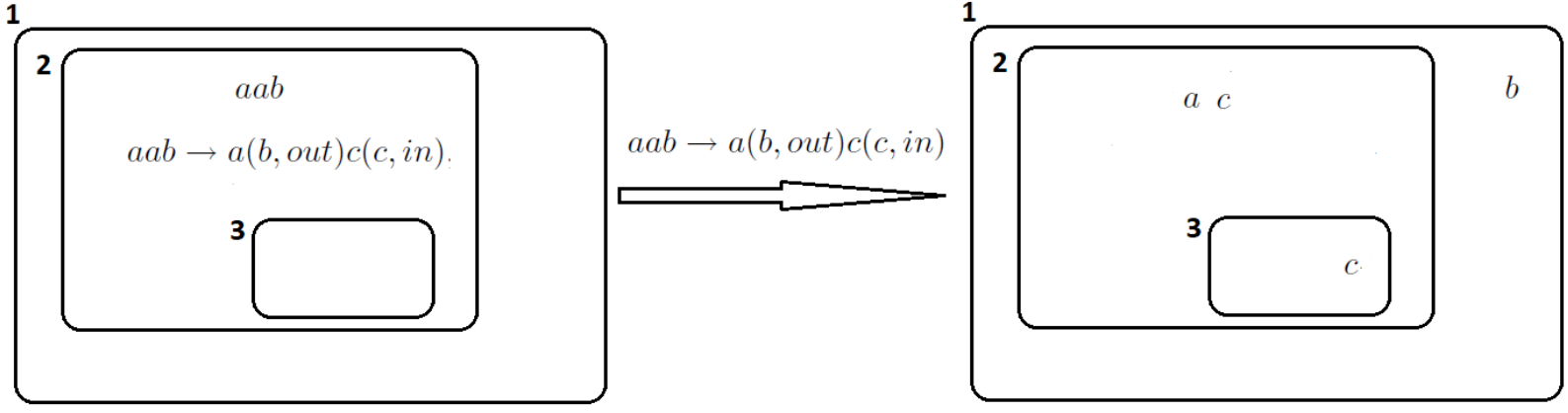


Components of membrane system:

- Rules
  - To move objects across membranes, target indications are added to the objects
  - “Here”: (Default) meaning object remains in the same region
  - “In”: Object goes immediately into a directly lower membrane, non-deterministically.
  - “Out”: Object exits the membrane, becoming an element of the region surrounding it.

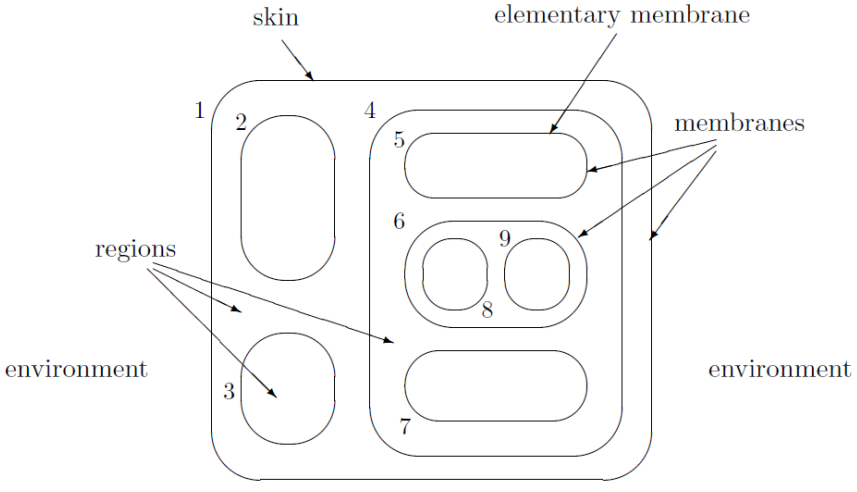
Components of membrane system:

- Rules
  - aab-> (a, here)(b, out)(c, here)(c, in)



Components of membrane system:

- Environment
  - The surroundings of P system.
  - Never hold rules.
  - Objects may pass into it during the computation.
  - Objects found within the environment at the end of the computation constitute all or part of its “result.”



A membrane structure

Computation:

