Research activities of the Membrane Society of Japan

Takeo Yamaguchi
Tokyo Institute of Technology

The Membrane Society of Japan

History

1978 The Membrane Society of Japan was established
(Prof. Nakagaki, Prof. Shimizu, Prof. Kimura)
1982 The European Membrane Society (EMS) was established.
1984 Japan-Europe Membrane Conference (former ICOM)
1987 1st ICOM (Tokyo) (Prof. Nakagaki)
1996 4th ICOM (Yokohama) (Prof. Kimura)
2002 1st Aseanian Membrane Society (AMS) meeting (Tokyo)
(Prof. Nakao)

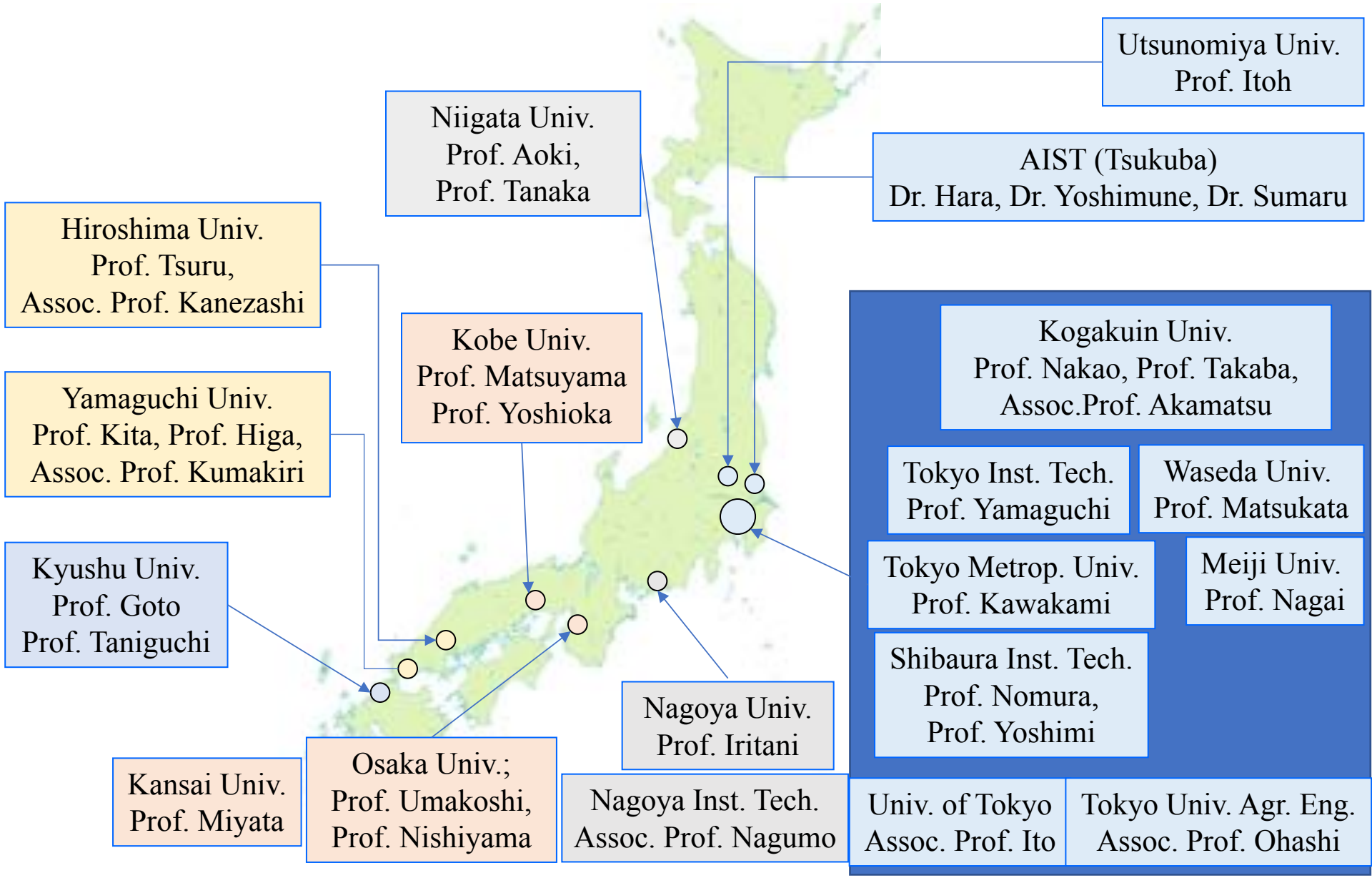
Mission

•To promote the advancement of science and technologies in ***synthetic membranes***, ***bio-membranes*** and ***their interdisciplinary fields***.

Boards in 2017

President:	Hideto Matsuyama *(Kobe Univ.)*
Vice President:	Atsuo Kumano *(Toyobo co ltd.)* Hiroyuki Saito *(Kyoto Pherm. Univ.)* Masahiro Goto *(Kyushu Univ.)*
Directors:	Emiko Okamura *(Himeji Dokkyo Univ.)* Hidetoshi Kita *(Yamaguchi Univ.)* Hiroyoshi Kawakami *(Tokyo Metro. Univ.)* Mikihisa Takano *(Hiroshima Univ.)* Masahiko Matsukata *(Waseda Univ.)* Masakazu Yoshikawa *(Kyoto Inst. Tec.)* Mitsuru Higa *(Yamaguchi Univ.)* Mutsumi Inaba *(Hokkaido Univ.)* Shin-ichi Nakao *(Kogakuin Univ.)* Shuji Nakatsuka *(Daicen Membrane Sys. Ltd.)* Takahiro Kawakatsu *(Kurita Water Ind. Ltd.)* Takashi Miyata *(Kansai Univ.)* Takeo Yamaguchi *(Tokyo Inst. Tech.)* Toru Maruyama *(Kyushu Univ.)* Toshinori Tsuru *(Hiroshima Univ.)* Yoshinori Marunaka *(Kyoto Pref. Univ. Medicine)*
Auditors:	Hidetoshi Kita *(Yamaguchi Univ.)* Kazuo Oki *(Tohoku Univ.)*

