



# Membrane Computing After Twenty Years

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**CMC 20**

\*Alexander Dumas: *Twenty Years After/Vingt ans après*, continuation of *The Three Musketeers/Les trois mousquetaires*

# Pre-history (of computer science):

David Hilbert (1928): what can be *mechanically* computed?

Answer: Alan Turing, 1936 (after several other proposals: Post, Church, Kleene, Gödel...)

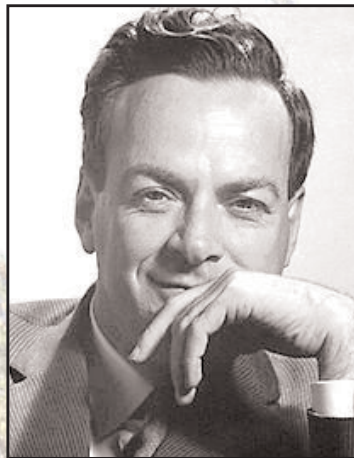
Turing PhD thesis, Princeton, 1939: *Systems of Logic Based on Ordinals*  
(supervisor: A. Church)



Actually, also in Natural Computing “everything” goes back to Turing (genetic, neural computing, oracles, hypercomputation...)

# Pre-history (of cellular/DNA computing):

Michael Conrad, Richard Feynman, Charles Bennett (1970)



## Initiators of DNA computing

Tom Head (1987)

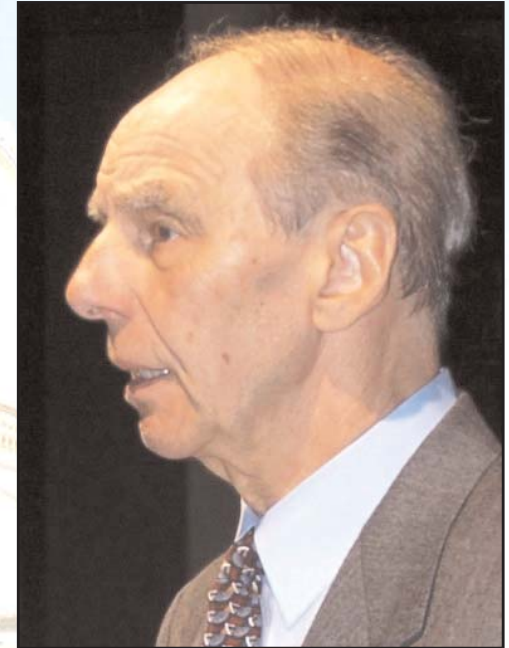
Leonard Adleman (1994)

# However...

J. Hartmanis: About the nature of computer science. *Bulletin of the EATCS*, 53 (June 1994), 170-190

J. Hartmanis: On the weight of computation. *Bulletin of the EATCS*, 55 (February 1995), 136-138

Adleman = demo, but the *weight* is a new (prohibitive) complexity measure



# However...

A lot of theory, experiments, toy problems solved, new technologies, nano-constructions, by-products, maybe classified applications (cryptography),...



It was in Turku  
(with Sheng Yu and Alexandru Mateescu)



Trois Mousquetaires...

Gh. Păun, G. Rozenberg, A. Salomaa:  
*DNA Computing. New Computing Paradigms*,  
Springer 1998; Tokyo 1999; Tsinghua Univ. Press,  
Beijing, 2004; Mir, Moskow, 2005

I also had a sword and a high hat...