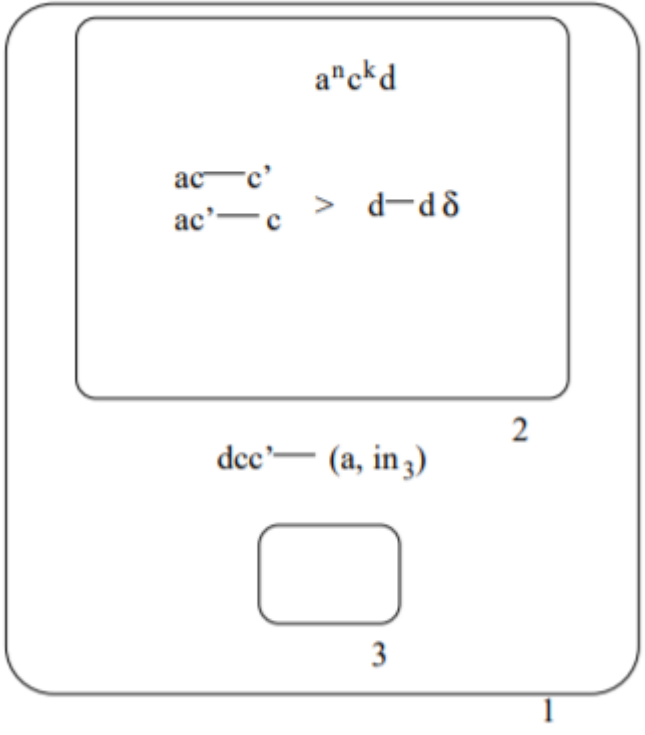
- A global clock is assumed for all regions of the system
- In each time unit, a transition of the system from one state to another by using rules, defined as the *configuration*, takes place.
- Computation halts when no further rules can be applied.
- Objects that have been passed to the environment or designated result membrane, are considered to be the result of the computation.

Feature of P system:

- Rules and the objects are chosen:
  - **Non-deterministically**
  - **In maximally parallel manner**

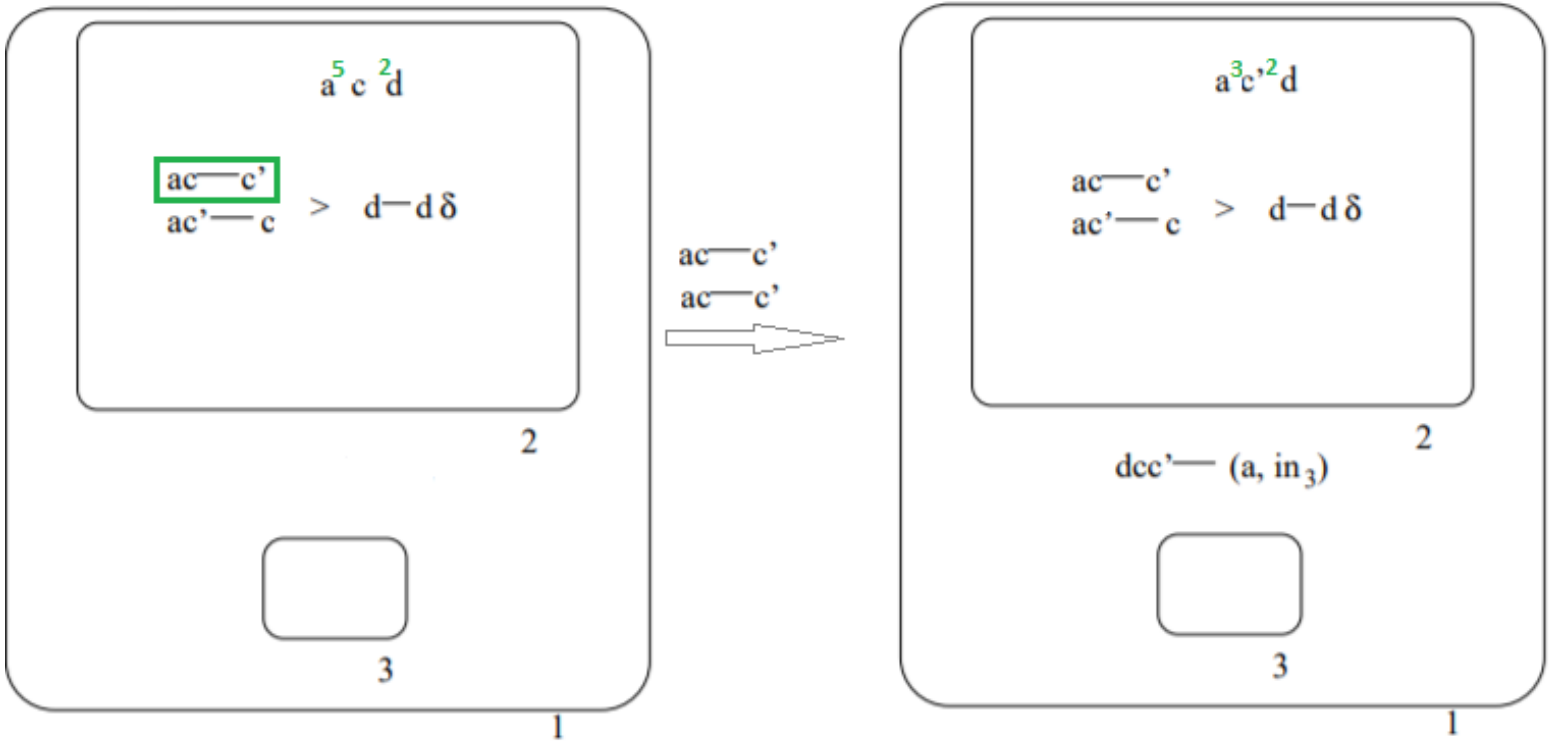
Example: Divisibility test

Whether n is divisible by k:



Example: Divisibility test

N=5; k=2:



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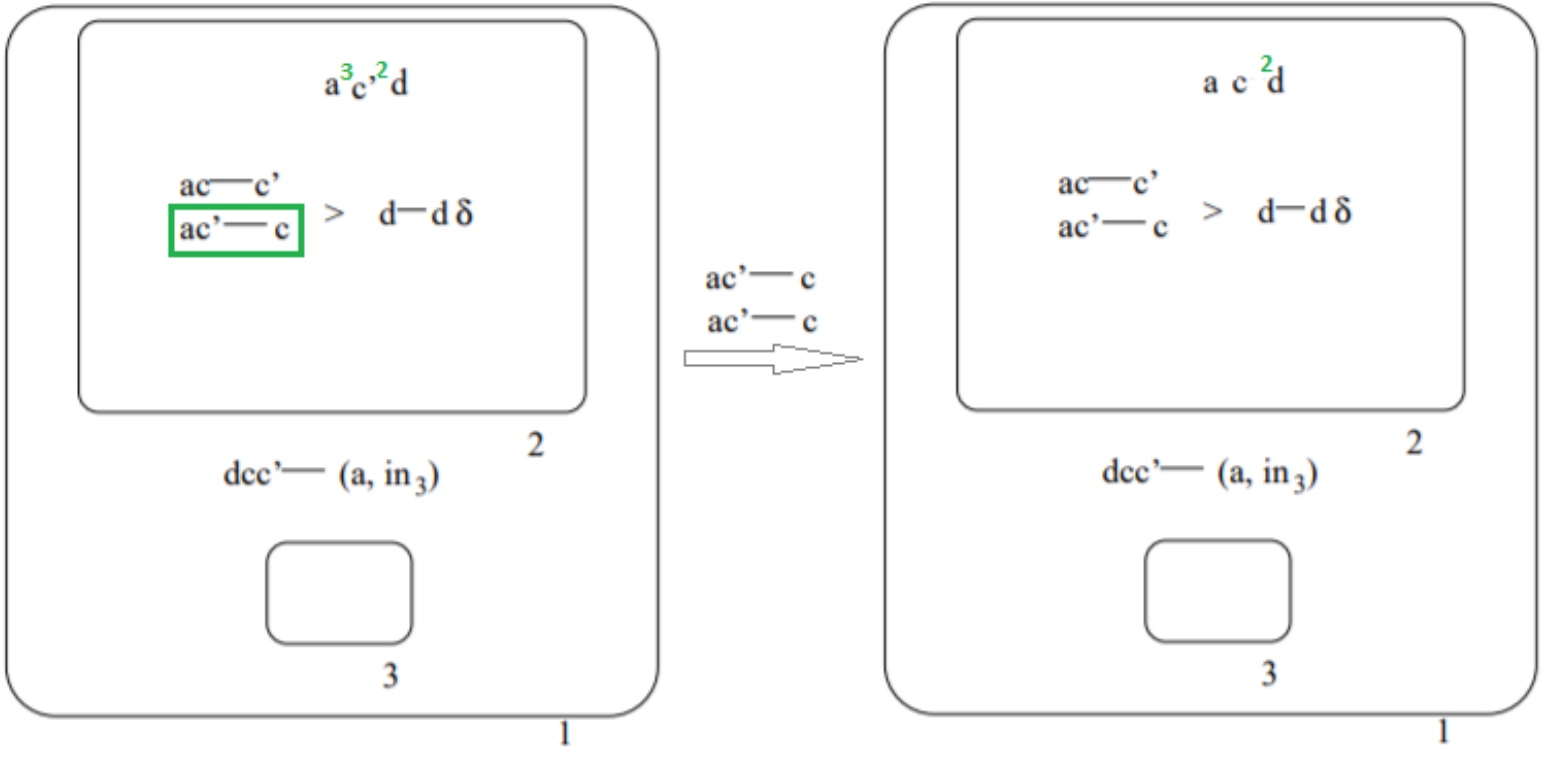

