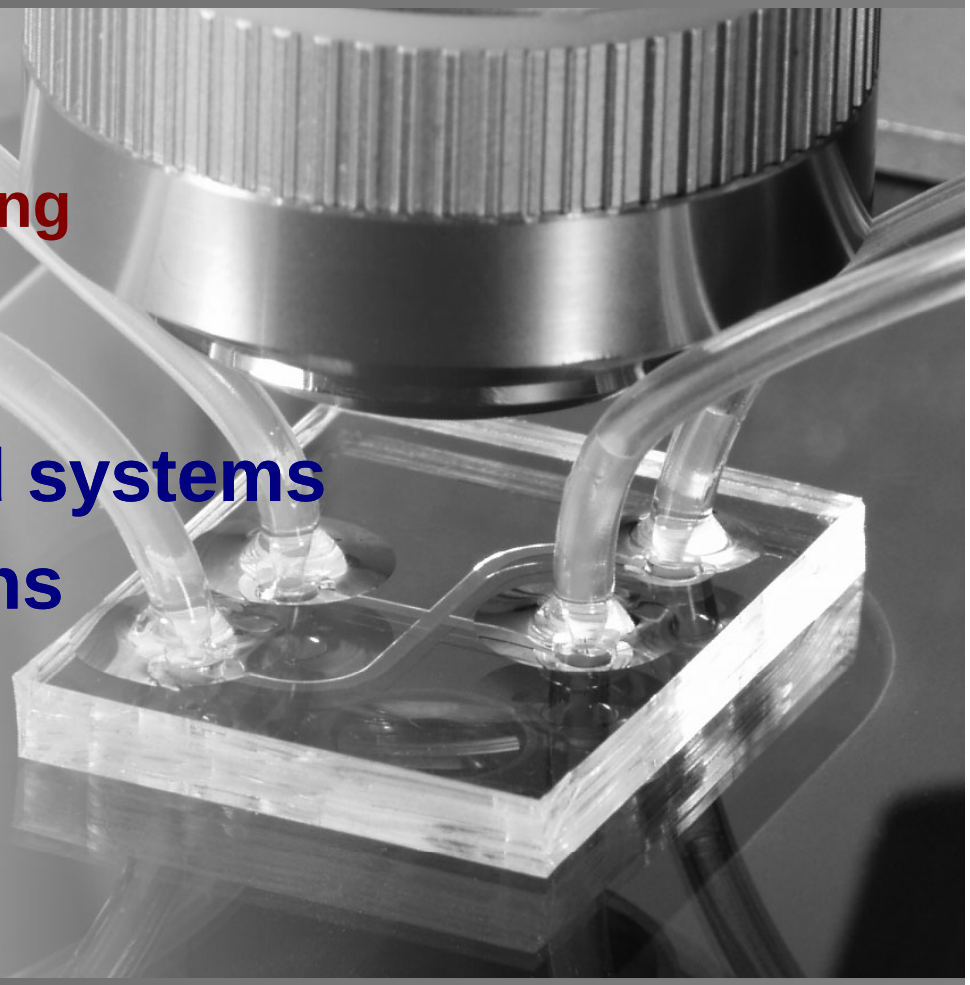


UT-SNU Exchange Lecture Courses

Introduction to Bioengineering

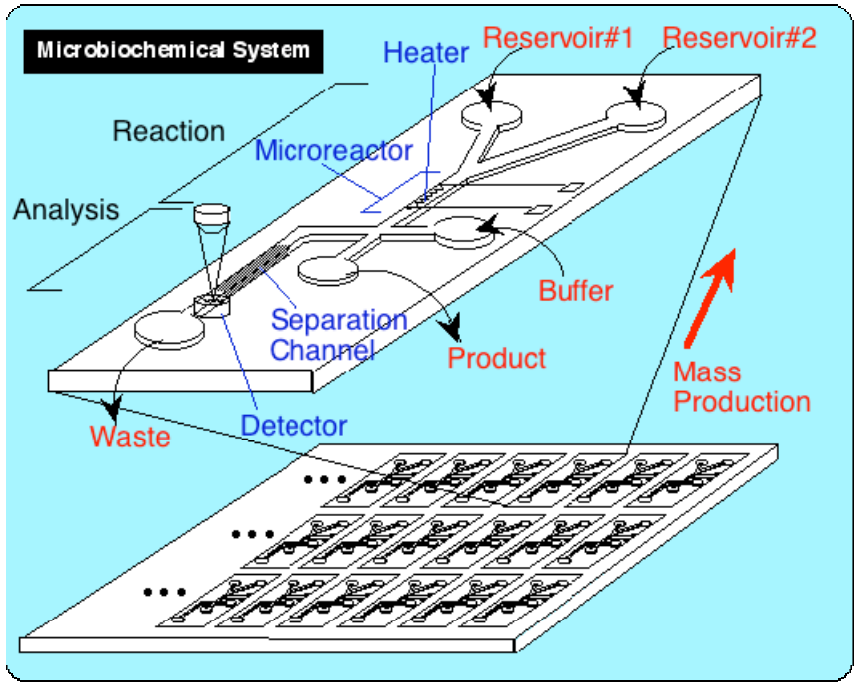
Microfluidic devices and systems for biological applications

Teruo Fujii

CIRMM-IIS, Univ. of Tokyo

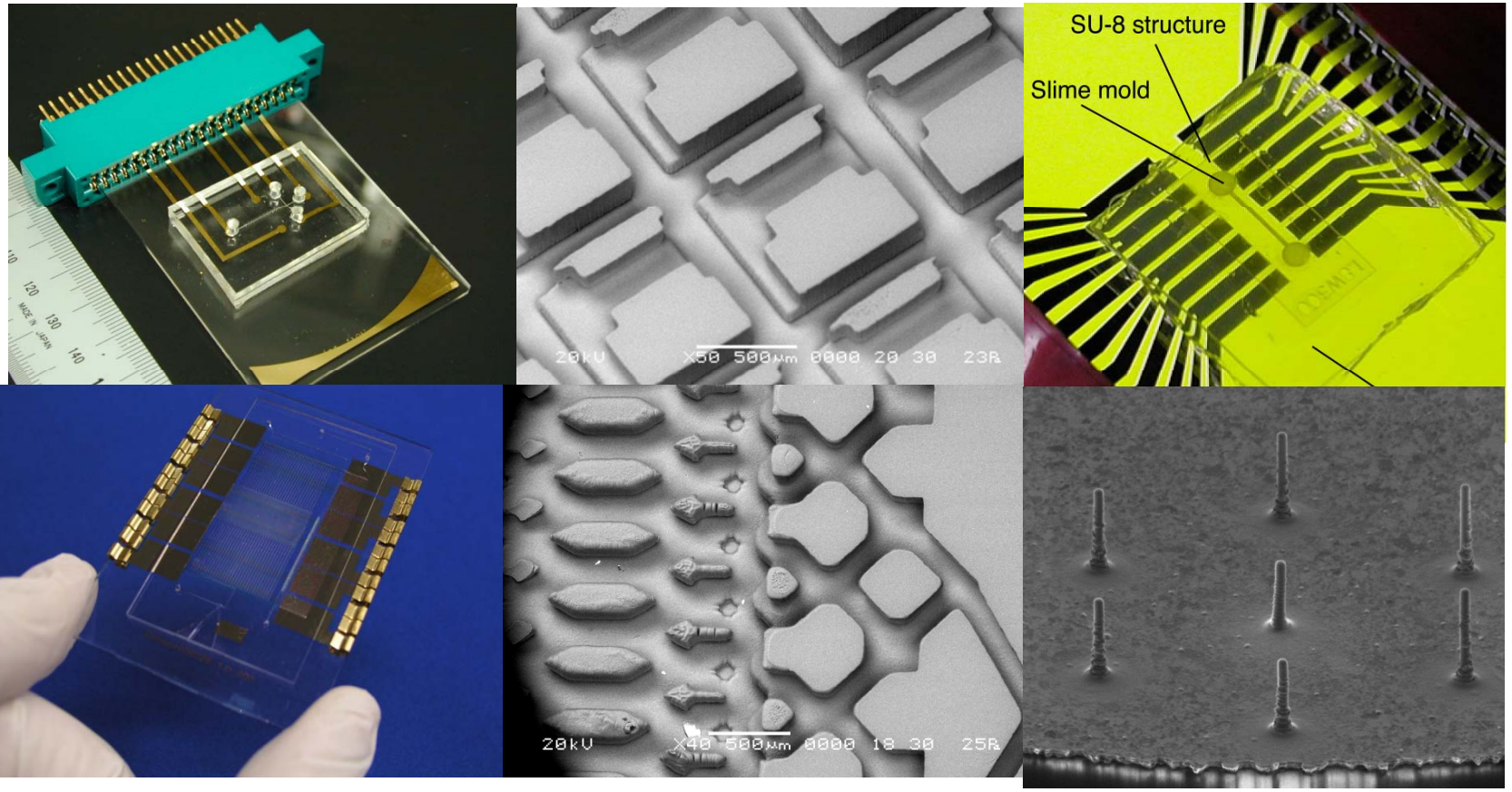
Microfluidics - Devices/Systems

Integrating chemical/biochemical operations on a chip

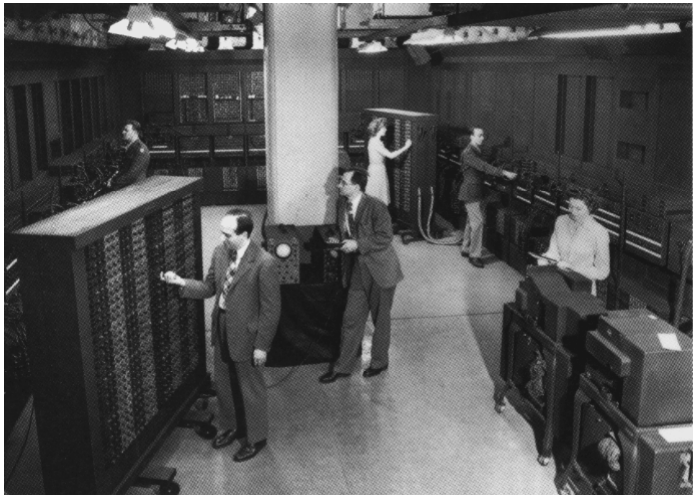


- ☐Microfabrication
  - →Semiconductor Technology
- ☐Miniaturization
  - →High Throughput Processing
- ☐Automation & Parallelization
  - →System Integration
- ☐Wide Variety of Applications
  - →Medical/Pharmaceutical, etc.