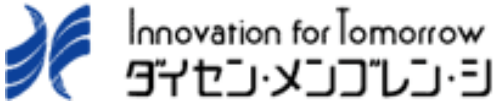
Academia (Synthetic and interdisciplinary fields)



Industries

RO/ NF

UF



MF

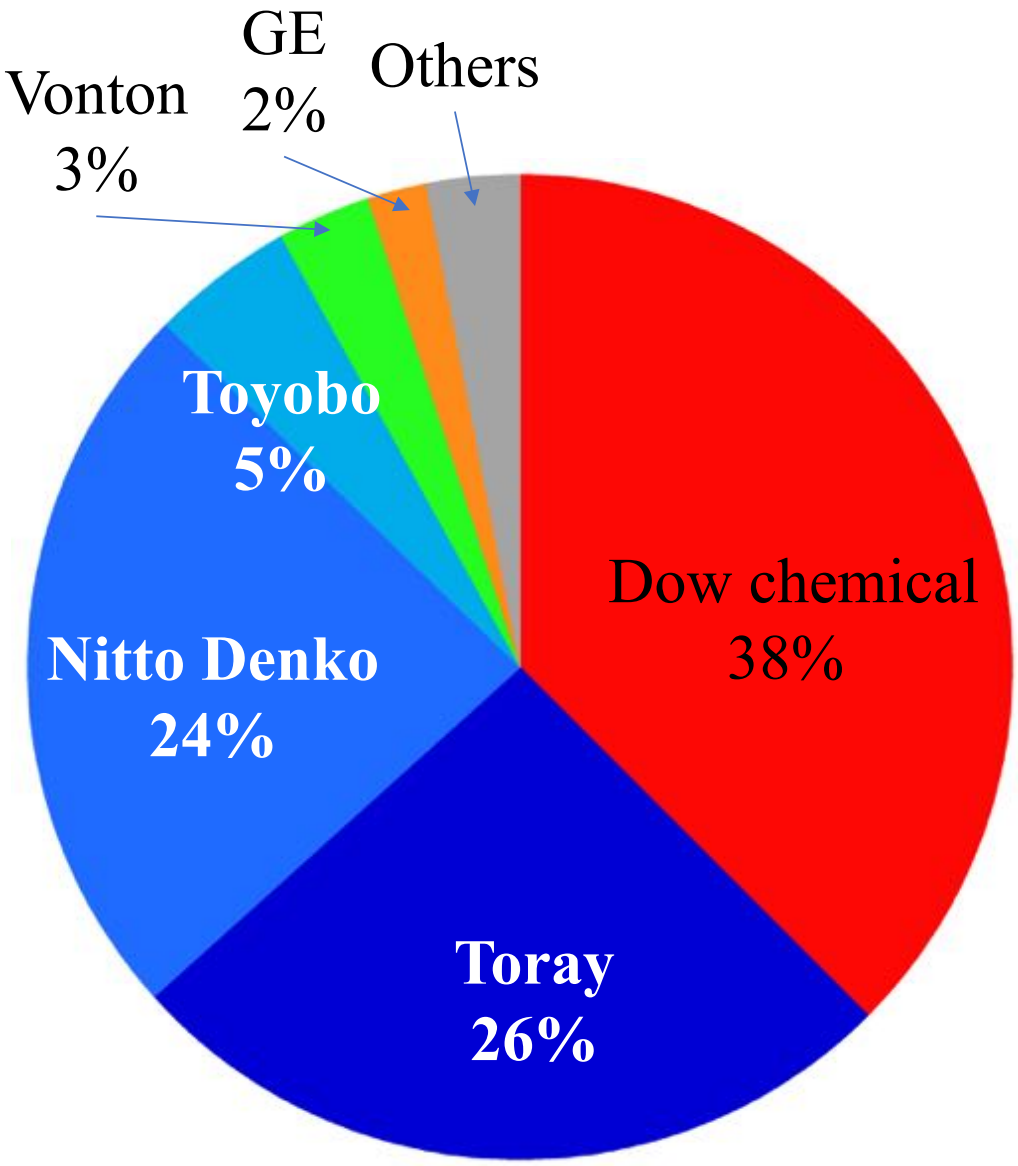
GS

PV

IE

Engineering

Share of RO and NF membranes in 2015

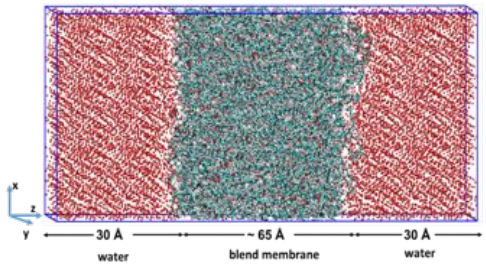


水資源関連市場の現状と将来展望 in Japanese：Fuji Economics 2016

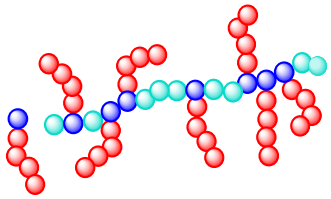
Research Activity: Polymeric Membranes (Fouling)

Experimental approach (Hierarchical study)