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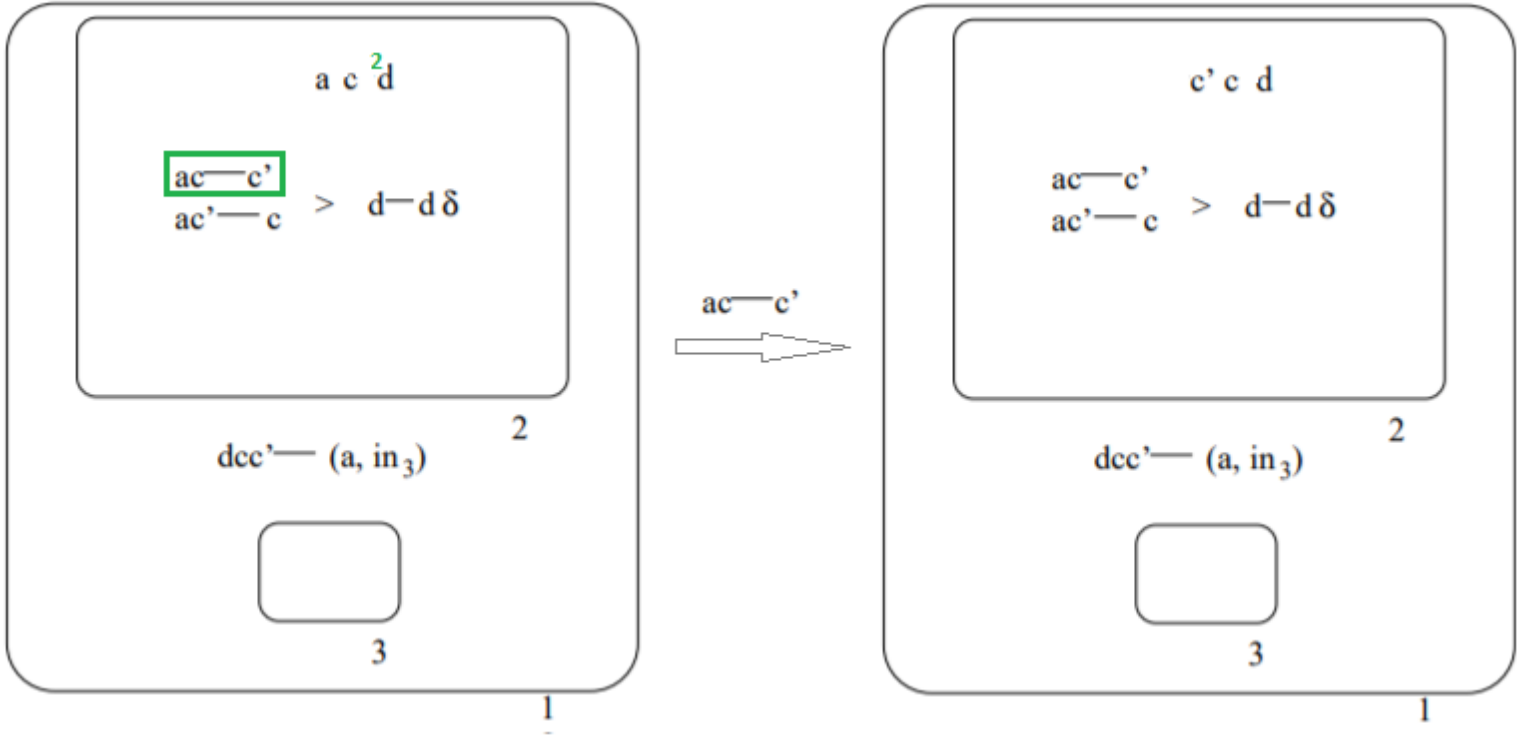

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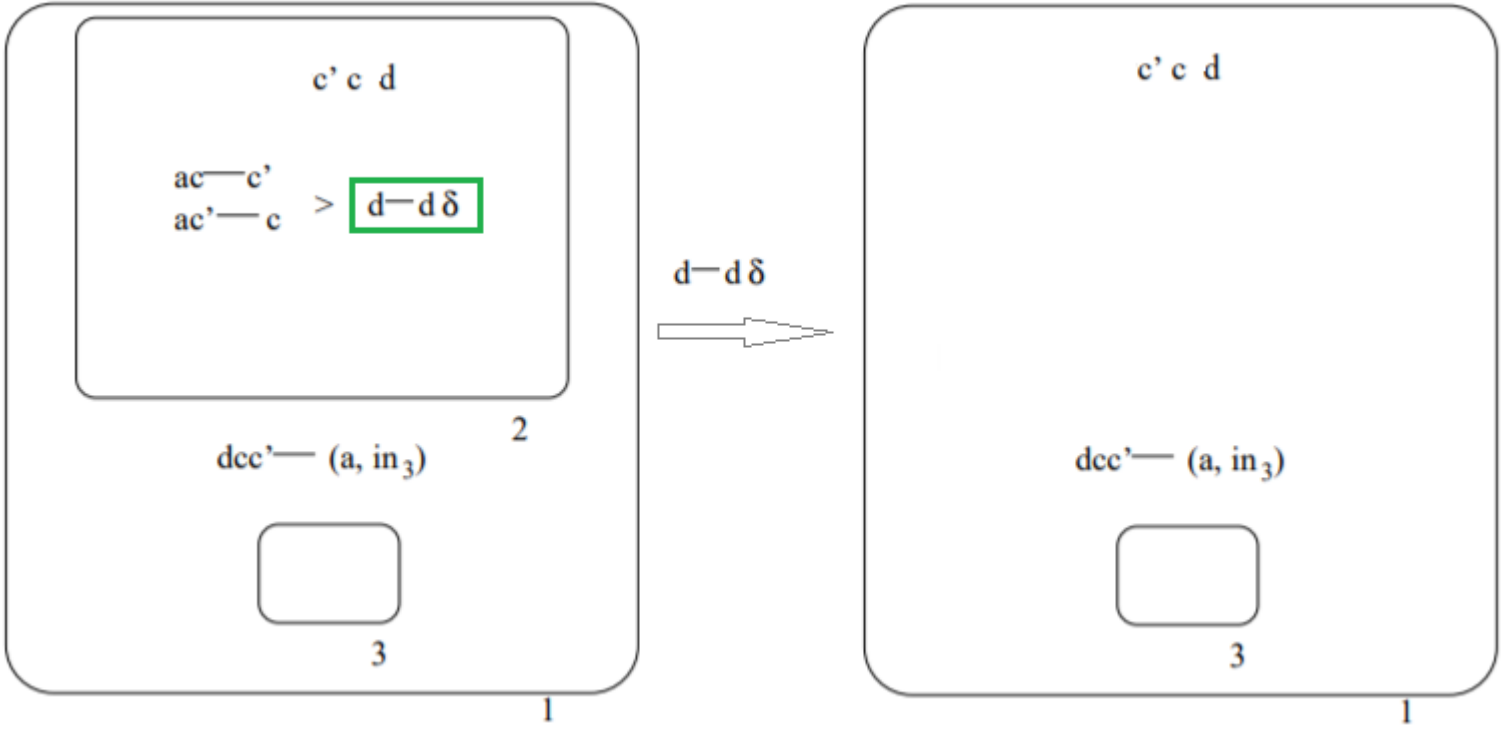