A Variety of Microfluidic Devices



Miniaturization of Electronic Devices

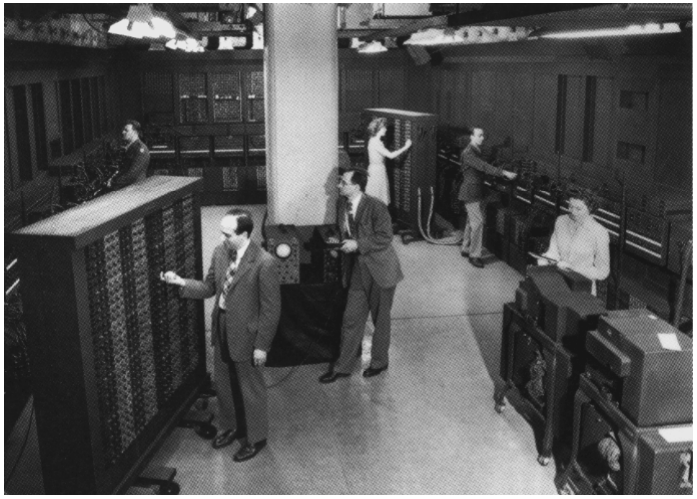


ENIAC, 1940s
30 ton,13 x 6.5 m^2
→ Single Purpose

~ 60years

LapTopPC
< (several) kg
→ Multi-function/purposes

Miniaturization of Electronic Devices



ENIAC, 1940s
30 ton,13 x 6.5 m^2
→ Single Purpose

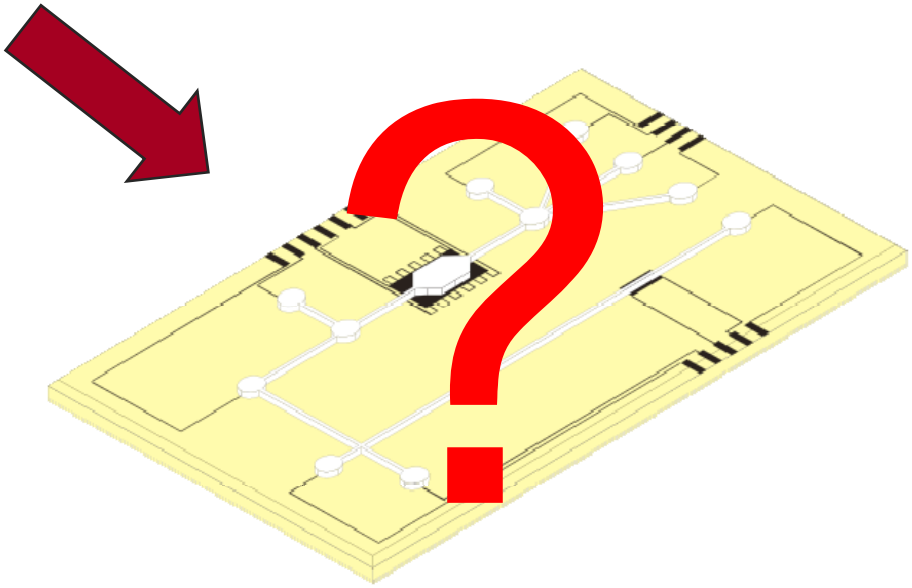
~ 70years

Mobile Phones
< 1 kg
→ Multi-function/purposes

Miniaturization of Fluidic Devices

Chemistry/Biology Lab.
→Room＋Operators
＋Analytical Machines

Desk Top Lab.
< kg
∽ ??years → Multi-Purposes



From
Deep Sea
to
Tissues and Embryos

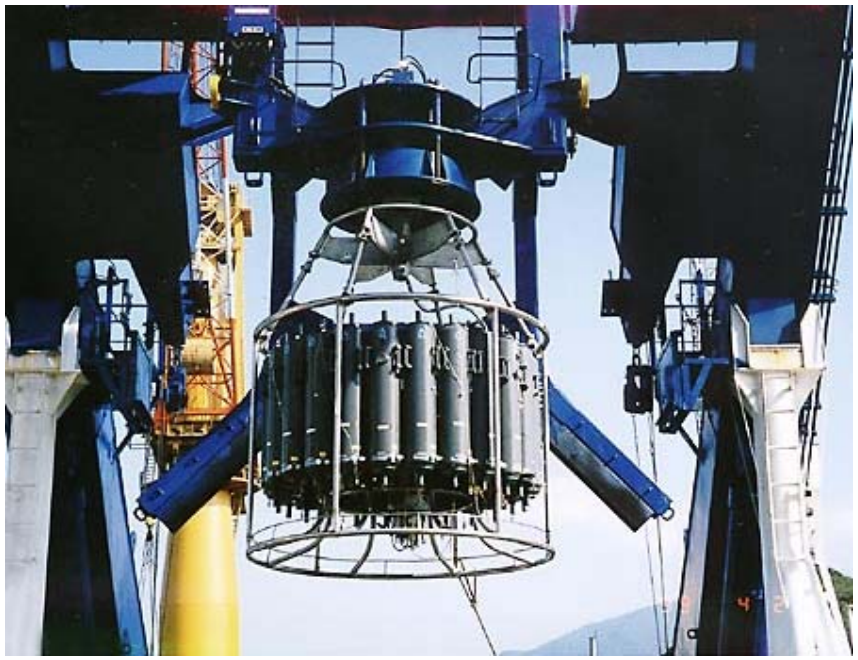

05/04/30 11:06:41
401
208.5
1480.8
2.1
HD: 205.9 -19.5
CCD: -47.9 -52.7

Conventional Method - Sampling-based

deployment

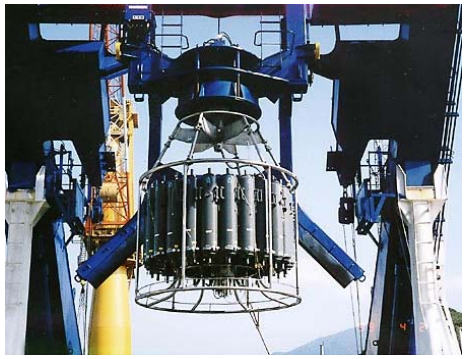
recovery

Seawater Sampling by Niskin Bottles



Rosette-Sampler with CTD Sensors

Changing the mode of analytical operations



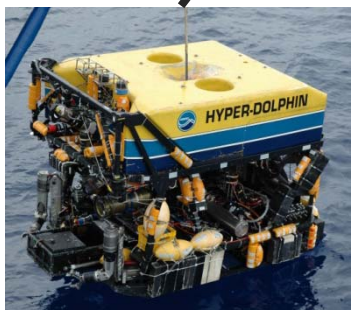
Sampling

Lab. Analysis

- ☐ Contamination Free
- ☐ Higher Resolution
- ☐ Long-term Monitoring
- ☐ Short/Zero Time lags
- ☐ Real-time Decisions