Molecular level → Polymer level → Commercial level



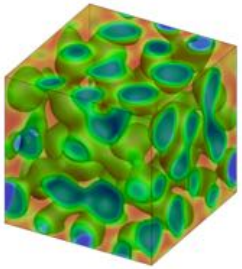
MD simulation

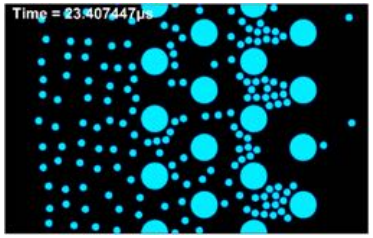


Polymer synthesis

Simulation approach

Structure formation simulation → Fouling simulation





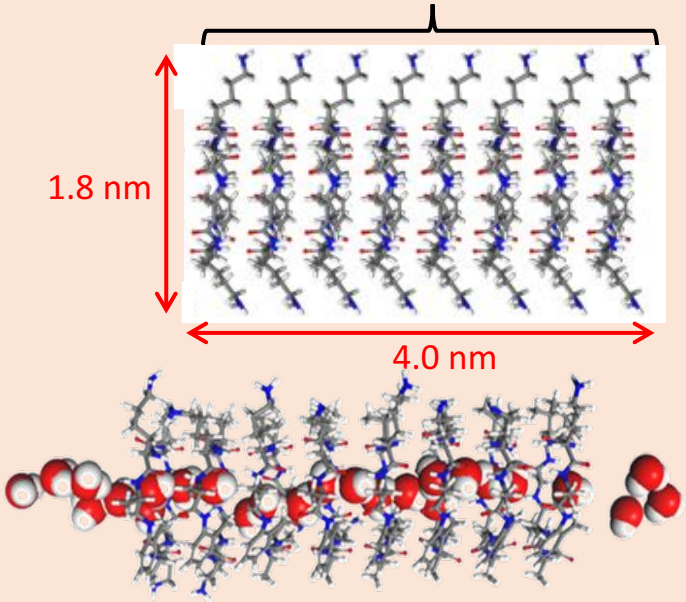
Understand fouling phenomena

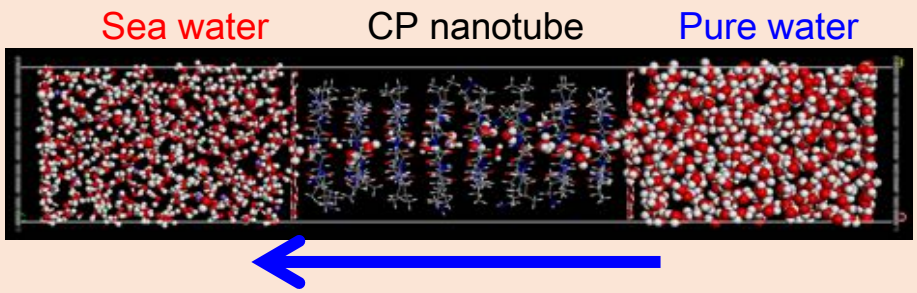
Hideto Matsuyama (Kobe Univ.)

Shin-ichi Nakao & Kazuki Akamatsu (Kogakuin Univ.)

Research Activity: Membrane Modeling and Systems

MD simulation



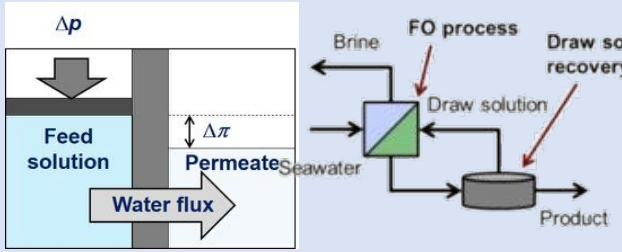


Tomohisa Yoshioka (Kobe Univ.)

Hiromitsu Takaba (Kogakuin Univ.)
Ryo Nagumo (Nagoya Institute of Tech.)

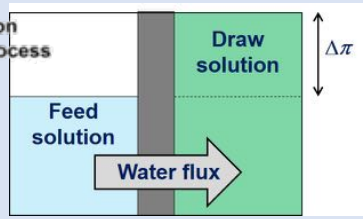
Transport model and Process simulation

Reverse osmosis (RO)

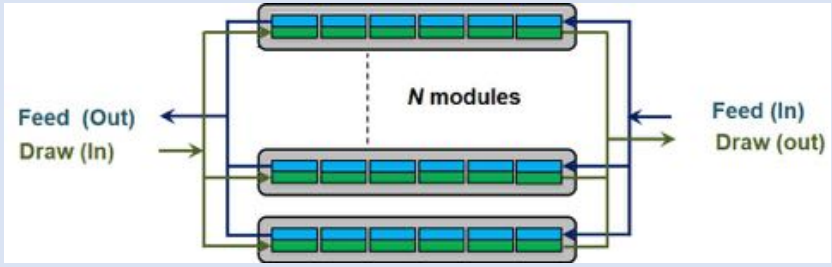


E_{RO} = 2.5 kWh / m^3 water

Forward osmosis (FO)



$E_{FO} = E_d + E_p$
E_d : water recovery from draw solution
$E_d = \Delta G / Q_{product}$
E_p : pressure drop

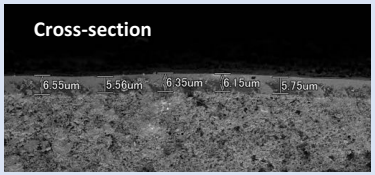


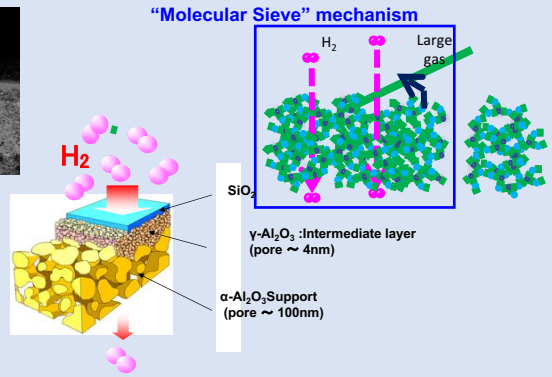
Takeo Yamaguchi (Tokyo Institute of Tech.)

PRO and RED system
Mitsuru Higa (Yamaguchi Univ.)

Research Activity: Inorganic Membranes 1

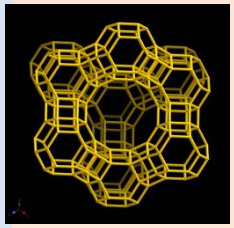
Chemical Vapor Deposition (CVD) membranes