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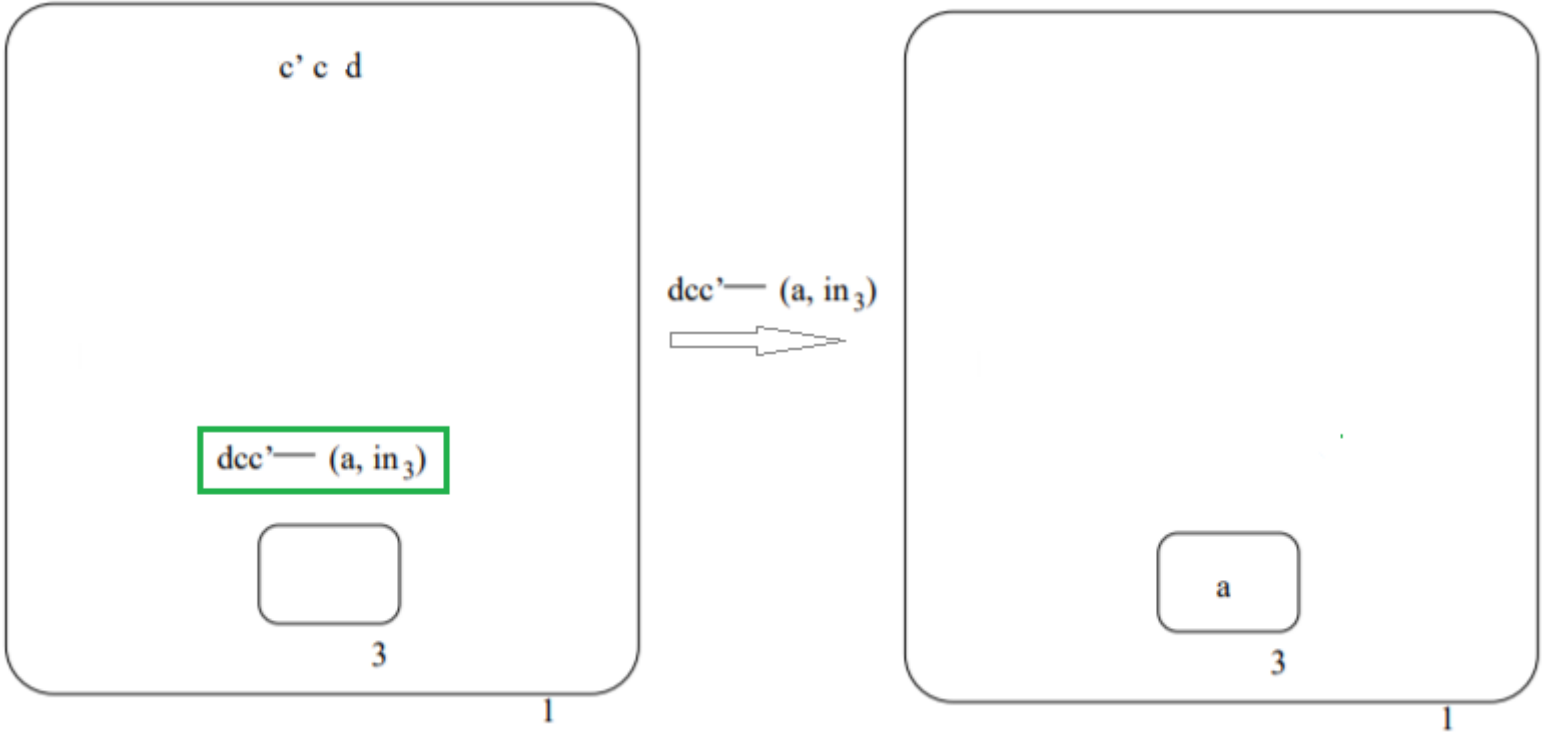
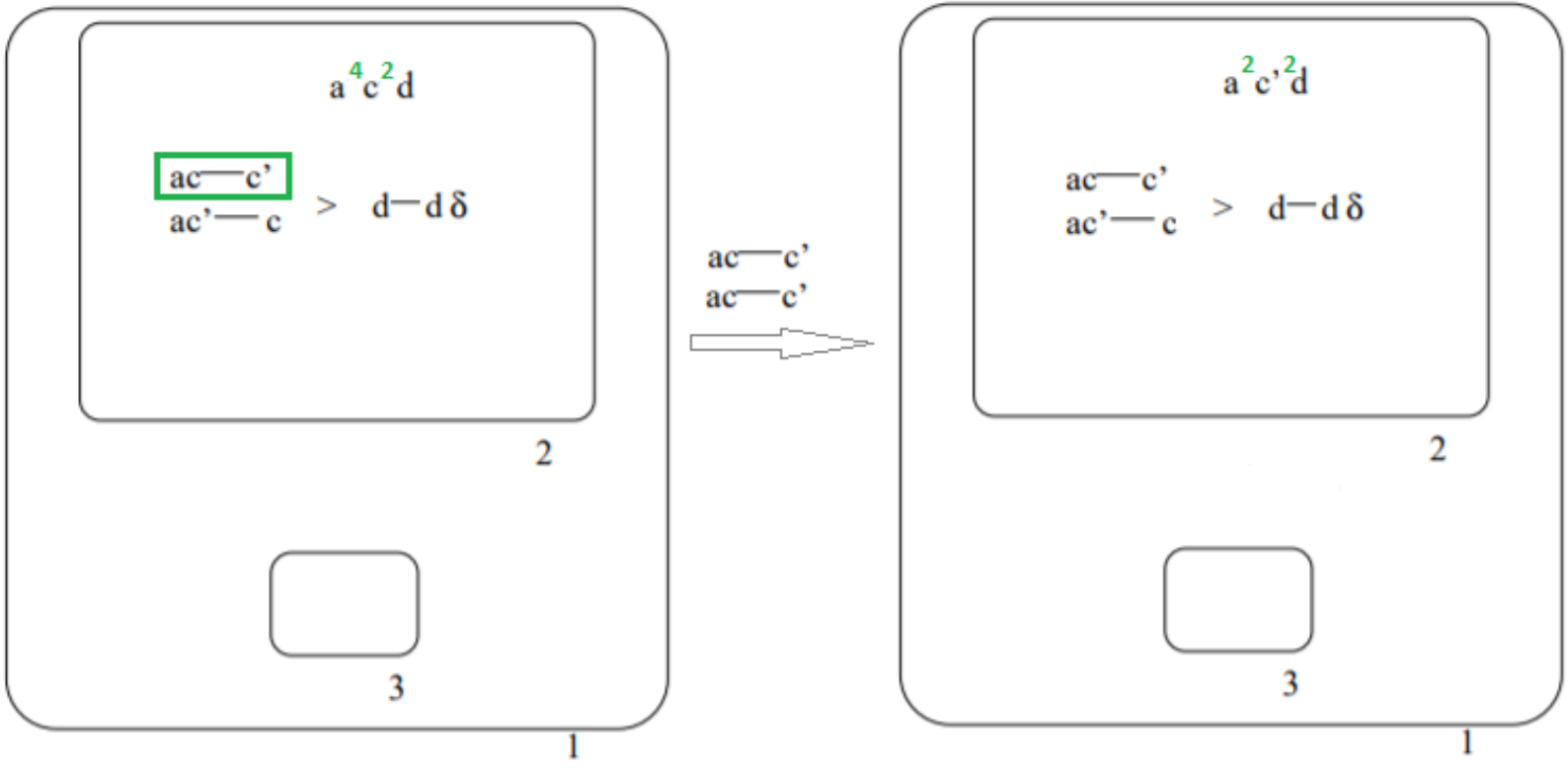