Measurement & Analysis

in situ



T. Fujii, Proc. UT2007,, Proc. ISSM2008

Microfluidic in situ Measurement Systems

IISA

Integrated *in situ* Analyzer

***IISA*-Gene: Gene Analysis/Detection**

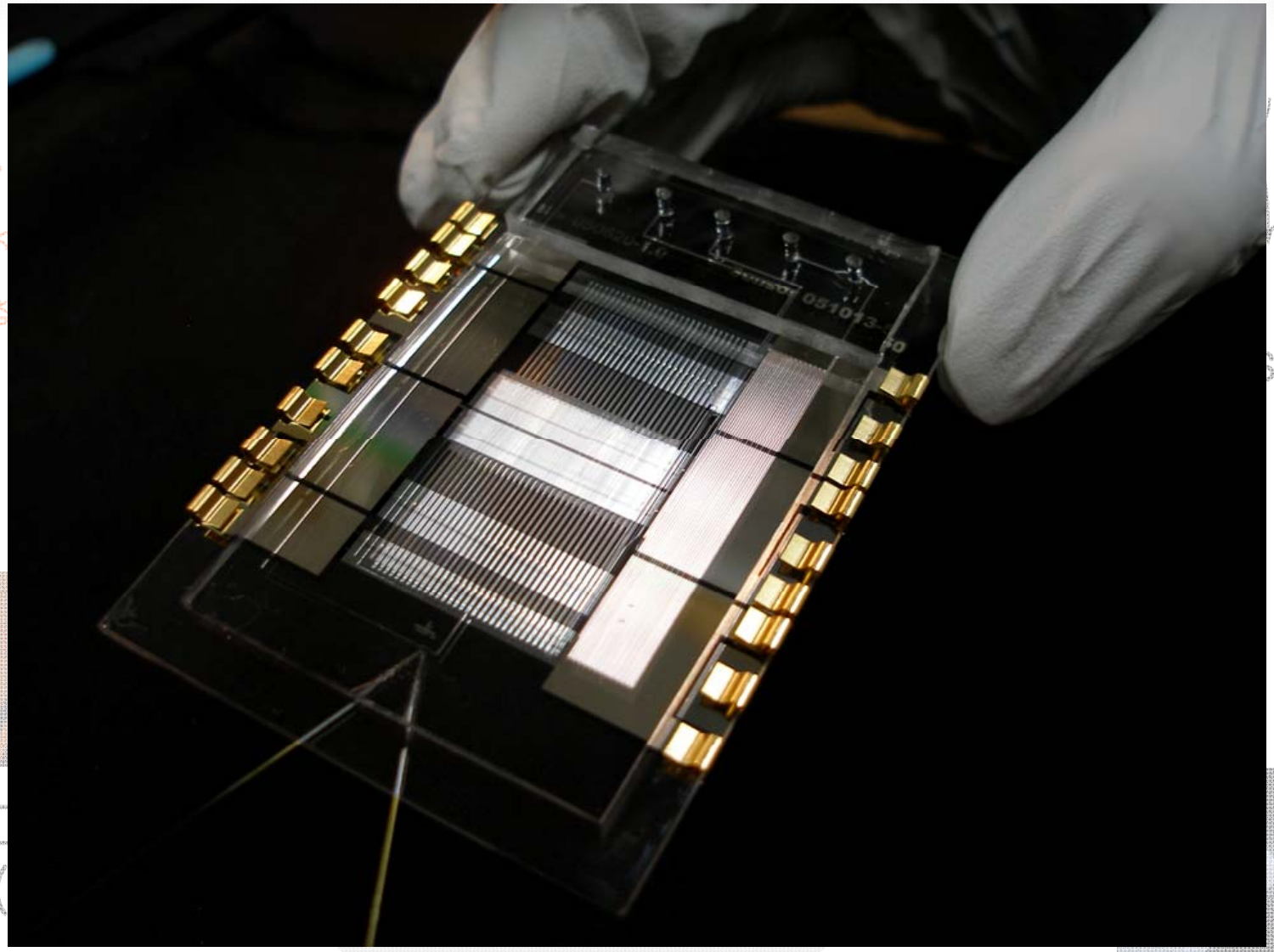
***IISA*-ATP: ATP Concentration**

***IISA*-Mn: Mn Concentration**

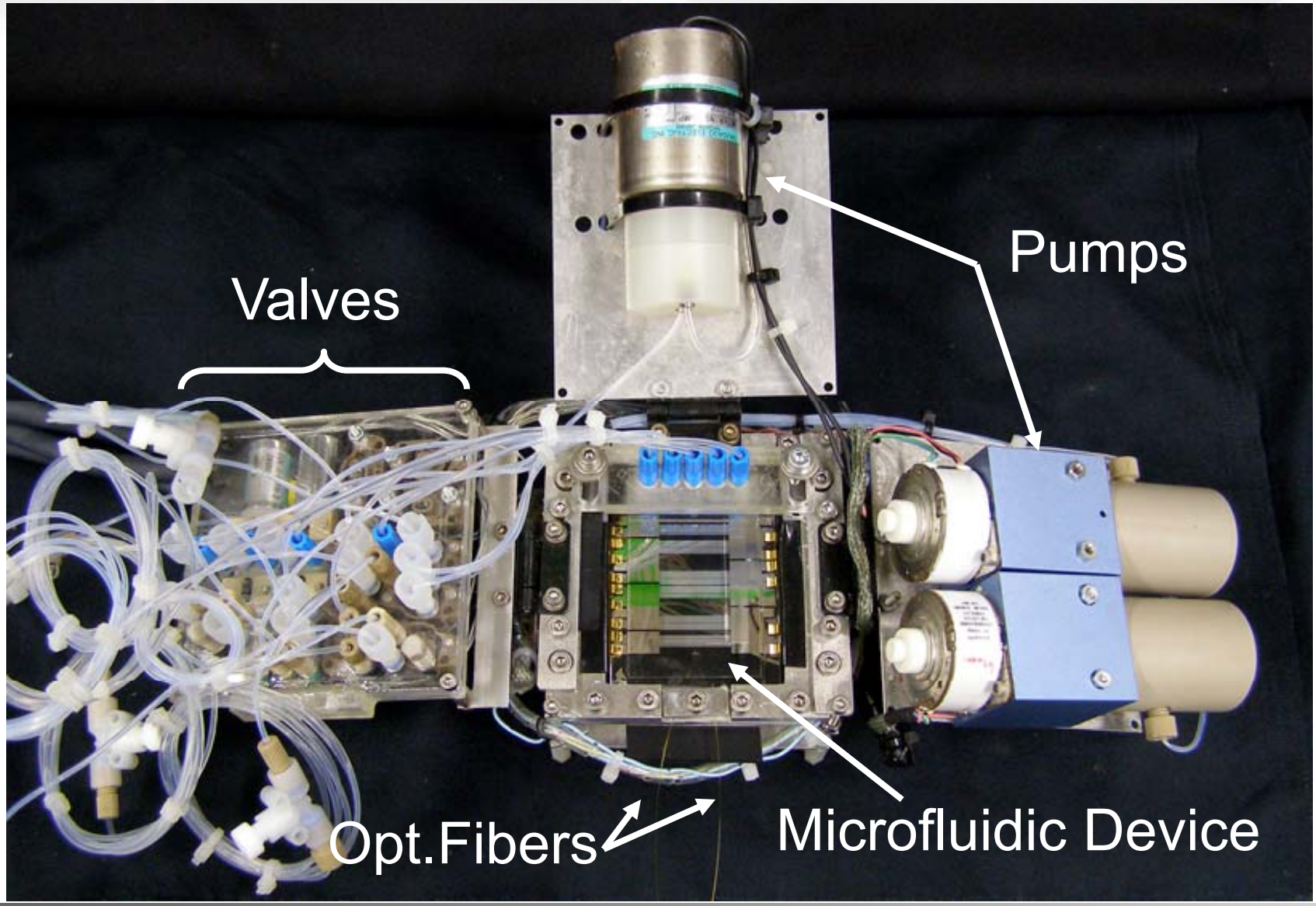
***IISA*-pH: pH Measurement**

→ Biological/Chemical Combined Measurement *in situ*

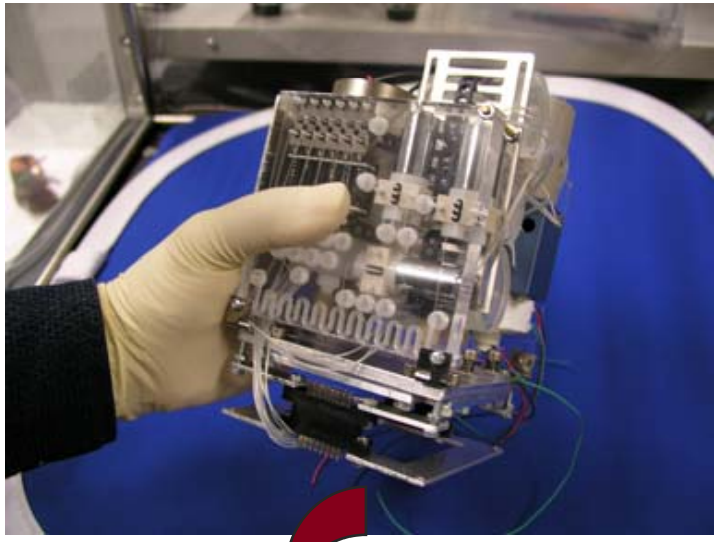
Microfabricated Flow-through PCR device

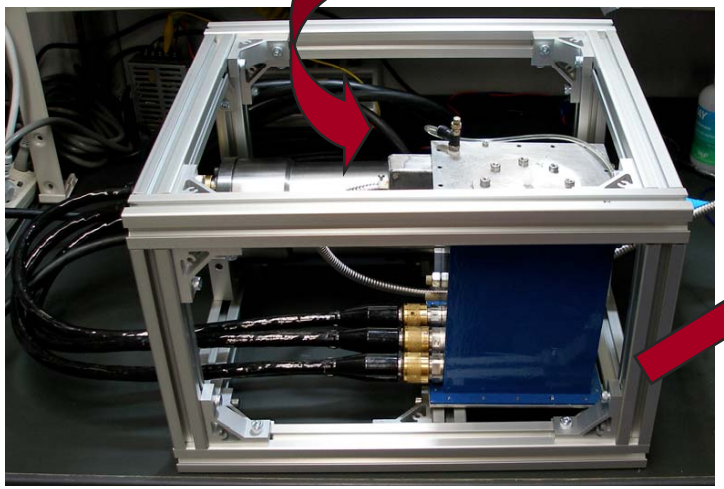