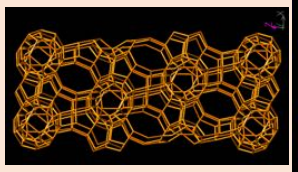


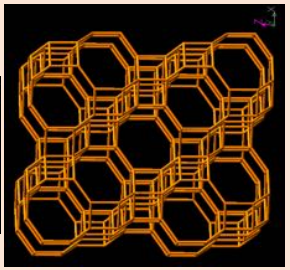


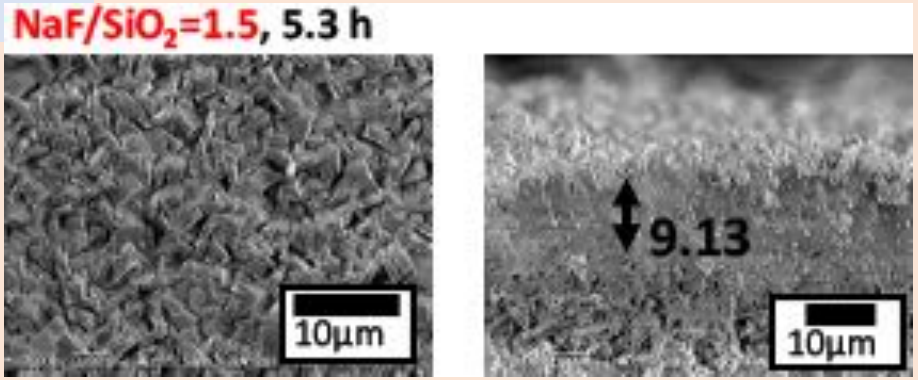
Shin-ichi Nakao & Kazuki Akamatsu
(Kogakuin Univ.)

Zeolite membranes



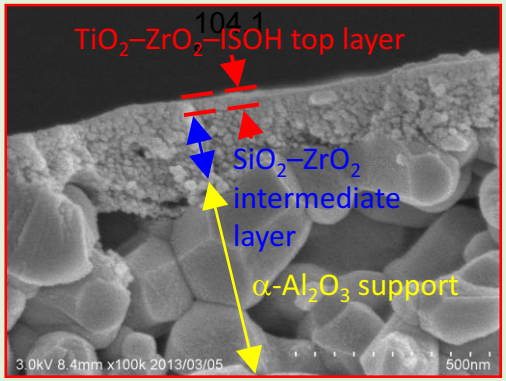






Masahiko Matsukata (Waseda Univ.),
Hidetoshi Kita & Izumi Kumakiri (Yamaguchi Univ.)
Mikihiro Nomura (Shibaura Inst. Tech.)

Sol-gel membranes



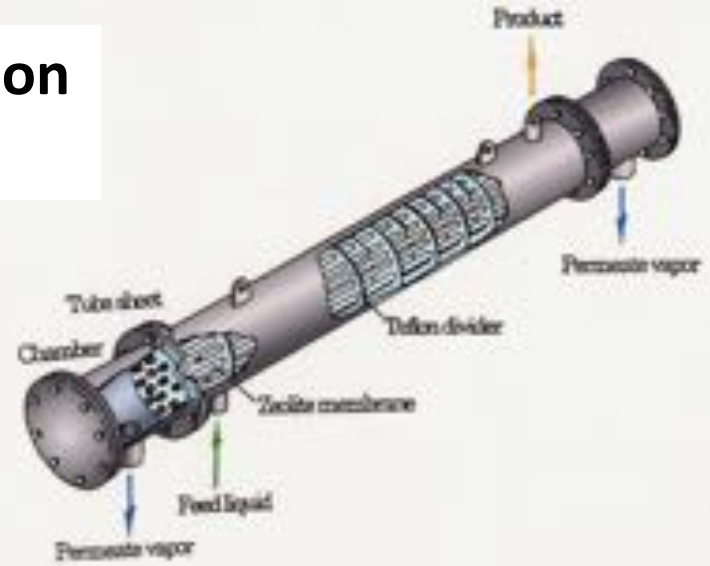
Cross section

500 nm

Toshinori Tsuru (Hiroshima Univ.)

More than 150 PV plants for dehydration of organic liquid are operated in Japan

Ex. 16 modules, 60 m^2
Dehydration of EtOH, 90 ⟶ 99.8 wt%,
600 *L*/h at 120°C, 6 kg/cm^2



Schematic view of the tubular-type pervaporation module

125 tubes, 3.75 m^2

Research Activity: Inorganic Membranes 2

Carbon membrane

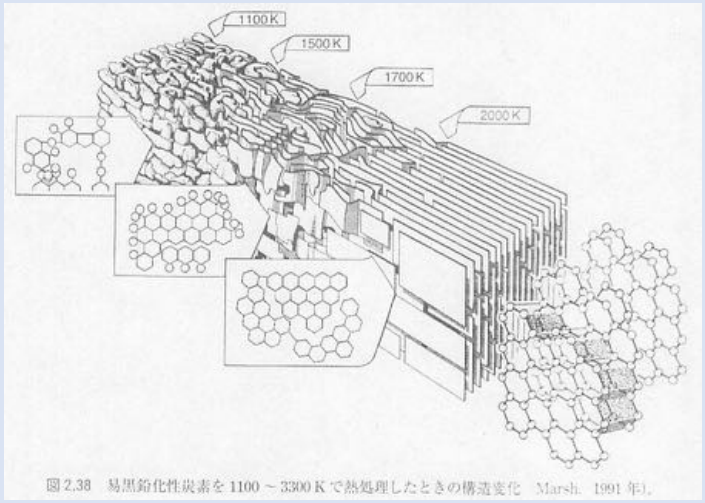
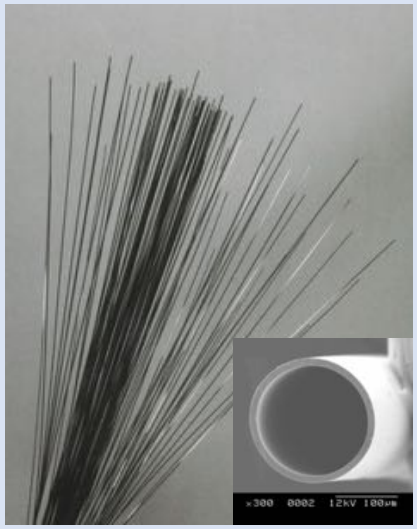
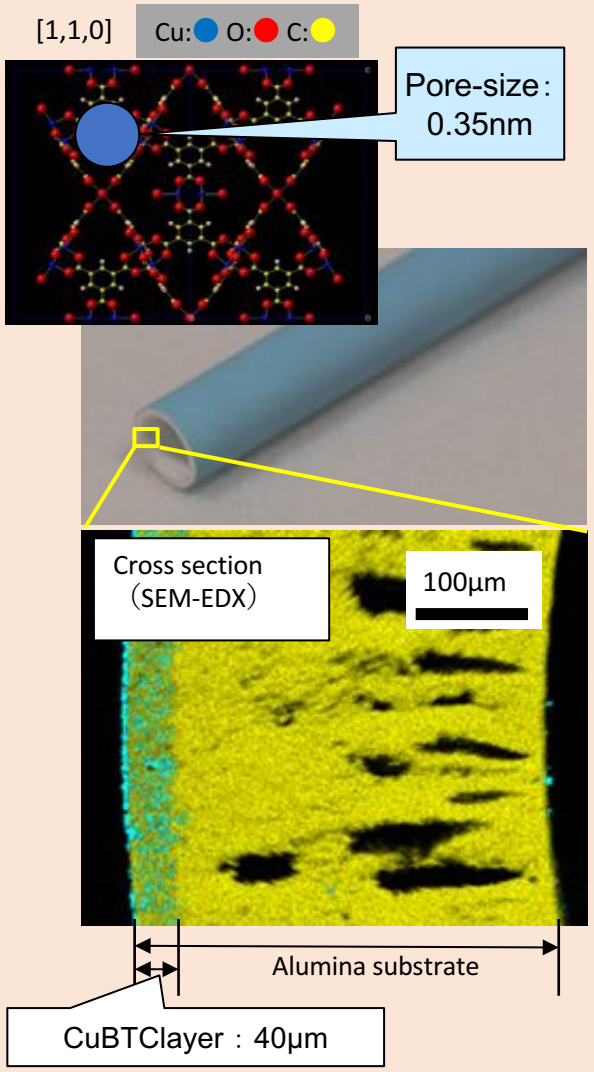