Example: Divisibility test

N=4; k=2:



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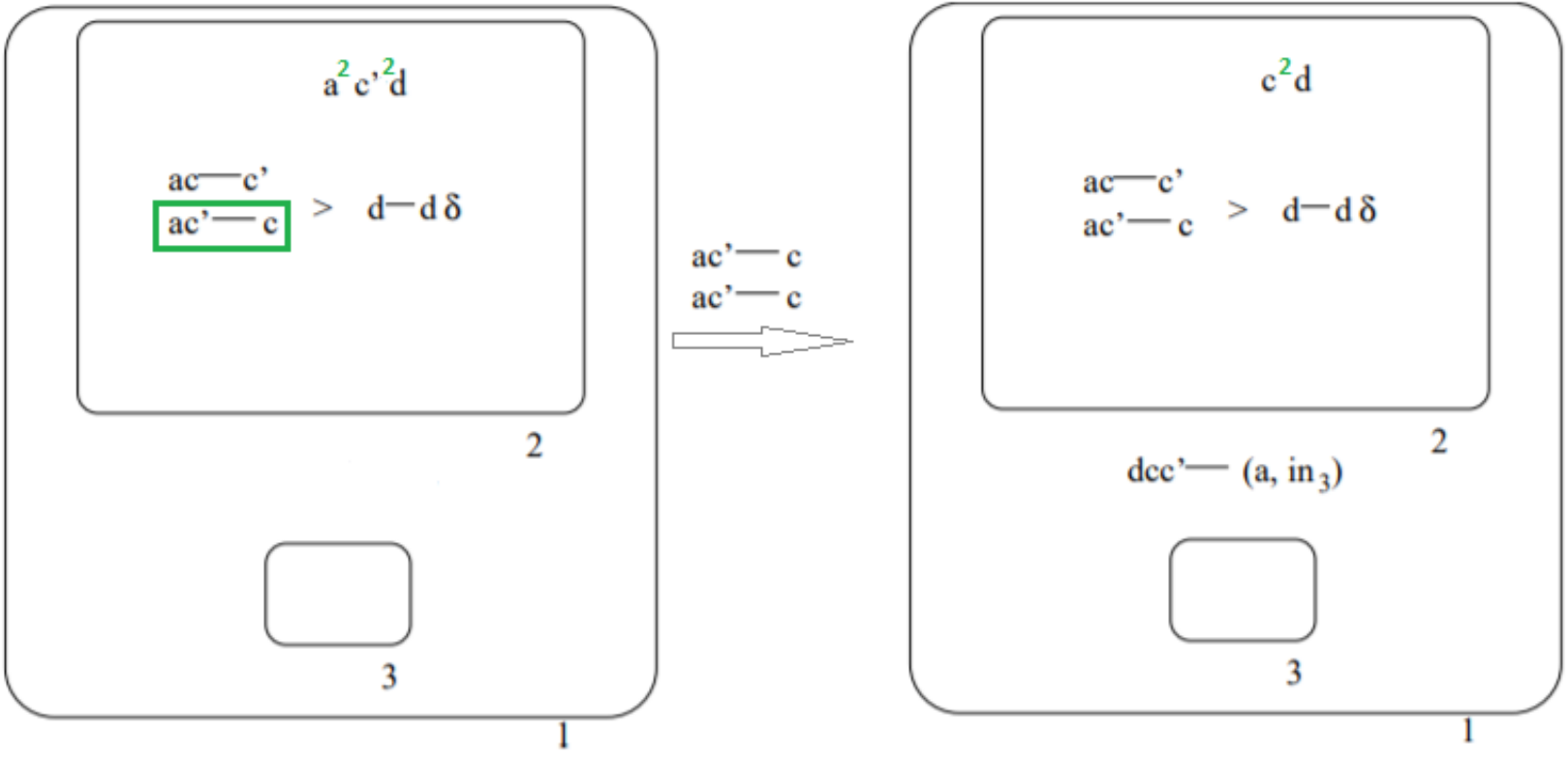