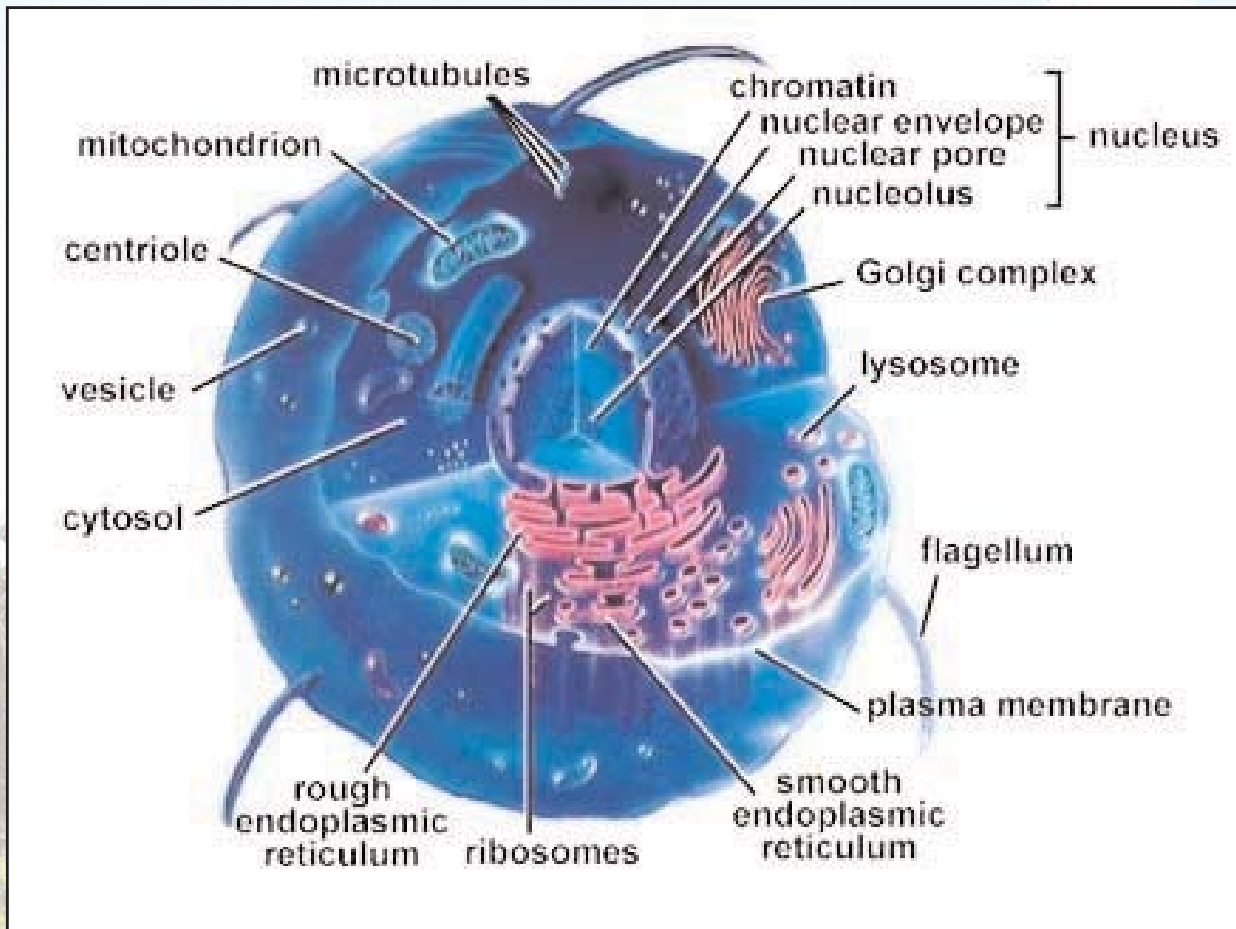


But a little bit too big for me...