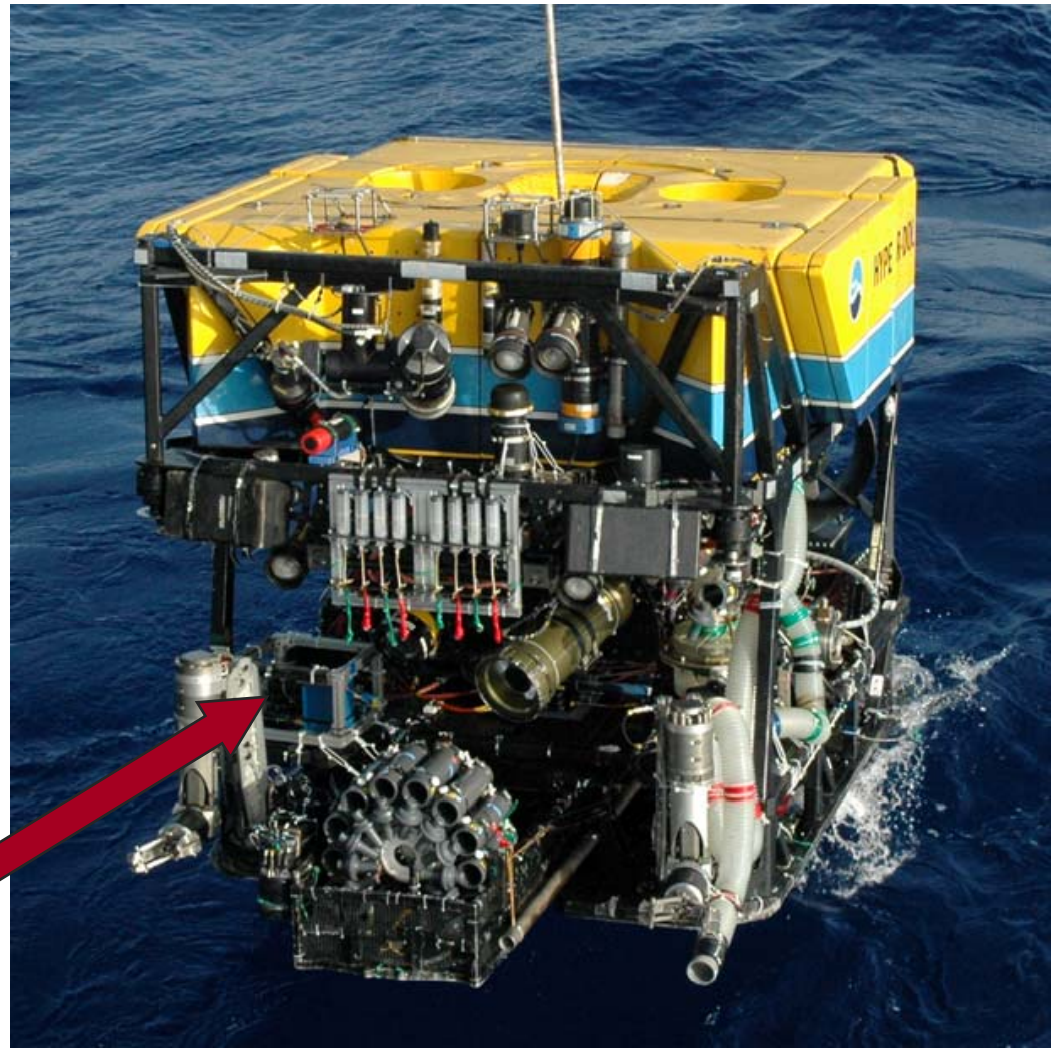
IISA-Gene Setup for Deployment



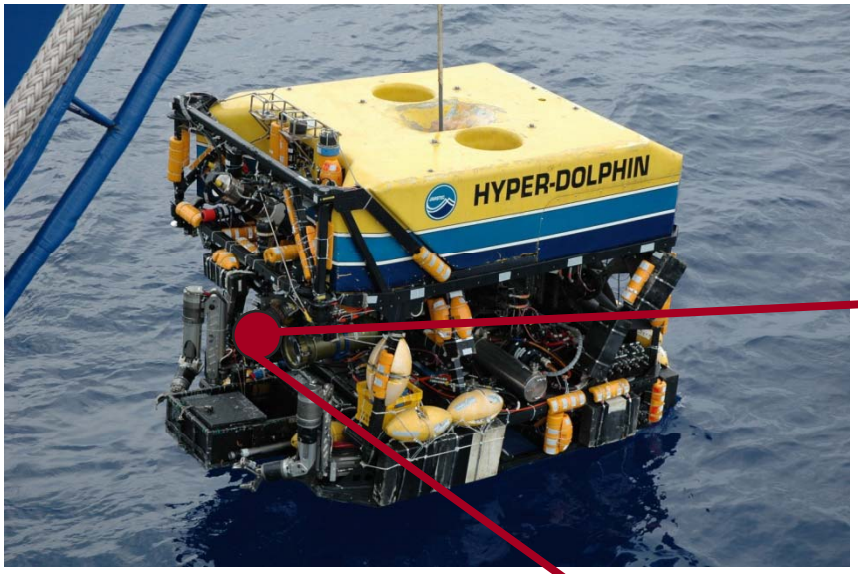
IISA-Gene on ROV







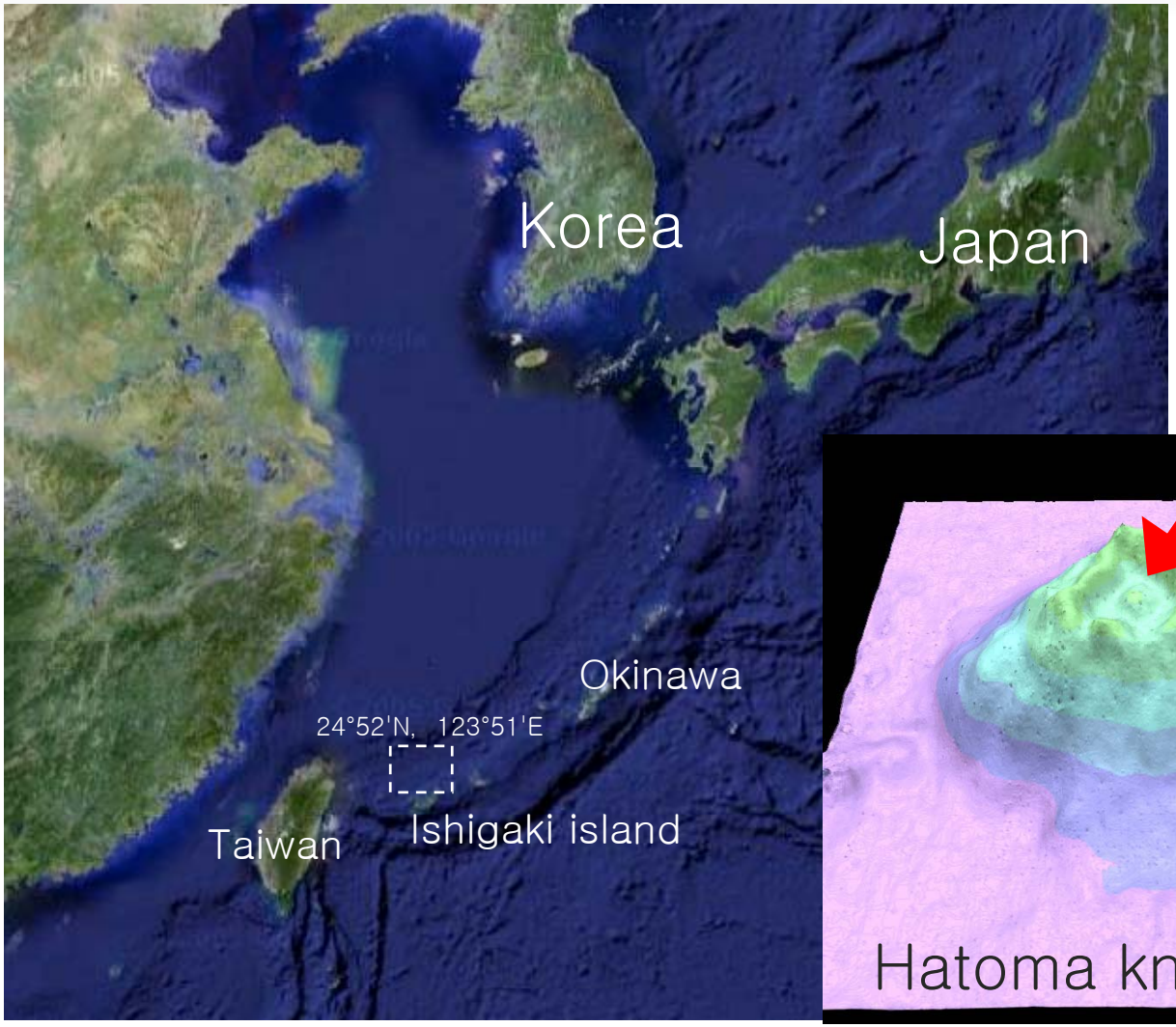
At-sea Testing of IISA-Gene



With a microfluidic device based In-situ Gene Analysis System (IISA-Gene)

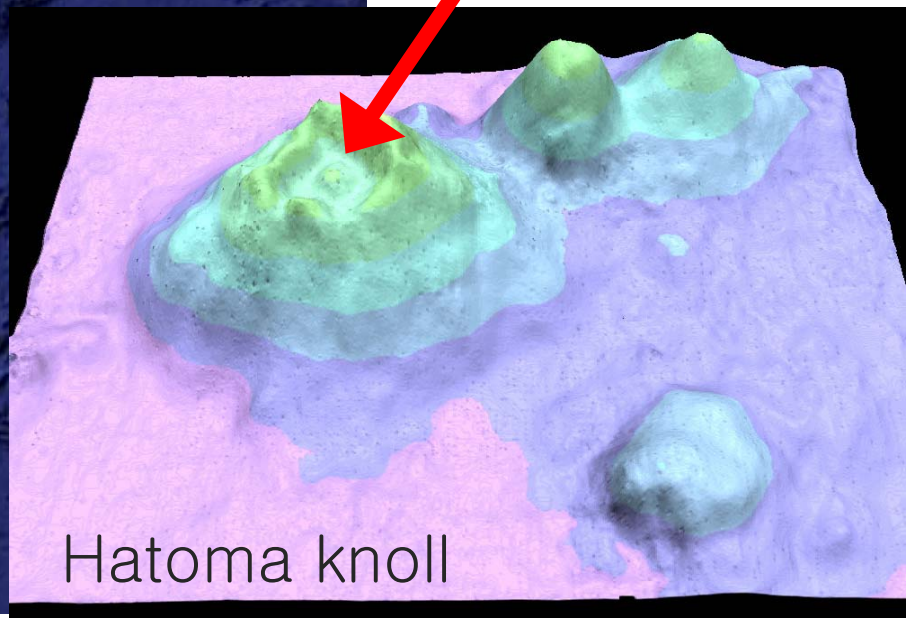
Hyper-Dolphin
(Remotely Operated Vehicle for Deep Sea Exploration)
went down to 1,500m Deep in Okinawa Trough (May 2005, July 2006, June 2008)

Hatoma Knoll (Okinawa Trough off Ishigaki Is.)