図 2.38　易黒鉛化性炭素を 1100 ～ 3300 K で熱処理したときの構造変化　Marsh, 1991 年).



Miki Yoshimune (AIST)

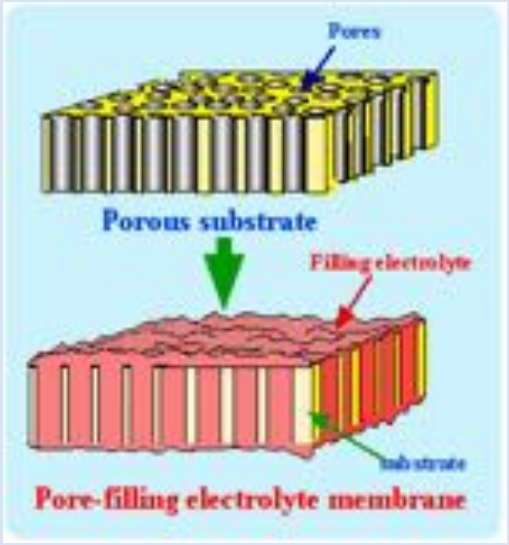
MOF membrane

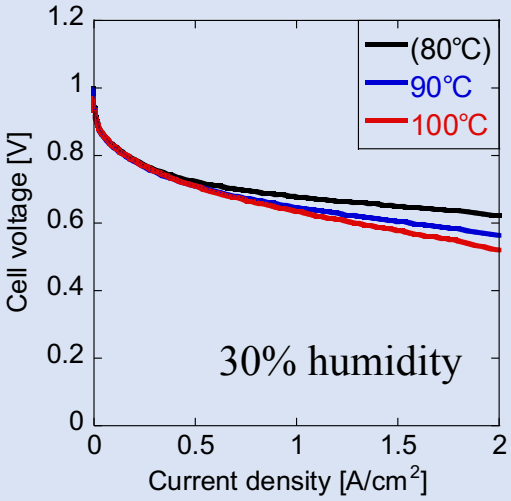


Nobuo Hara (AIST)

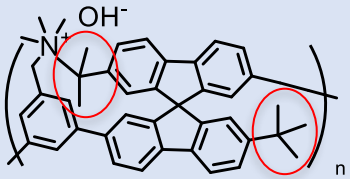
Research Activity: Electrolyte Membranes and Ion Exchange Membranes

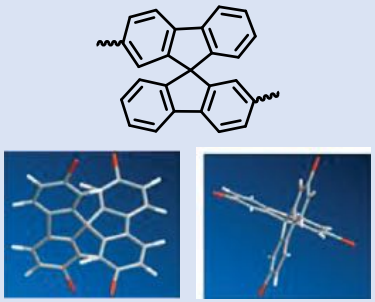
Pore-filling membrane

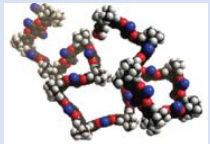




Tough anion-exchange membrane

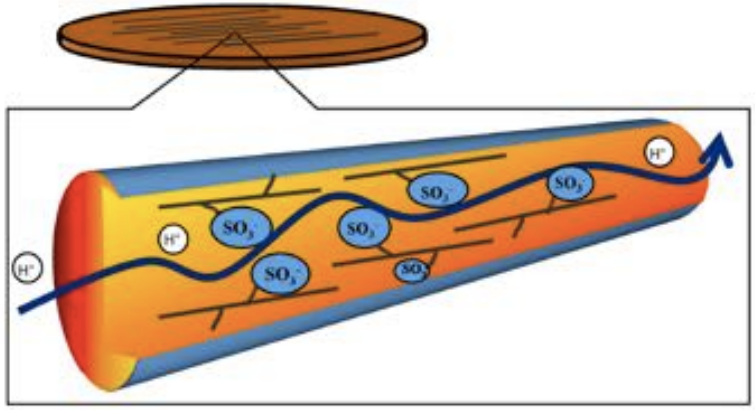


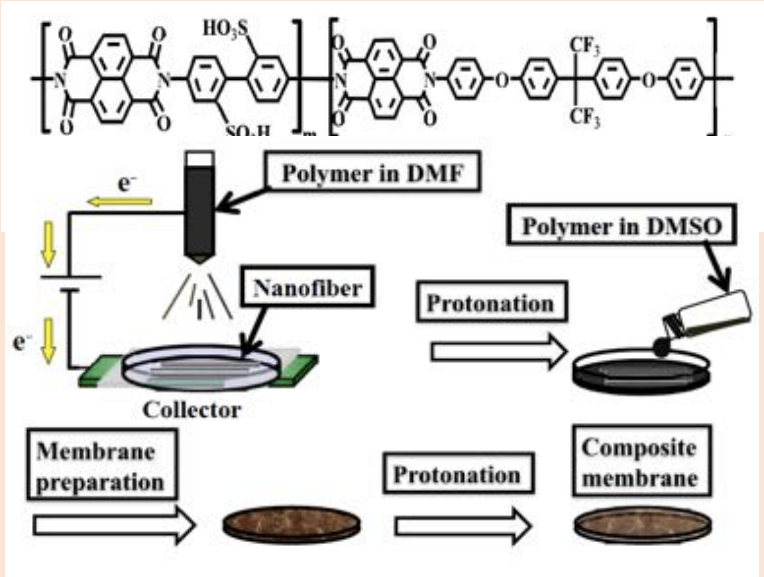




Takeo Yamaguchi
(Tokyo Institute of Tech.)