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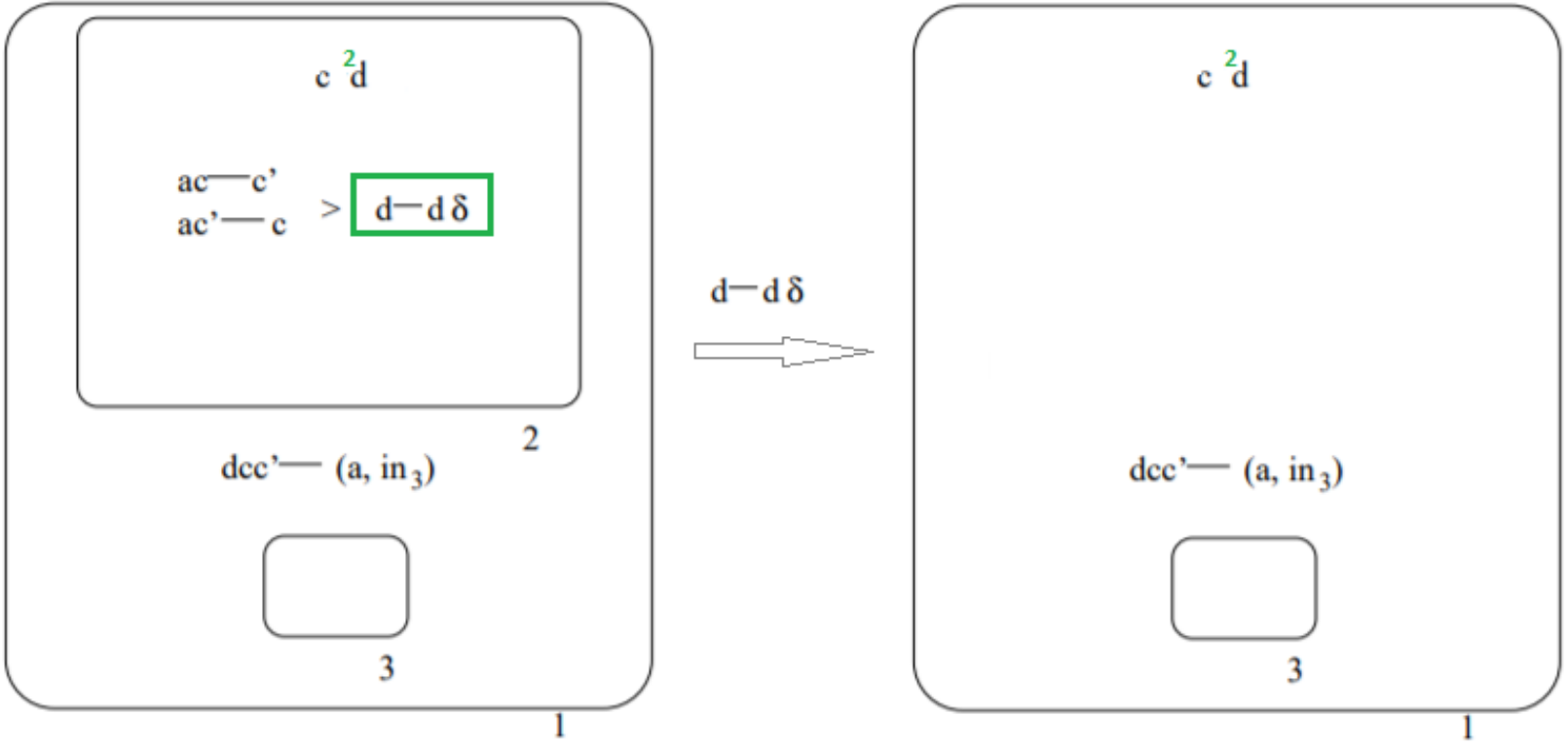
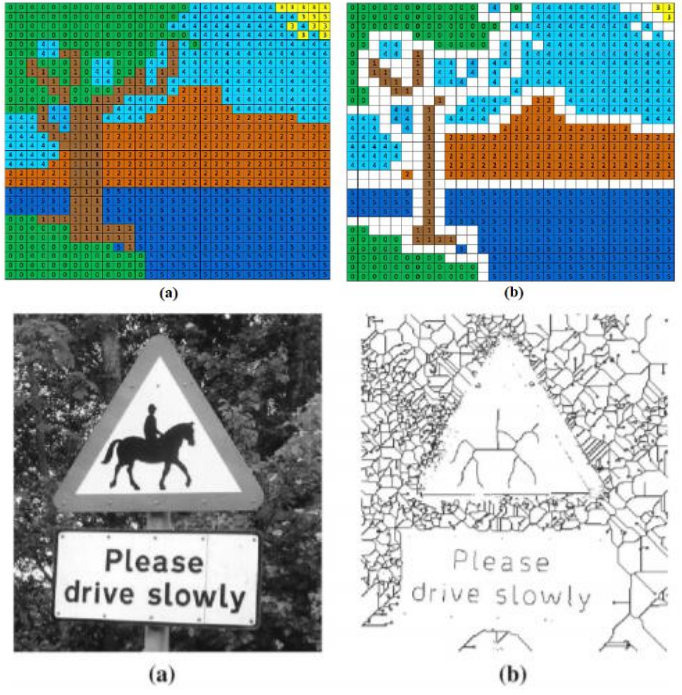


Applications:

- Membrane computing has been implemented in many real world applications in the areas of:
  - Biology
  - Optimization problem
  - Design of logic gates
  - SAT problem
  - Cryptography
  - Robot control
  - Digital Image Processing

Application in Digital Image Processing:

- Image segmentation
- Smooth 2D image by removing noise
- Skeletonizing images



Concluding remarks:

- Most classes of P systems, even with reduced complexity, are Turing complete.
- P systems with enhanced parallelism, can solve problems typically in a polynomial.
- Speed-up is obtained by trading space for time i.e. producing an exponential workspace in a linear time by means of membrane division, membrane creation, membrane separation etc.

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Thank You….