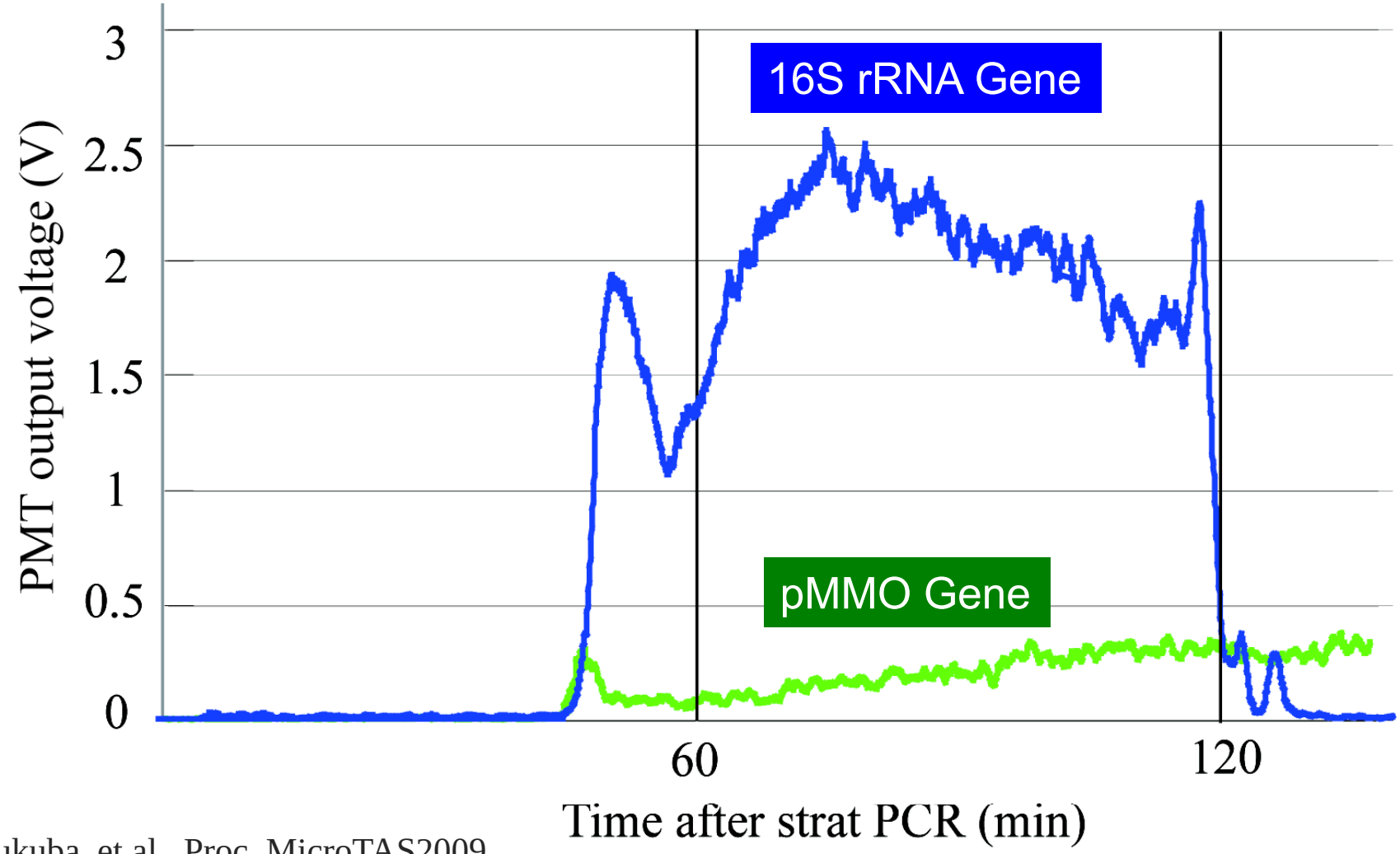
2008.06.12-06.18

Dive #848∽#855



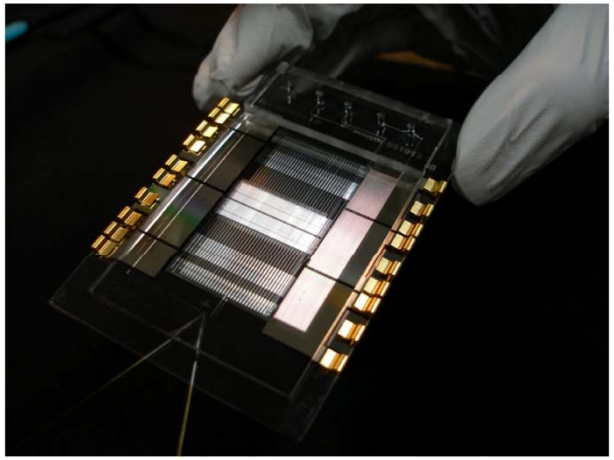
IISA-Gene in Operation

IISA-Gene Results



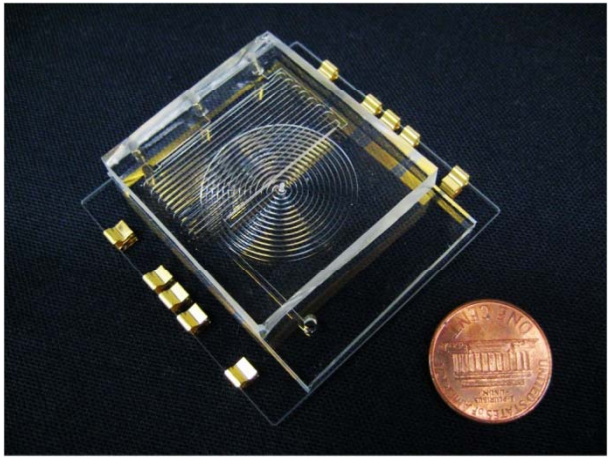
T. Fukuba, et al., Proc. MicroTAS2009

Microfluidics-based in situ Measurement Systems



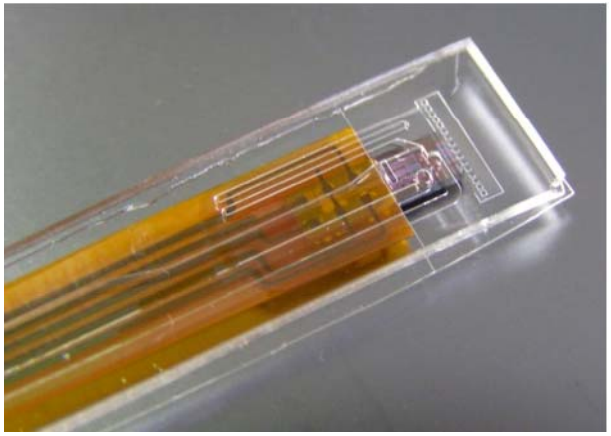
Gene

ATP



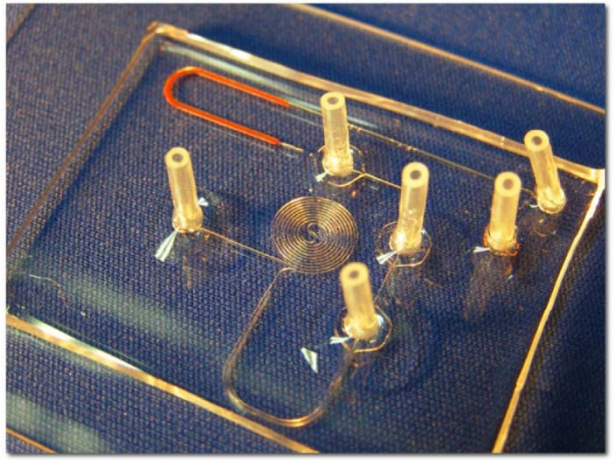
IISA

Integrated *in situ* Analyzer



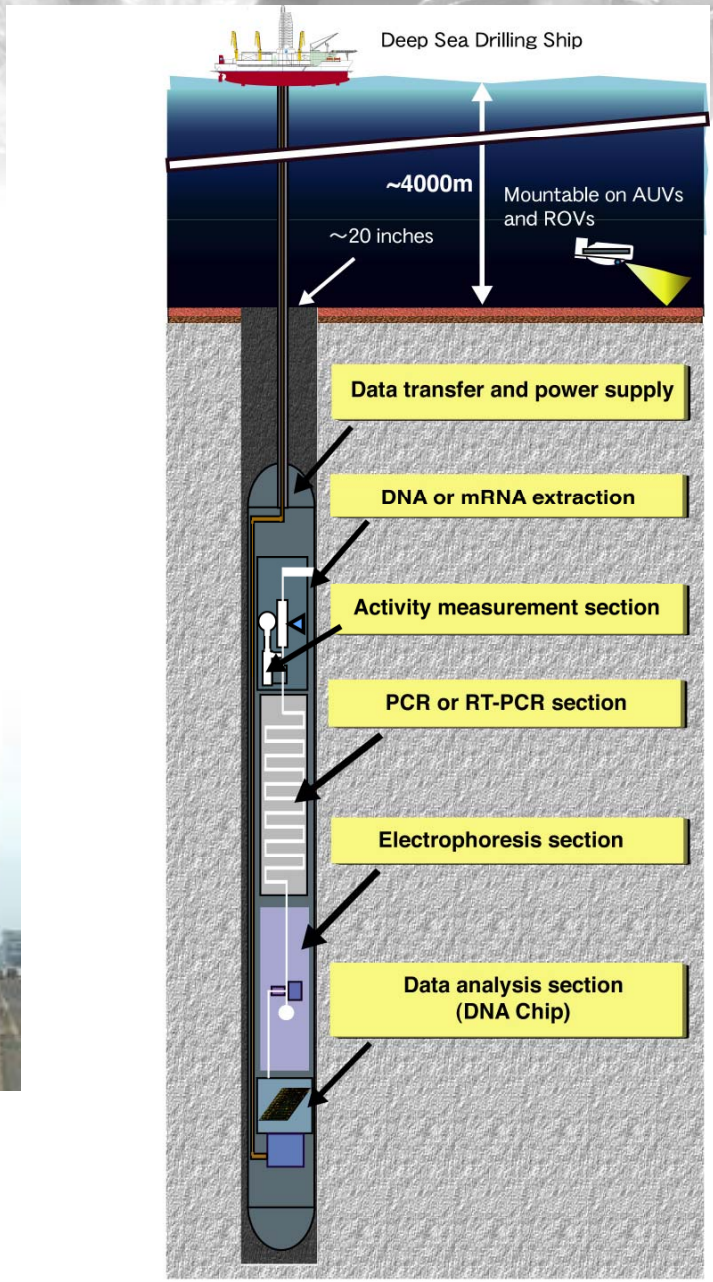
pH

Mn



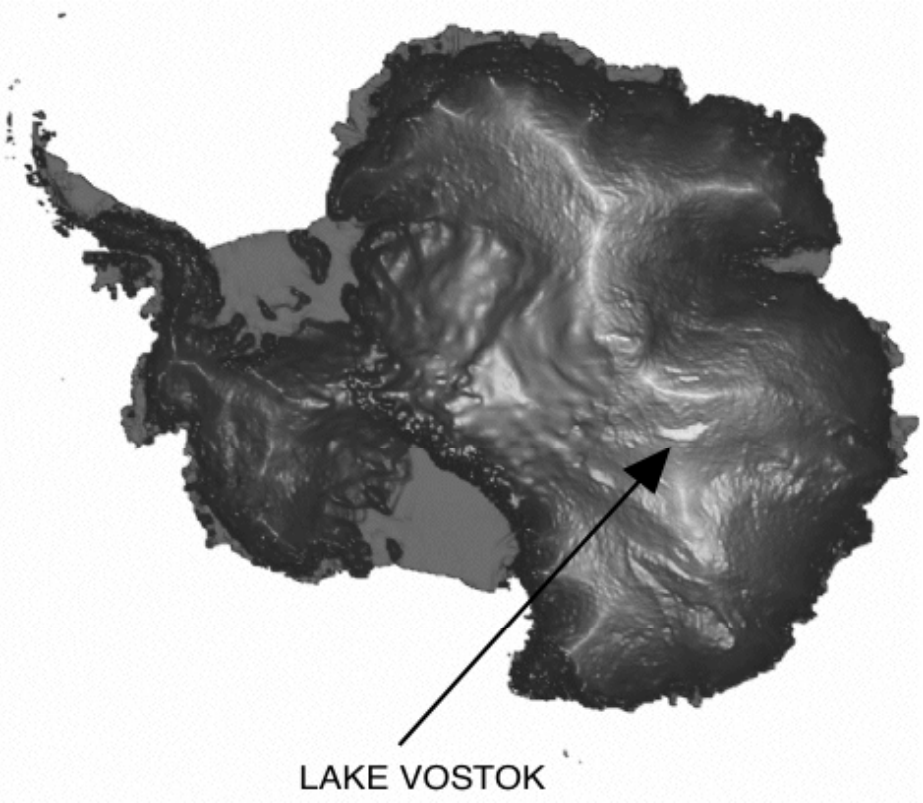
T. Fukuba, et al., Proc. MicroTAS2008

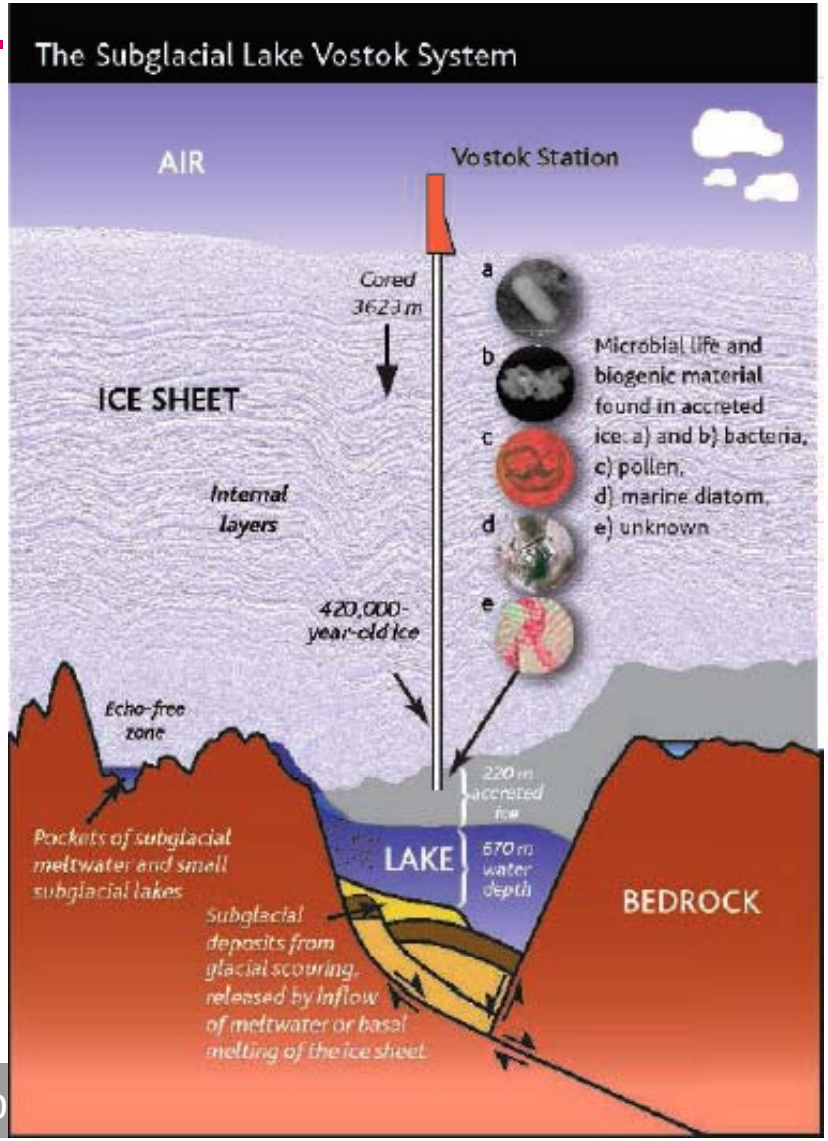
Borehole Measurement



Measurement in Subglacial Lakes

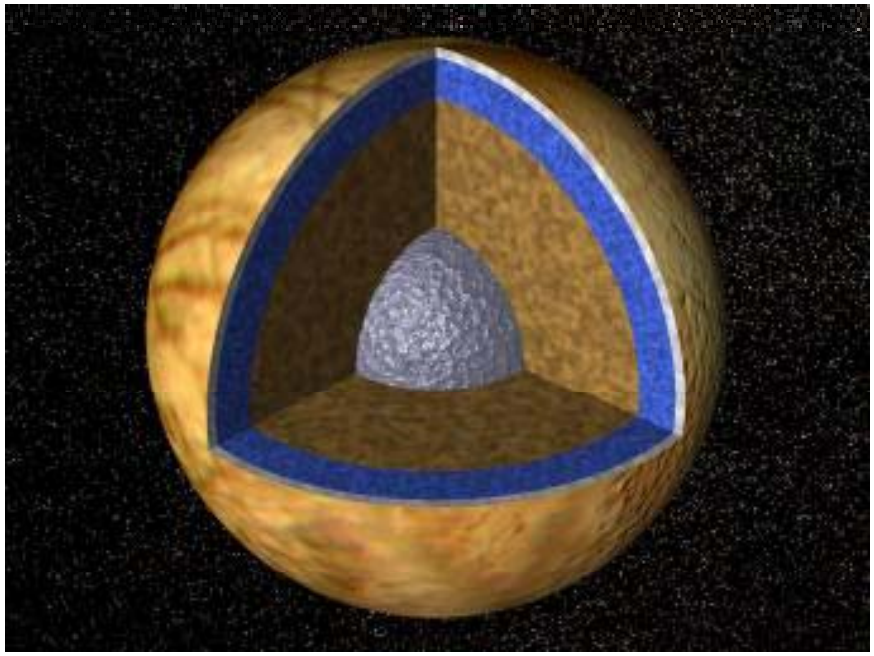
Antarctic…..

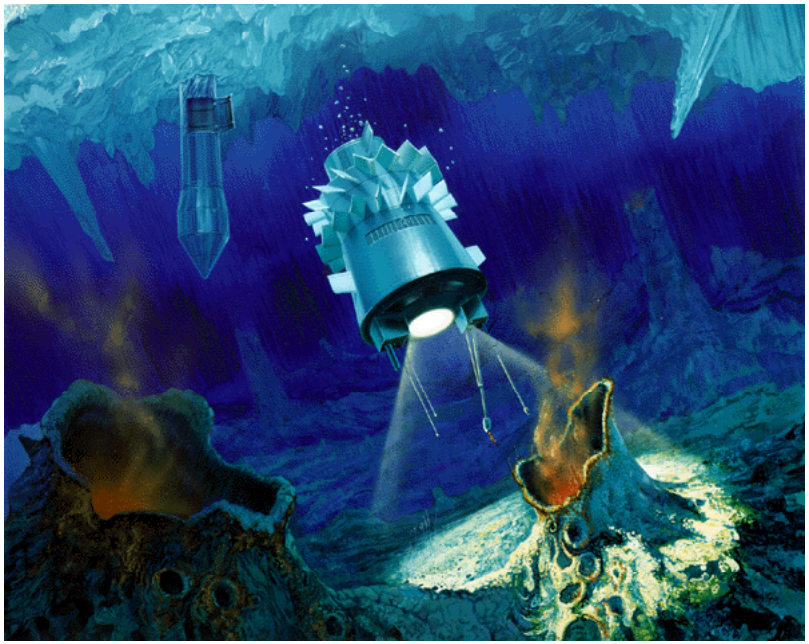




And Planetary Exploration !!!

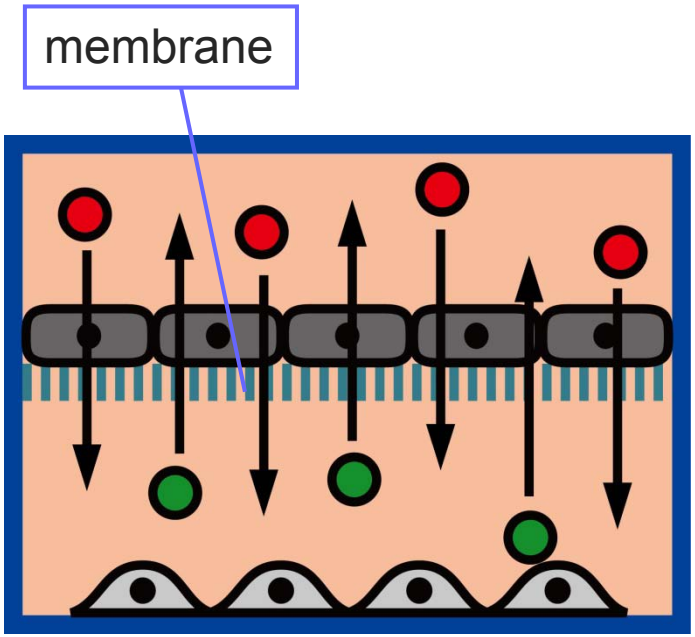
To Europa !!??

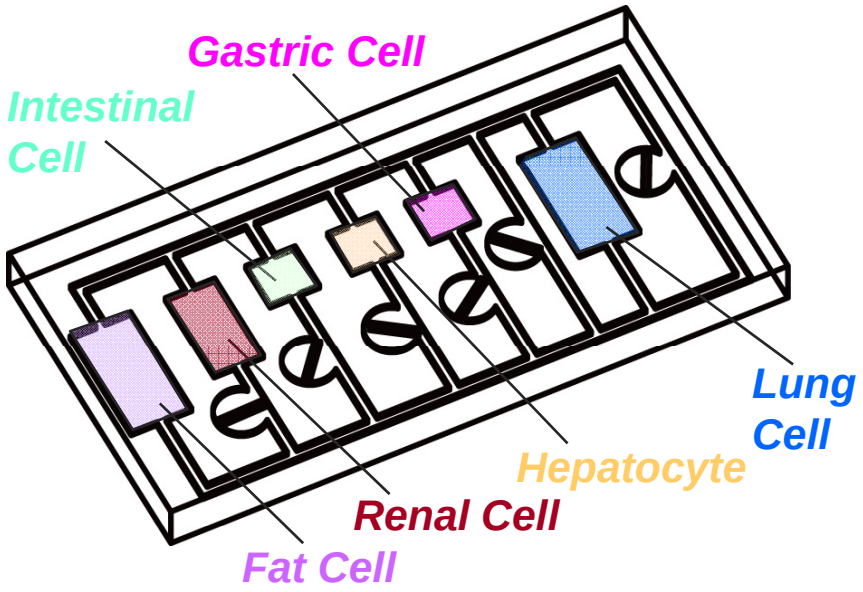




From
Deep Sea
to
Tissues and Embryos

Multiple Compartments/Cell types