Nano-fiber membrane

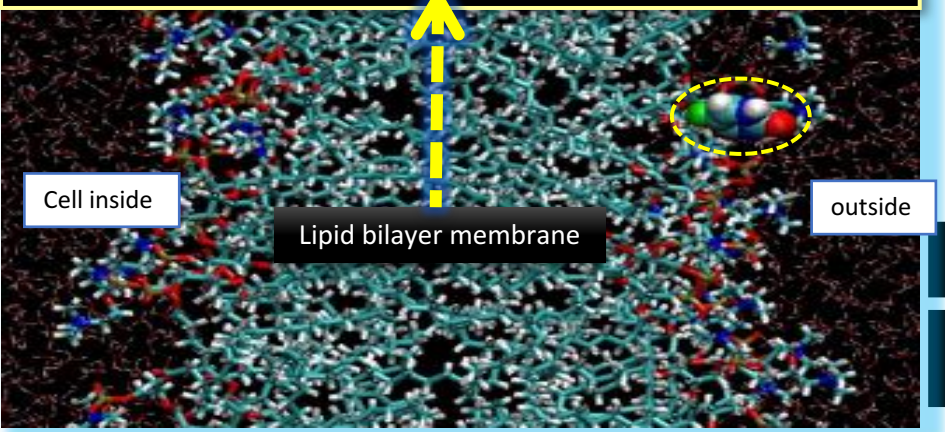




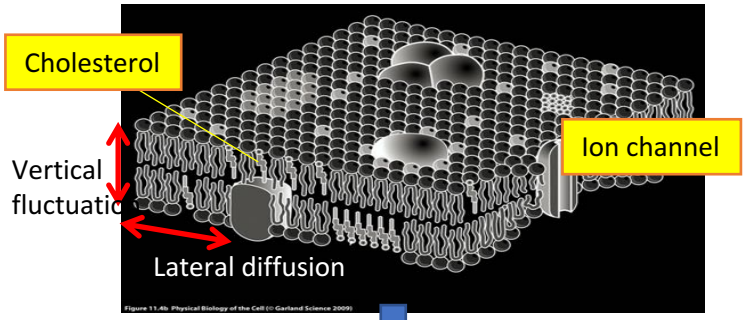
Hiroyoshi Kawakami
(Tokyo Metro. Univ.)

Research Activity: Bio-membranes

Mechanism of the delivery of drugs and bioactive chemicals ⇔
Molecular dynamics in the membrane



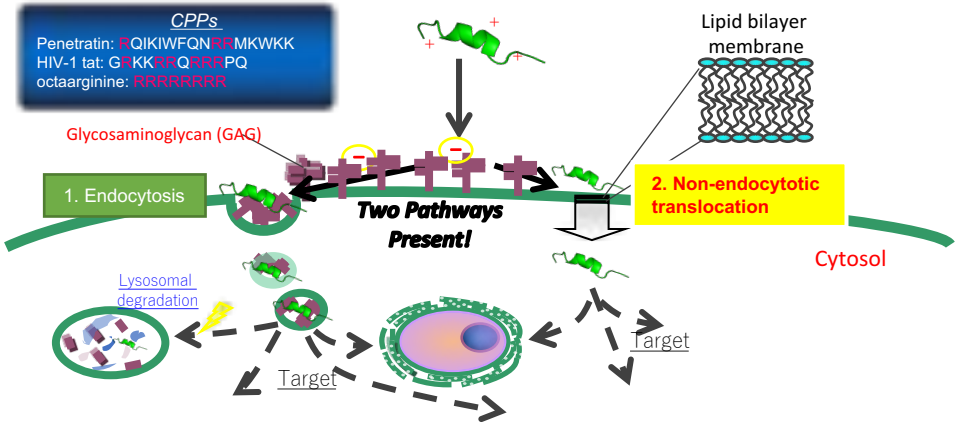
Dynamic cell membranes



Cell membranes are the dynamic system.

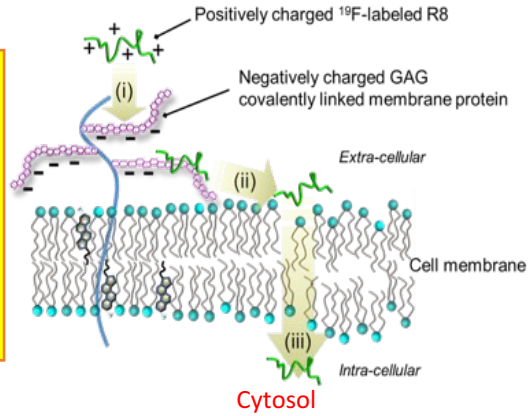
Incorporation of ion channel proteins also modifies the membrane.

Membrane Permeation of Cell-Penetrating Peptide (CPP)
Two Pathways of Translocation process



Plausible Mechanism for Non-Endocytic, Energy-Independent Translocation of ^{19}F-R8 into Cells

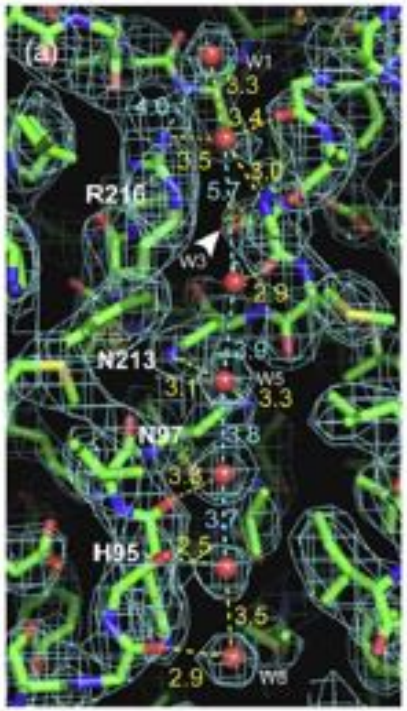
The mechanism involves
(i) binding of ^{19}F-R8 to GAG at the cell surface, followed by
(ii) the transfer to the cell membrane, and
(iii) the entry into cytosol.