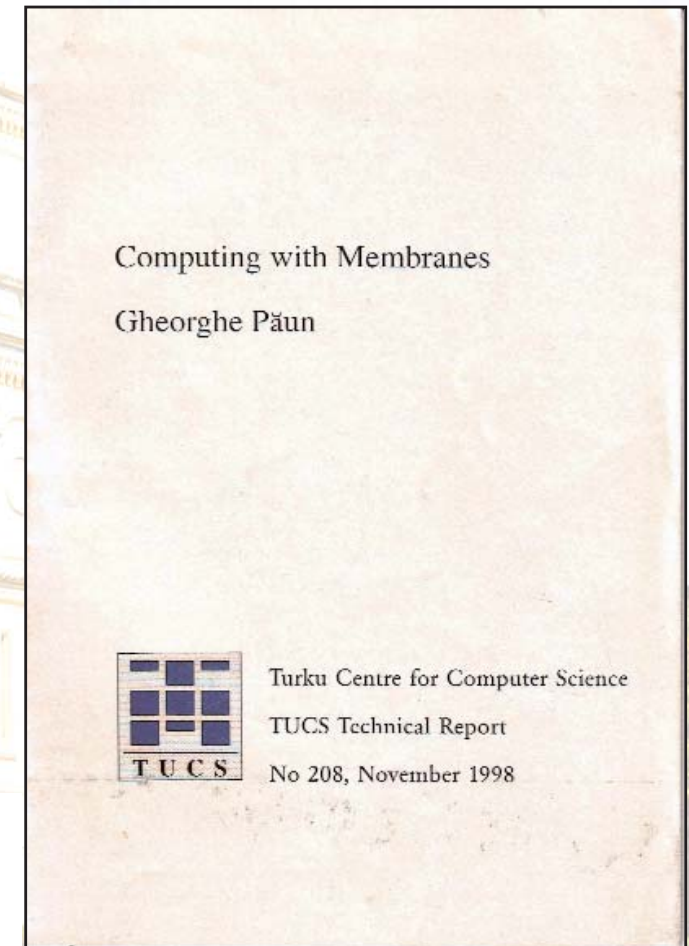


Gh. Păun, G. Rozenberg, A. Salomaa:  
*DNA Computing. New Computing Paradigms*,  
Springer 1998; Tokyo 1999; Tsinghua Univ. Press,  
Beijing, 2004; Mir, Moscow, 2005

# And the idea arised: **let us go to the cell!**



Gh. Păun: Computing with Membranes.  
*Journal of Computer and System Sciences*,  
61, 1 (2000), 108-143



Computing with Membranes

Gheorghe Păun



Turku Centre for Computer Science

TUCS Technical Report

No 208, November 1998



## Some basic references:

Gh. Păun: Computing with Membranes. *Journal of Computer and System Sciences*, 61, 1 (2000), 108-143 (cell-like P systems, symbol objects, string objects)

Gh. Păun: P systems with active membranes: Attacking NP-complete problems, *J. Automata, Languages, and Combinatorics*, 6, 1 (2001), 75-90

A. Păun, Gh. Păun: The power of communication: P systems with symport/antiport, *New Generation Computing*, 20, 3 (2002), 295-306

C. Martin-Vide, J. Pazos, Gh. Păun, A. Rodriguez-Paton: Tissue P systems, *Theoretical Computer Sci.*, 296, 2 (2003), 295-326