Vertical Coupling through a membrane

Horizontal Coupling through fluidic paths

Membrane-based Devices

Multi-chamber Devices

Assisted Reproductive Technologies (ART)

・The first baby to be conceived by *in vitro* fertilization (ivF)

In 1978, Ms Louise Joy Brown was born at Oldham General Hospital, UK, through a planned caesarean section. The ivF procedure was done by Dr. Patrick Steptoe (Oldham General Hospital) and Dr. Robert Edwards (Cambridge Univ.).
In Japan, the first case was in 1982 at Tohoku Univ. by Dr. Suzuki.

July 25, 1978: Patrick Steptoe, Jean Purdie, and Louise Brown..in the arms of Bob Edwards

(1978)

Baby son joy for test-tube mother

The world's first "test-tube baby", Louise Brown, has spoken of her joy at giving birth to her first child.

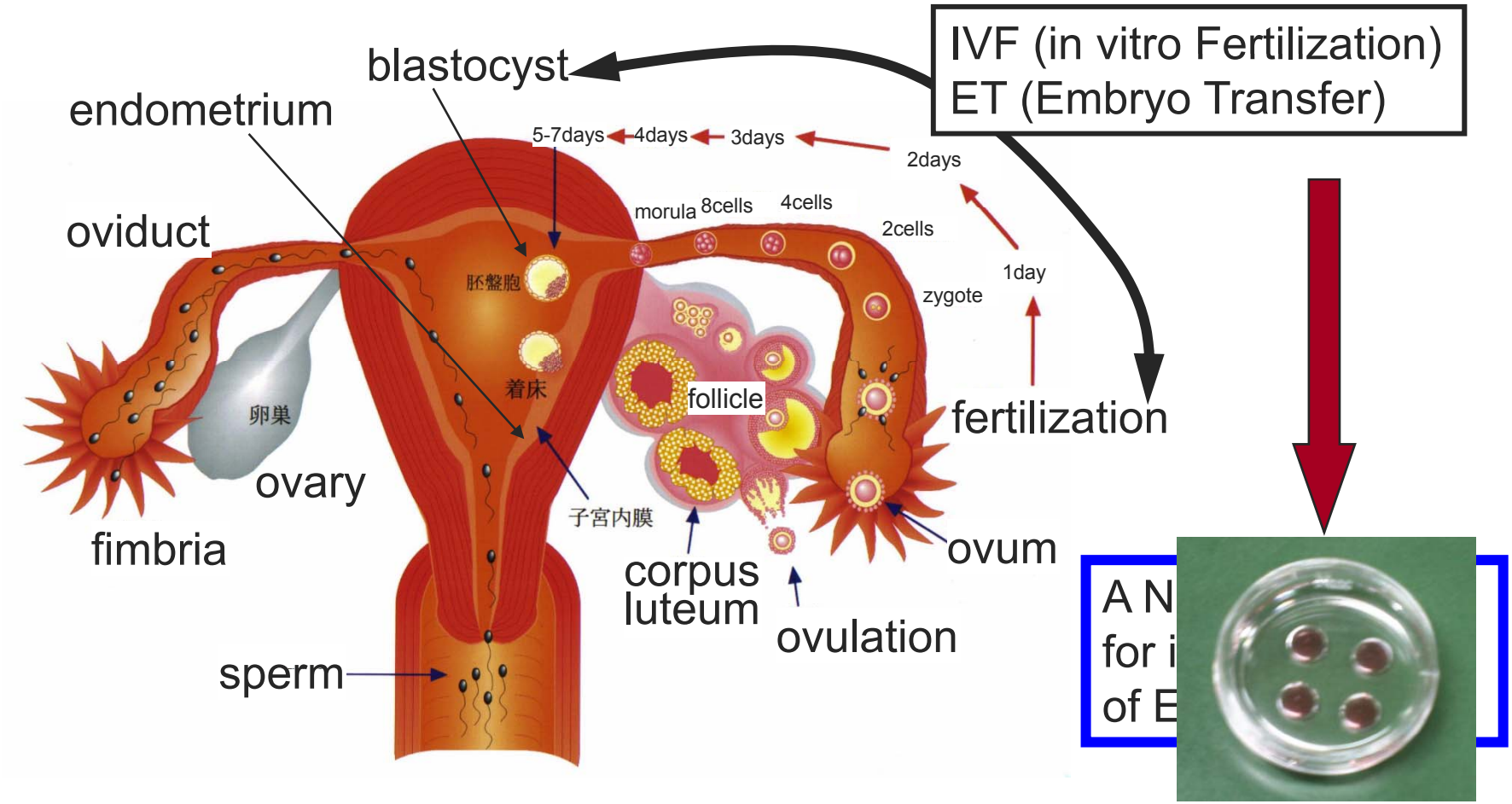
Baby Cameron was born on 20 December in Bristol, where his 28-year-old mother lives with husband Wesley Mullinder.