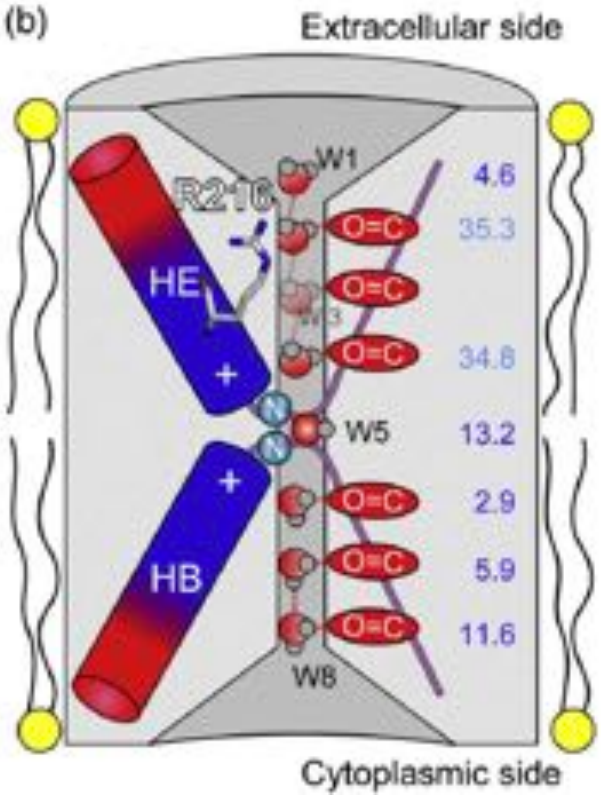


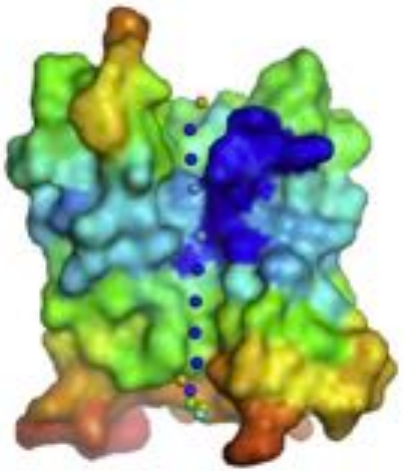
Prof. Emiko Okamura *(Himeji Dokkyo Univ.)*

Aquapoline

AQPs efficiently and specifically conduct water
while completely preventing proton permeation.







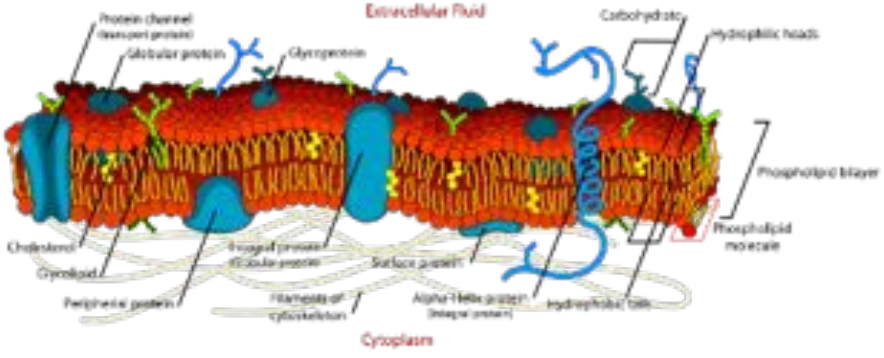
Hydrophobic pore
Pore size 3 Å
N-N distance 2.8 Å±0.2 Å

Hydrogen-bondings were cut at the pore entrance
and a single water molecule can be permeated.

K. Tani and Y. Fujiyoshi *et al.,* J. Mol. Biol. 389, 694 (2009)

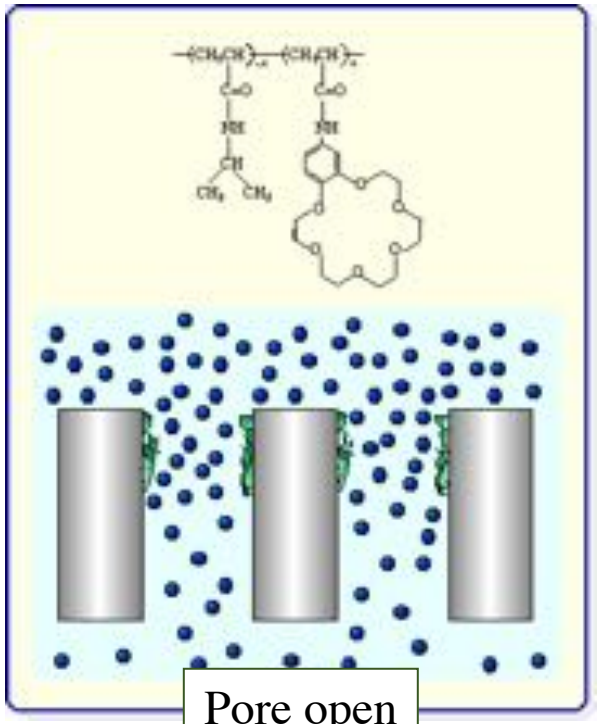
Research Activity: Bio-mimetic and Bio-inspired Membranes 1