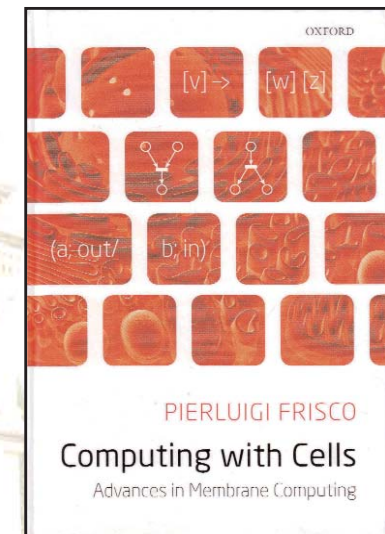
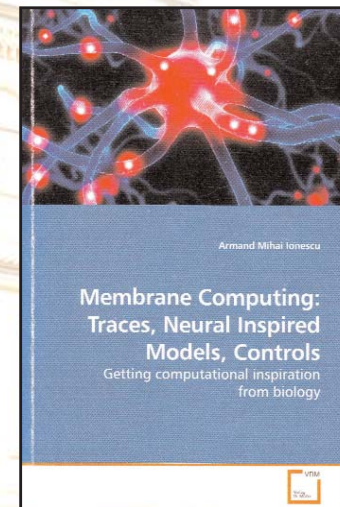
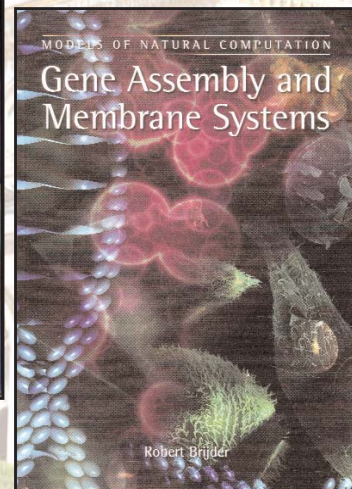
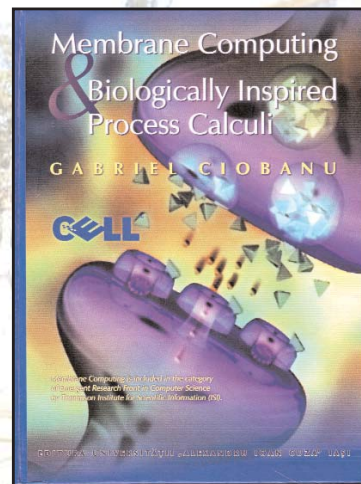
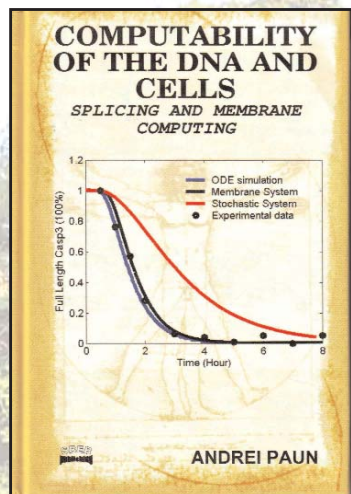
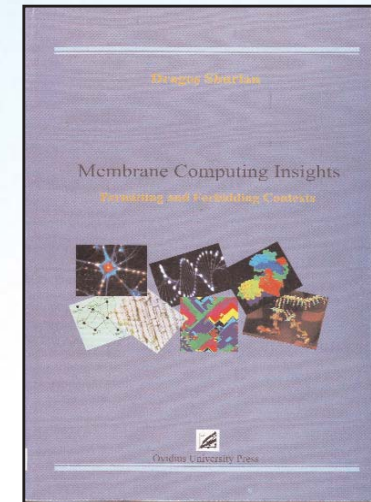
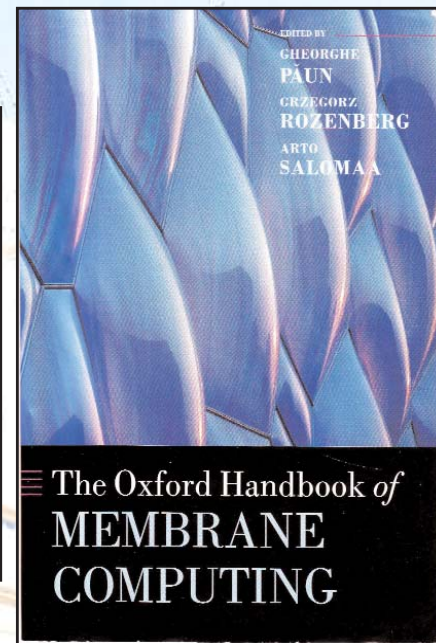
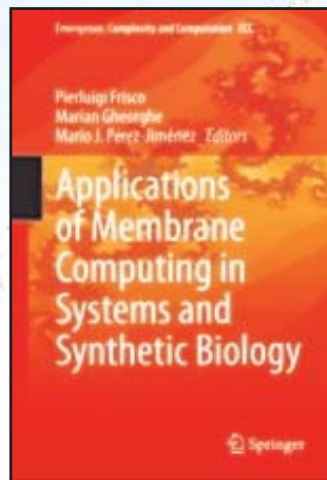
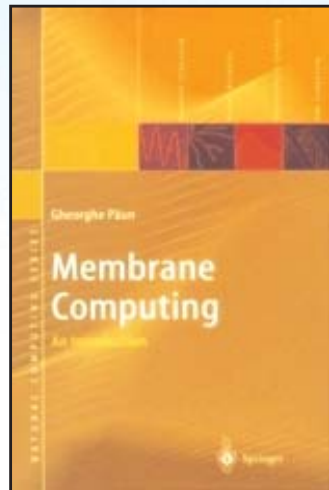
Gh. Păun, R. Păun: Membrane computing and economics: Numerical P systems, *Fundamenta Informaticae*, 73, 1-2 (2006), 213-227