Louise Brown was the first of many

(2006)

Already ~30 years, but the success rate is still low (25-35%)

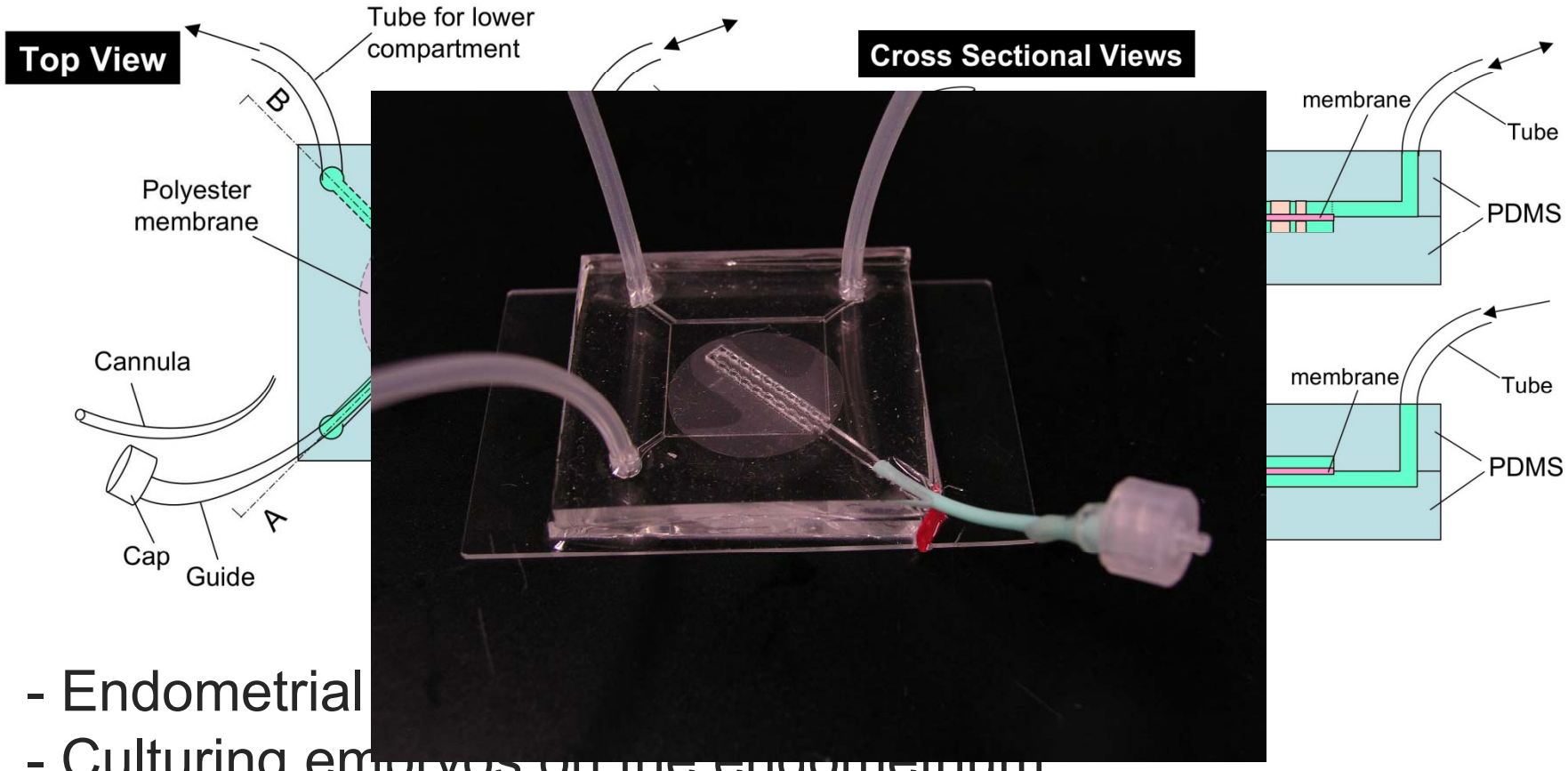
Mechanism of Pregnancy & ART



First ivF baby in 1978

15,000 babies/year (1.3%) in Japan

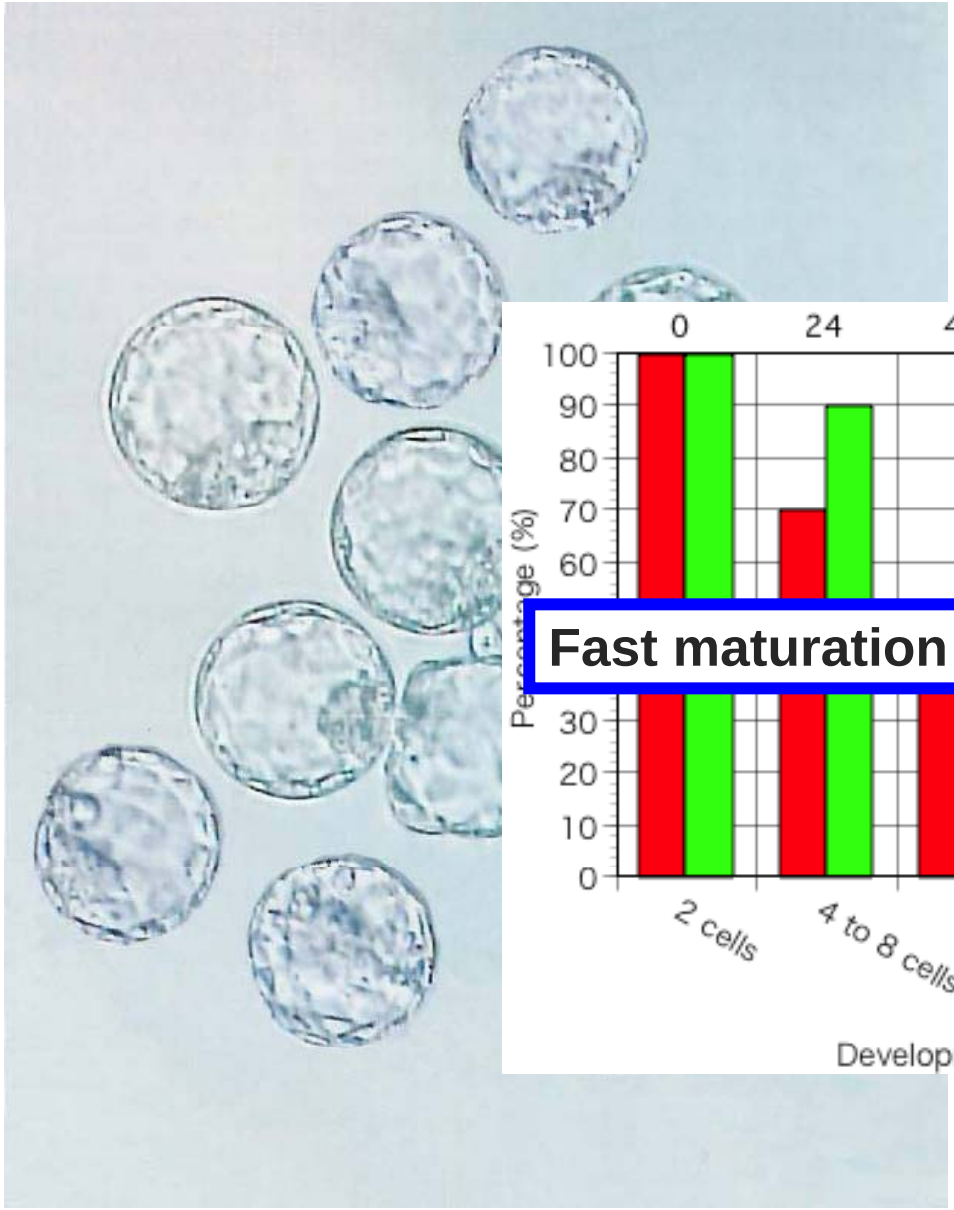
Microfluidic Embryo/Endometrium Co-culture Device

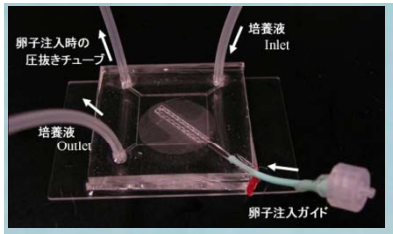


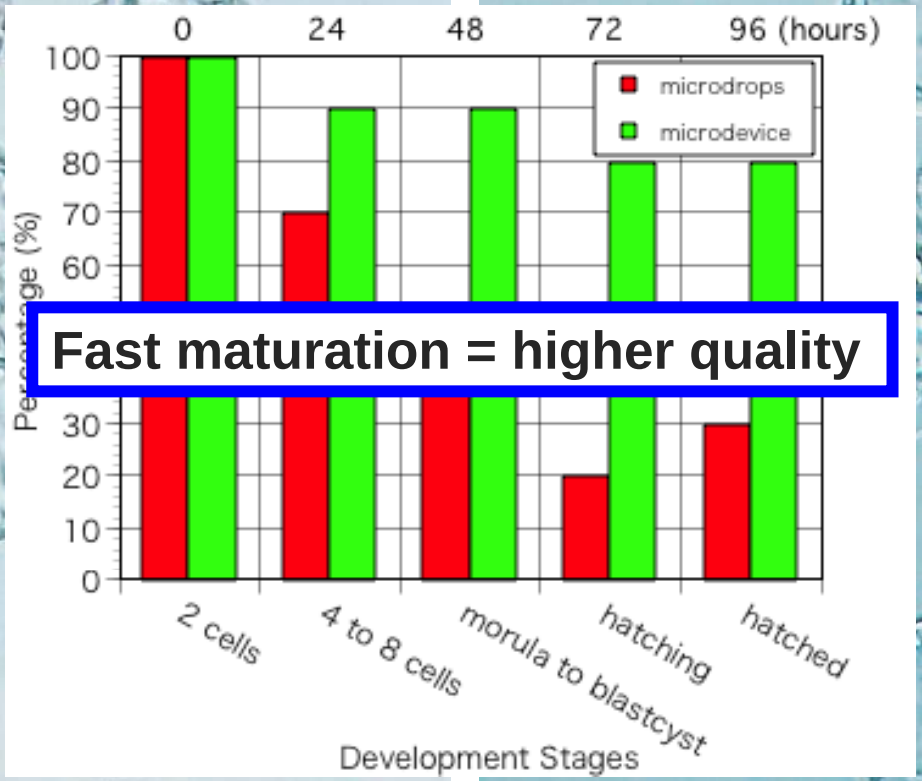
- Endometrial
- Culturing embryos on the endometrium