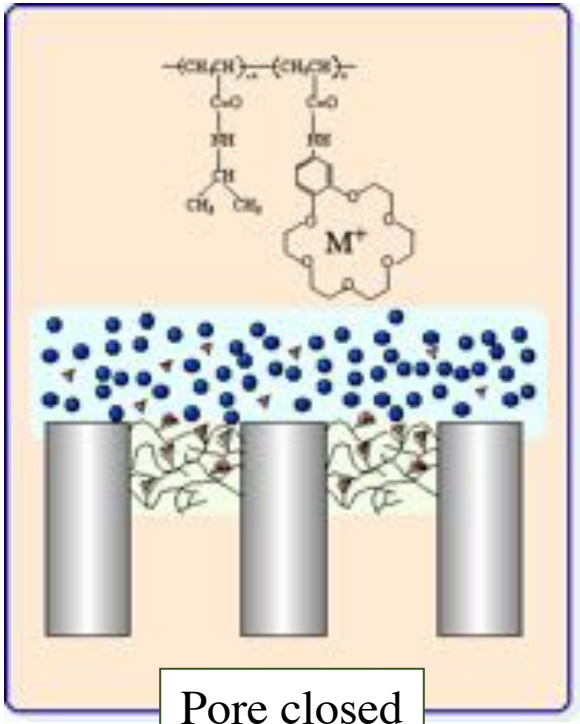
Bio-membrane
Bio-membrane system



Molecular recognition gating membrane

Bio-inspired membrane

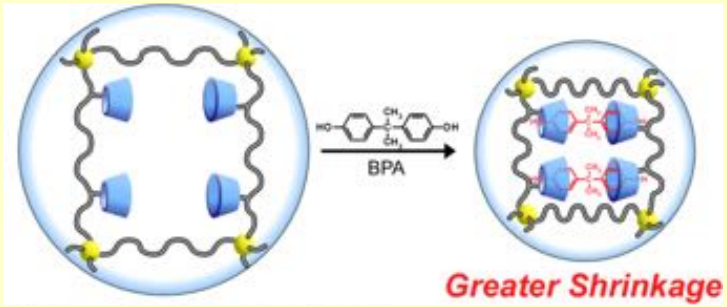




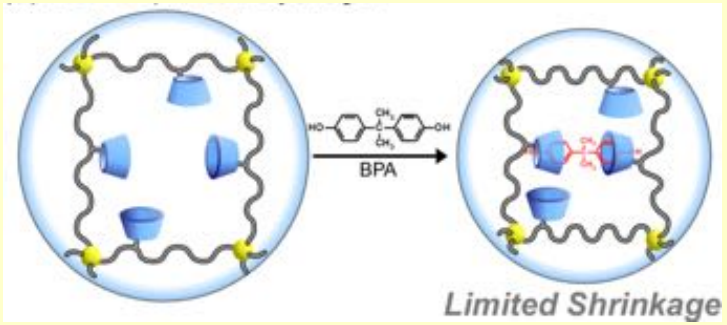
Takeo Yamaguchi (Tokyo Institute of Tech.)

Research Activity: Bio-mimetic and Bio-inspired Membranes 2

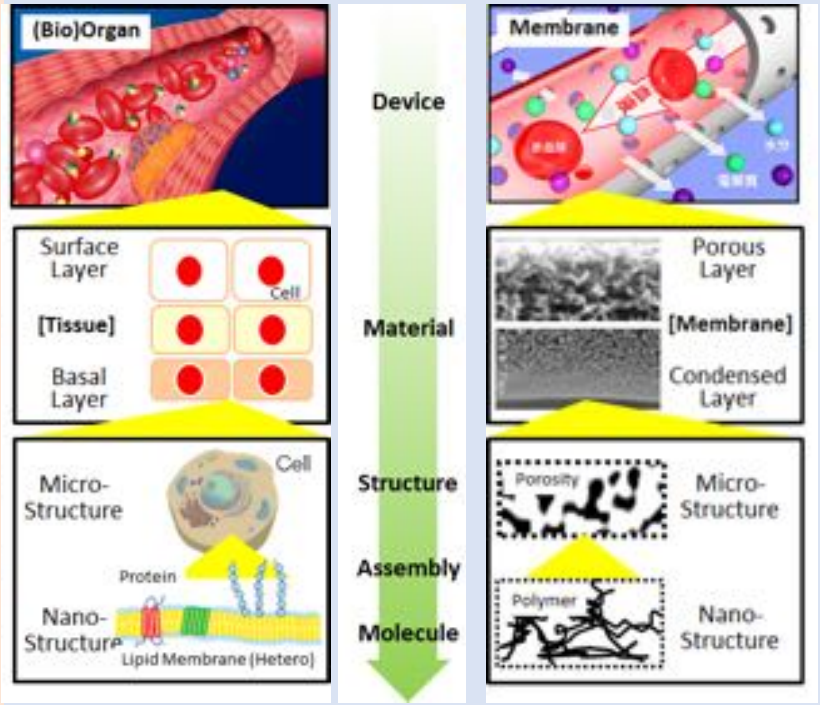
BPA-imprinted gel



Nonimprinted gel



Takashi Miyata (Kansai Univ.),



Meso-Scale Unit
(Self-Organizing System)

Hiroshi Uamakoshi (Osaka Univ.)

Summary

If you ask us what is The Membrane Society of Japan.

- “***When you join the membrane society of Japan, you can understand all of membrane research fields including synthetic membranes, bio-membranes and interdisciplinary field*”.**

- 437 people and 34 industrial companies are belonged to the society.

- Another important mission is to gather the membrane researchers from different fields at one place and merge and exchange their knowledge and information to **create new membrane research fields**.

Acknowledgments

Prof. Hideto Matsuyama (*Kobe University*)

Prof. Toshinori Tsuru (*Hiroshima University*)

Dr. Masahide Taniguchi (*Toray co ltd.)*

Dr. Takahiro Kawakatsu (*Kurita co ltd.)*

Dr. Atsuo Kumano *(Toyobo co ltd.)*

Prof. Emiko Okamura *(Himeji Dokkyo Univ.)*

Prof. Takashi Miyata (*Kansai Univ.)*

Prof. Hiroshi Uamakoshi (*Osaka Univ.)*

Prof. Hiroyoshi Kawakami *(Tokyo Metro. Univ.)*

Prof. Tomohisa Yoshioka (*Kobe Univ.)*

Prof. Mikihiro Nomura (*Shibaura Inst. Tech.)*

Assoc. Prof. Kazuki Akamatsu (*Kogakuin Univ.)*

Dr. Nobuo Hara (*AIST*)