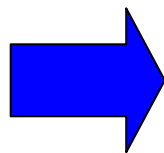


ロボット (機械) の知能化, 自律化



“TMSUK IV”



“Kismet” MIT's AI Lab



ソニー“AIBO”

ペットロボット



ST “Seal”(産総研)



オムロン“ネコロ”



NEC “パペロ”



三菱重工業

機械（ロボット）間，機械と人のコミュニケーション

不特定機器

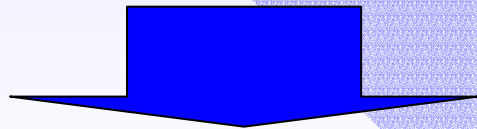
- ・コミュニケーション相手の認識

不特定フォーマット

- ・言葉の理解

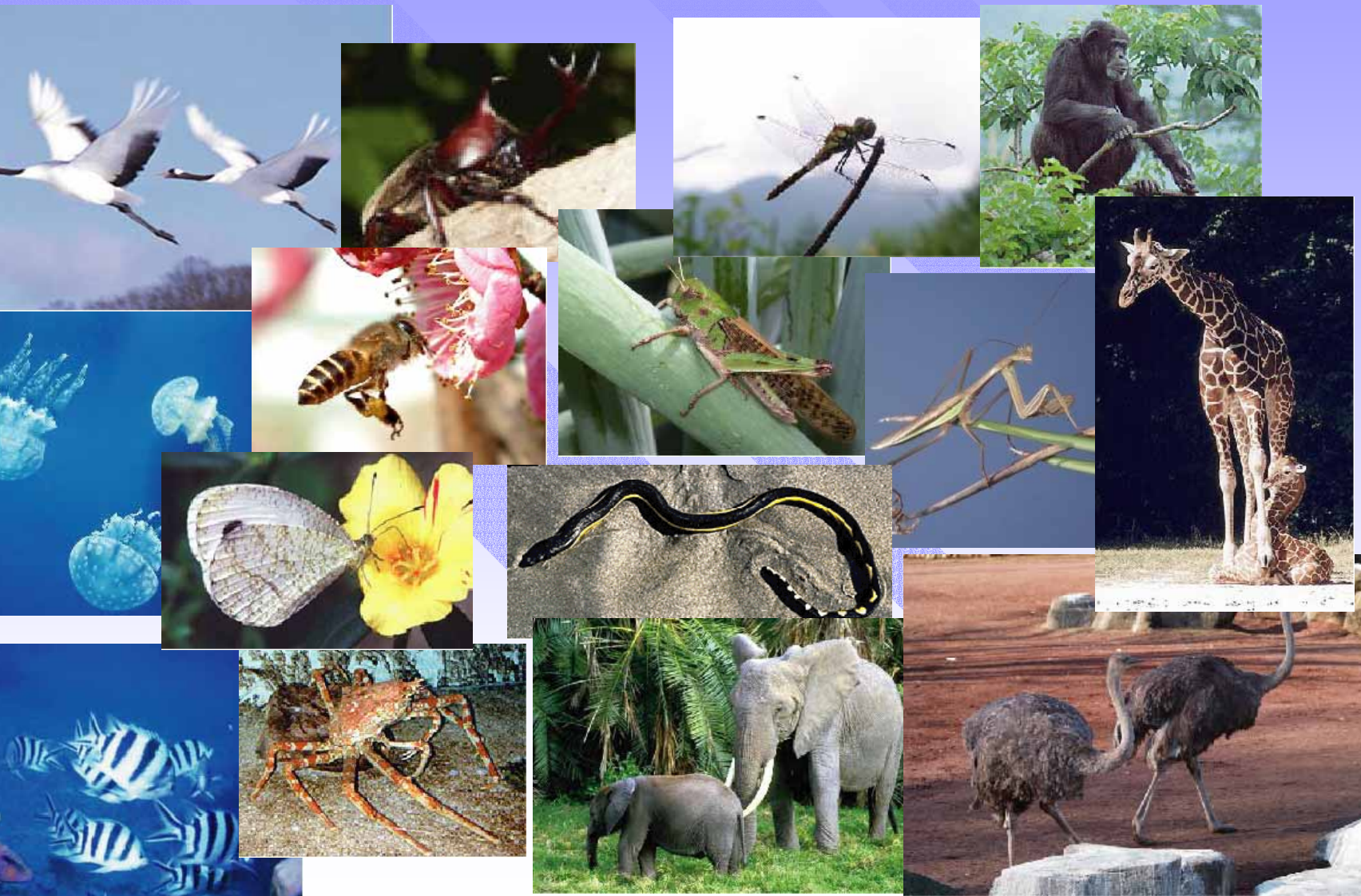
不特定情報

- ・コミュニケーション相手の環境の認識
- ・不特定情報の推定，補間

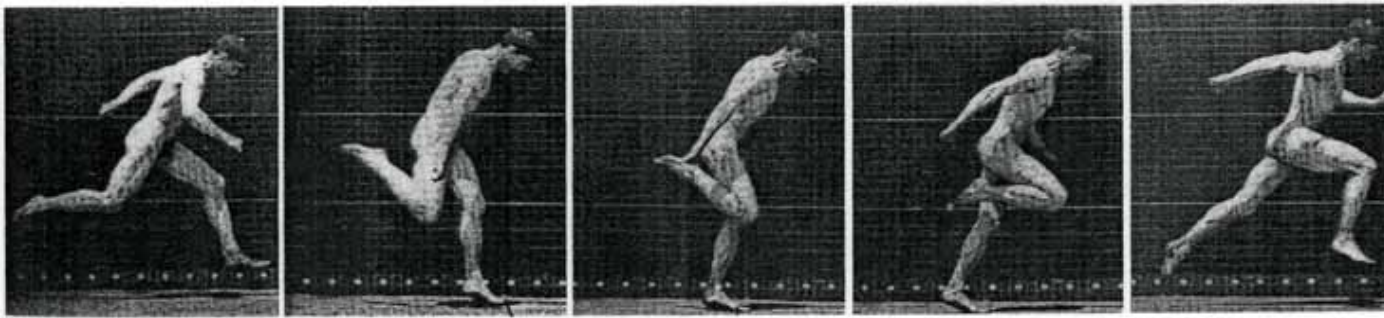
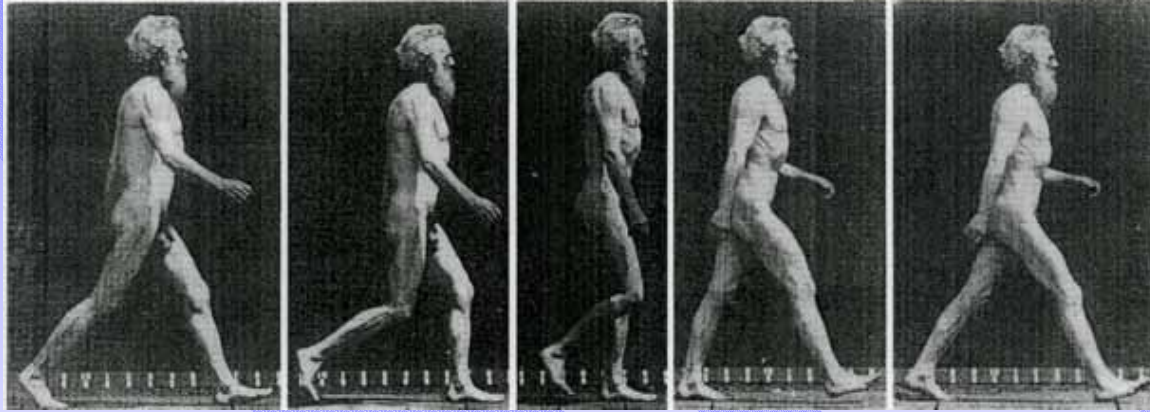