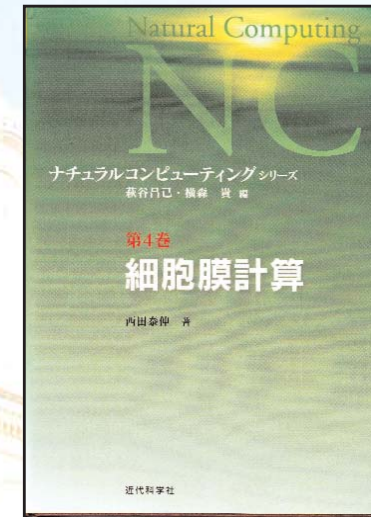
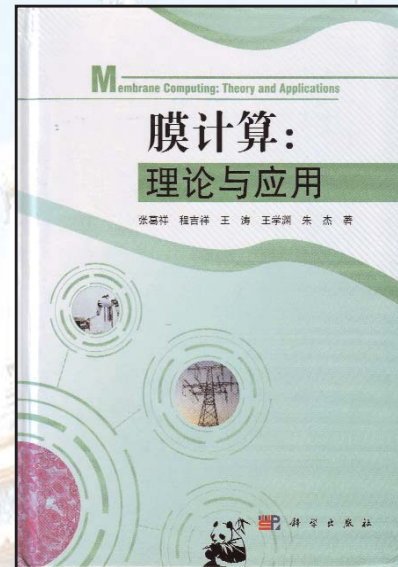
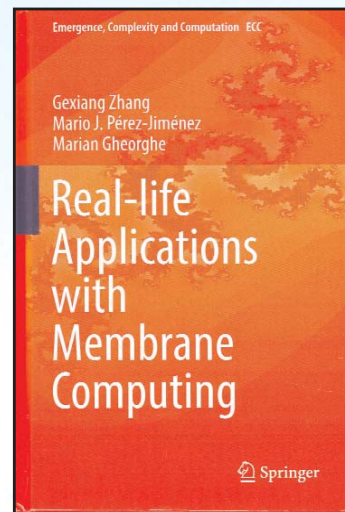
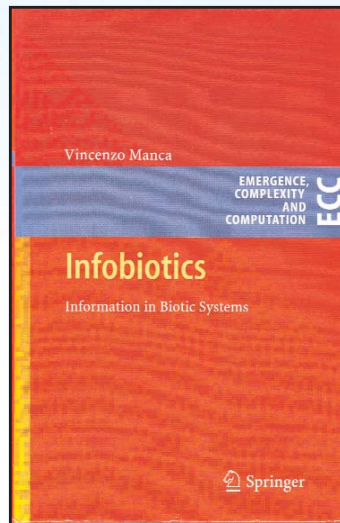
M. Ionescu, Gh. Păun, T. Yokomori: Spiking neural P systems, *Fundamenta Informaticae*, 71, 2-3 (2006), 279-308

Gh. Păun, M.J. Perez-Jimenez: Solving problems in a distributed way in membrane computing: dP systems, *International J. of Computers, Communication and Control*, 5, 2 (2010), 238-252

Other branches: conformon, population, kernel, metabolic, multi-environment, polymorphic, etc. etc. etc. etc. ...

# Monographs/volumes





Web sites:

<http://psystems.disco.unimib.it>

<http://ppage.psystems.eu/>

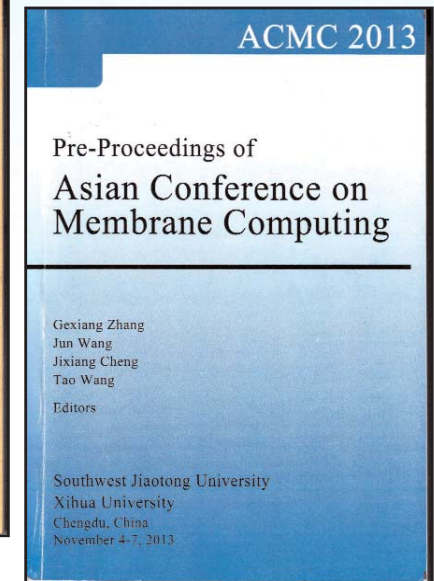
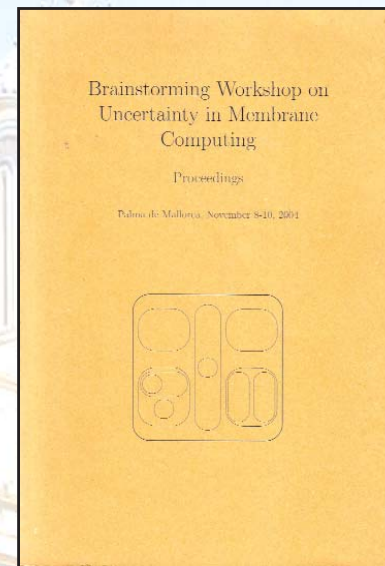
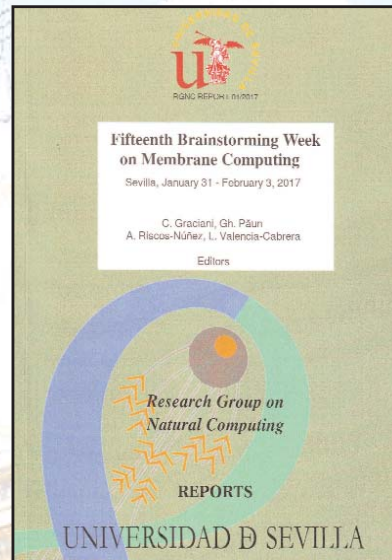
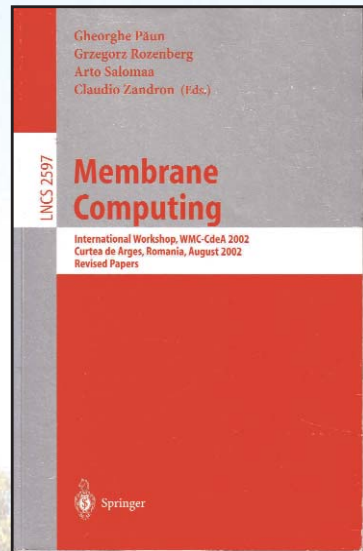
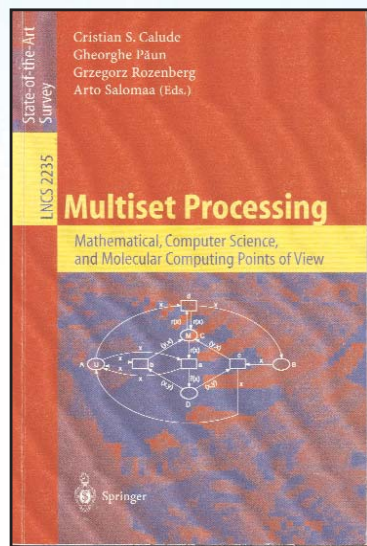
[www.gcn.us.es](http://www.gcn.us.es)

<http://membranecomputing.net/IMCSBulletin/>

<http://imcs.org.cn/>

<https://www.springer.com/computer/theoretical+computer+science/journal/41965>

# Meetings



**Workshop on Membrane Computing (WMC):** Curtea de Argeș (2000, 2001, 2002), Tarragona (2003), Milan (2004), Vienna (2005), Leiden (2006), Thessaloniki (2007), Edinburgh (2008)

**Conference on Membrane Computing (CMC):** Curtea de Argeș (2009), Jena (2010), Fontainebleau (2011), Budapest (2012), Chișinău (2013), Prague (2014), Valencia (2015), Milan (2016), Bradford (2017), Dresden (2018), **Curtea de Argeș (2019)**



# Brainstorming Week on Membrane Computing

**Tarragona, 2013**  
**Sevilla, 2014 - 2018**

**...very efficient!**

## Bibliography (estimation):

- more than 3000 papers
- more than 100 PhD theses
- 50 - 60 monographs and collective volumes (including a handbook)
- more than 30 special issues of international journals

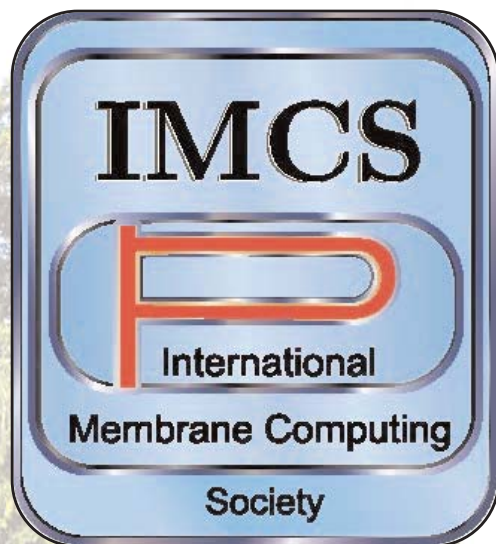
ISI (Institute for Scientific Information (<http://esi-topics.com>), February 2003, nominated “Computing with membranes” as *fast breaking paper* and, in October 2003, the S/A paper was considered “the citation leader in the category of Emergent Research Front in Computer Science: Membrane Computing”

## **Important step:**

### **The International Membrane Computing Society (IMCS)**

- founded during 14th Brainstorming Week on Membrane Computing, Sevilla, Spain, 1-5 February 2016
- web address: <http://imcs.org.cn/>
- main goals: “connecting people” and promoting MC to young researchers
- two publications: **Bulletin of IMCS**  
<http://membranecomputing.net/IMCSBulletin/>  
and **Journal of Membrane Computing (JMC)**, Springer-Verlag  
<https://www.springer.com/computer/theoretical+computer+science/journal/41965>
- three annual Prizes: (i) The PhD Thesis of the Year, (ii) The Theoretical Result of the Year, (iii) The Application of the Year.