→ Mimicking in vivo

S. Ostrovidov, et al., Proc. MicroTAS2004







Fast maturation = higher quality

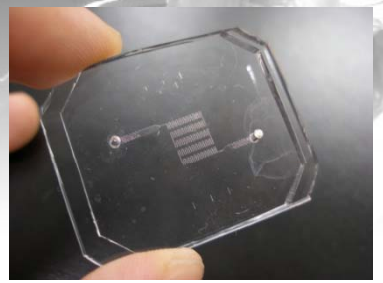
Microdrops

Microdevice

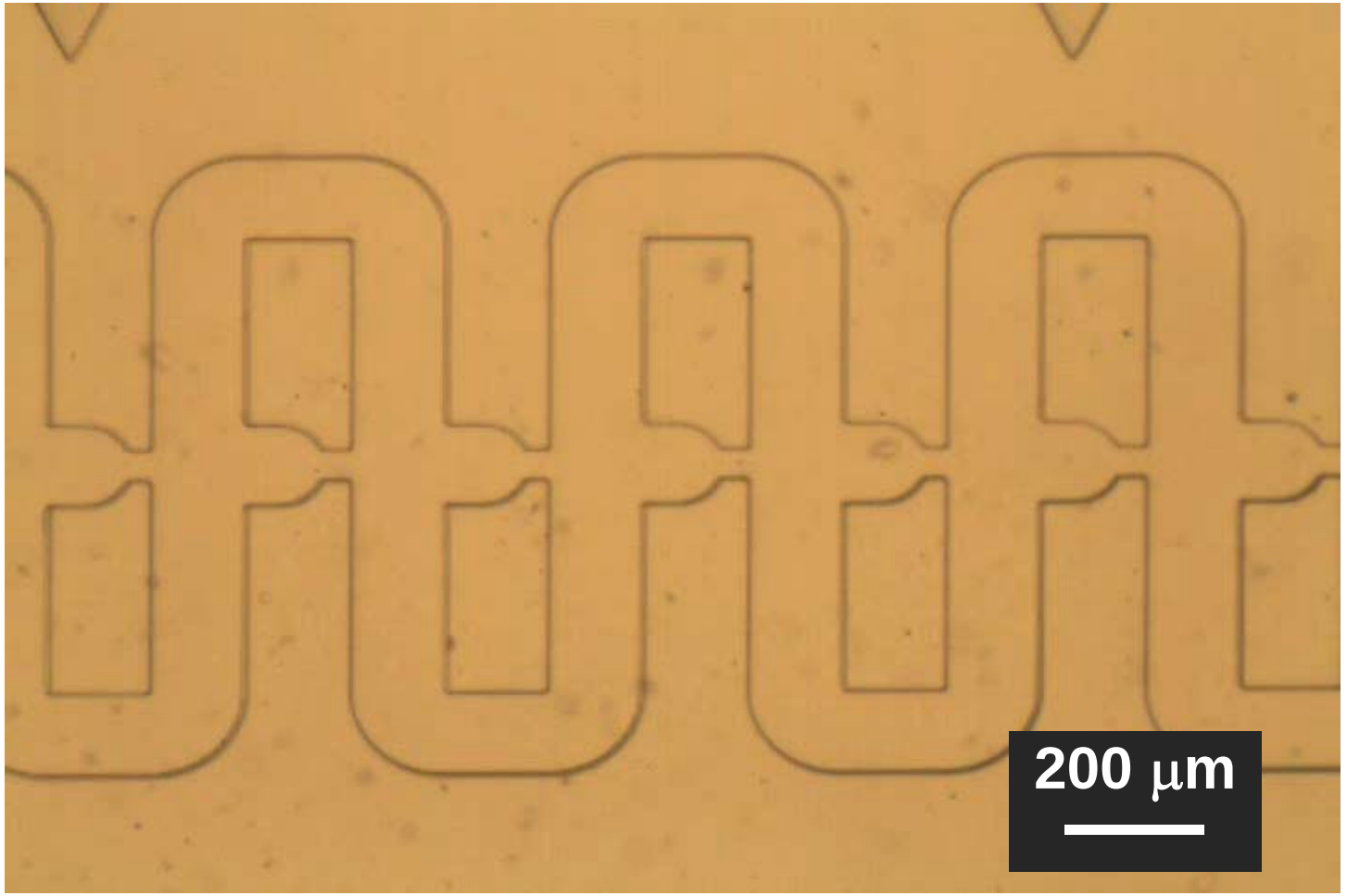
72 hours of culture

Toward
High-throughput Handling of Embryos for

Toward High-Throughput Embryo Handling



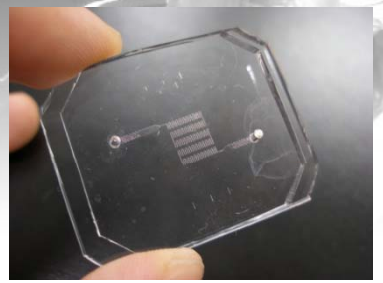
Mouse Embryos: 80 μm

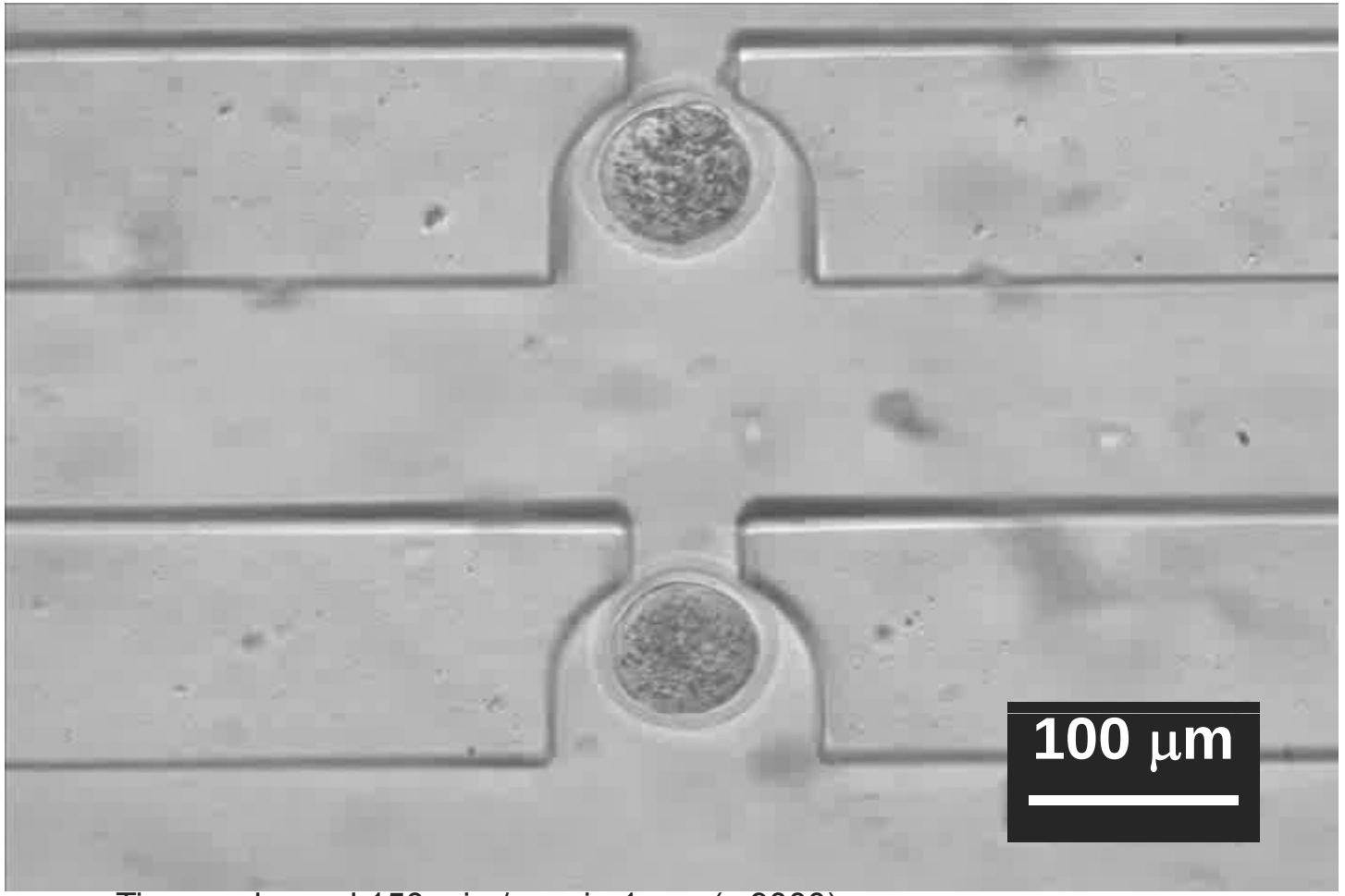


H. Kimura, et al., Proc. MicroTAS2009

Flow Rate:1 μL/min

Monitoring Individual Embryos





Time scale: real 150 min / movie 1 sec (x 9000)
Total: 100 hours

Flow Rate: 0.5 μL/min

Challenges and Opportunities

Adding a new axis in analysis

- ☐ Modelling Tools for Molecules, Cells, Organs (to identify their dynamics)
- ☐ Advanced Cell/Tissue Culture Techniqnes (with dynamic control/manipulation)
- ☐ Drug/Toxicity Testing System
- ☐ On-site Environmental Monitoring

Connecting spaces

- ☐ Portable Bioanalytical Tool (on-site diagnosis/biodetection, etc.)
- ☐ Health Monitoring at Home (cooperation with hospitals/insurance co.)
- ☐ Simultaneous Monitoring of Wide Areas
- ☐ Materials Transfer !! (On-site Synthesis) (Materials Display via Internet)

Applied Microfludic Systems Lab.

http://www.microfluidics.iis.u-tokyo.ac.jp