- four yearly dedicated meetings: the European Branch of International Conference on Membrane Computing (**ECMC**), the Asian Branch of International Conference on Membrane Computing (**ACMC**), the Brainstorming Week on Membrane Computing (**BWMC**) and the Chinese Workshop on Membrane Computing (**CWMC**)





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Gheorghe Păun

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Grzegorz Rozenberg  
Kamala Krithivasan  
Oscar H. Ibarra  
Takashi Yokomori  
Jürgen Dassow  
Lila Kari  
Cristian S. Calude

Institution Members

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Individual  
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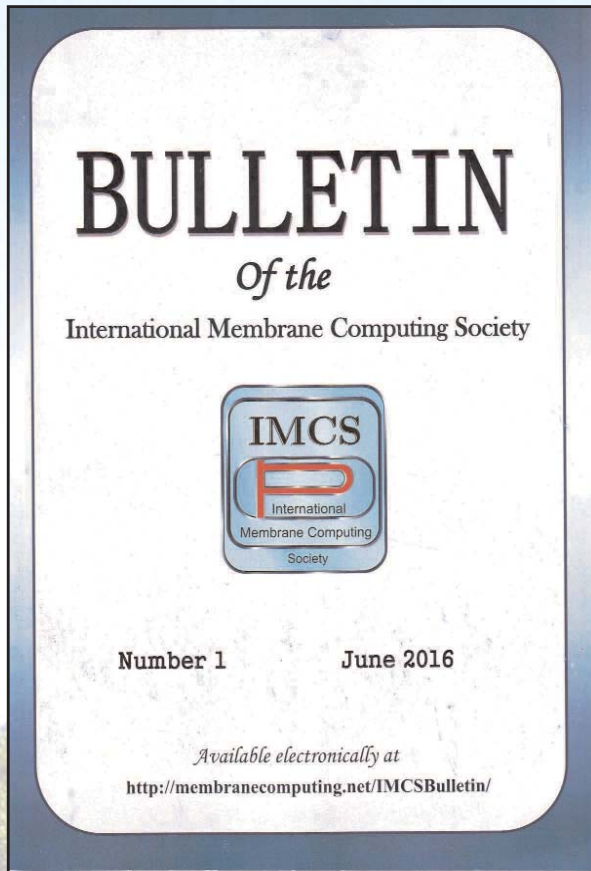
K.G. Subramanian

Jun Wang

Xingyi Zhang

10-20 members

20-30 members



**Journal of Membrane Computing**  
Editor-in-Chief: Linqiang Pan  
Honorary Editor-in-Chief: Gheorghe Păun  
Managing Editor: Gexiang Zhang

**CMC20 JMC Prizes: All authors of papers accepted before CMC20 will get a “Special Curtea de Argeş Prize” during CMC20, with the authors of the first three papers getting a “Very Special Curtea de Argeş Prize”!...**

## What next?

**It completely depends on us...**

### Personal “dreams”:

- to continue one further decade, two further decades...
- to see a new strong theoretical direction of research
- to get more and more practical applications (“a killer app”?...)
- to make JMC a successful journal (regular publication, high quality/impact, smooth/efficient editorial work,...)
- to make IMCS successful: good communication and collaboration, devotion to our community, cordial-friendly-constructive behavior (starting with promptly answering e-mail messages and continuing with observing deadlines...)
- to meet as many MC researchers as possible next year in Curtea de Argeș...

A large, ornate white building with multiple domes and arches, surrounded by greenery and a hedge. The building features intricate architectural details, including arched windows and decorative moldings. In the foreground, there is a well-manicured hedge and a small white structure with a dome. The background shows lush green trees under a clear blue sky.

**Thank you very much!**