高度な知能の必要性

バイオ発想ロボット



二足歩行



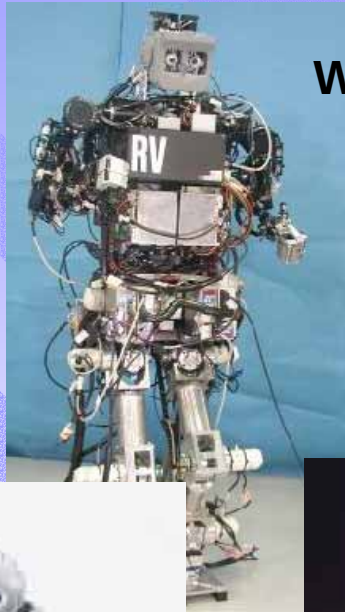
E. Muybridge

二足歩行

ASIMO



WABIAN



H7



HRP-2

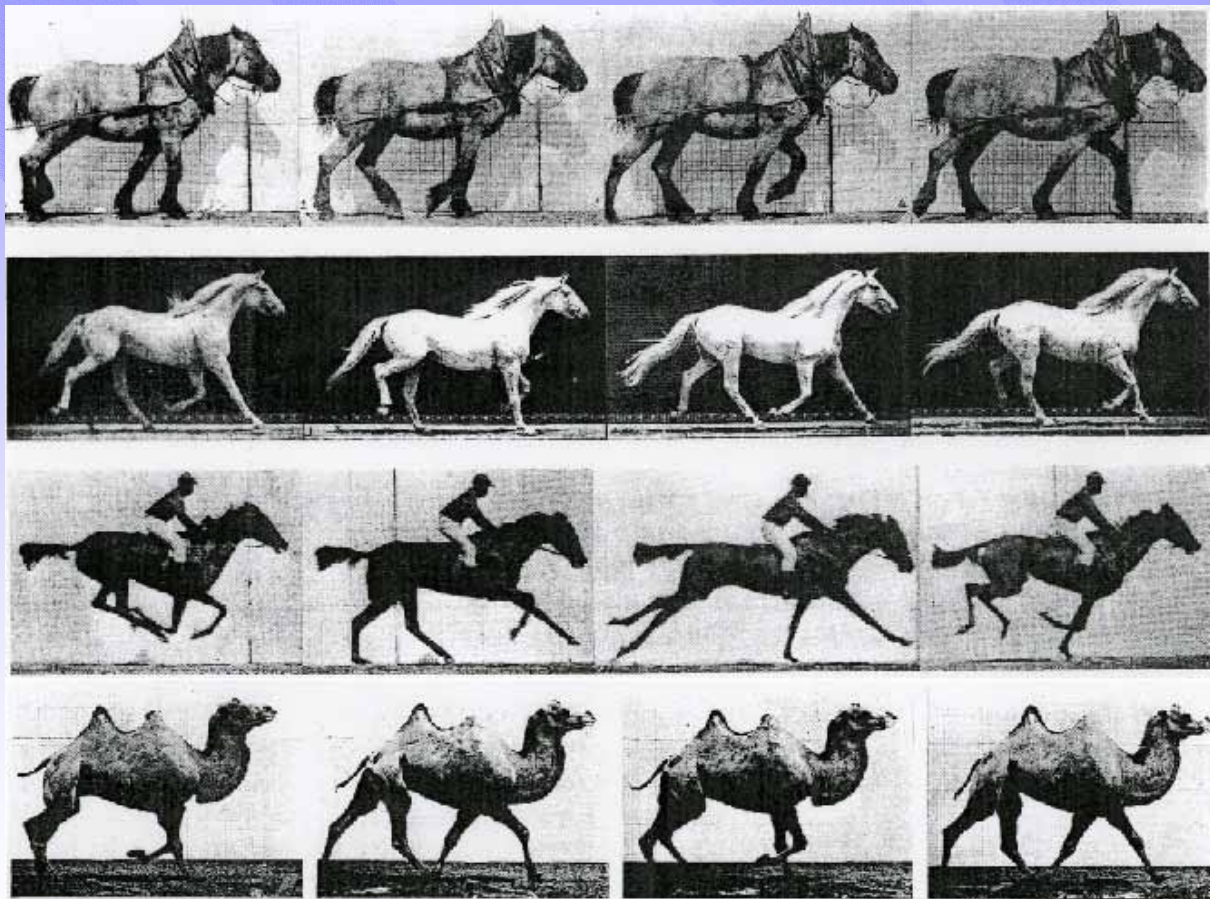


QRIO



Passive Dynamic Walker

四足步行

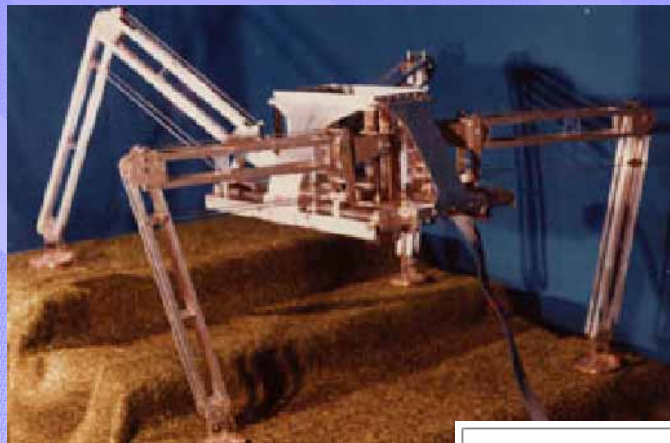


E. Muybridge

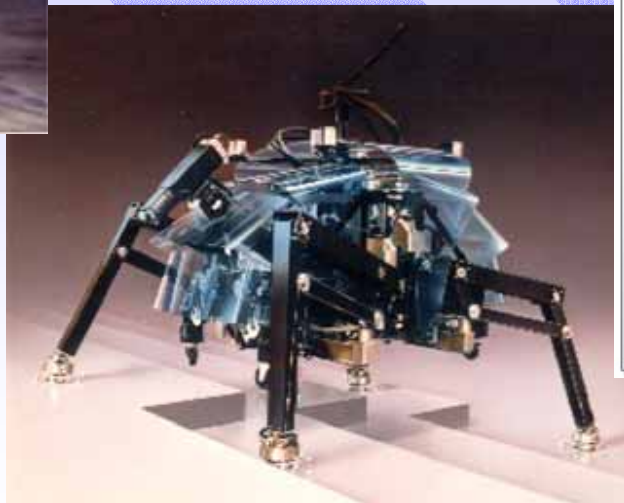
四足歩行ロボット



quadruped



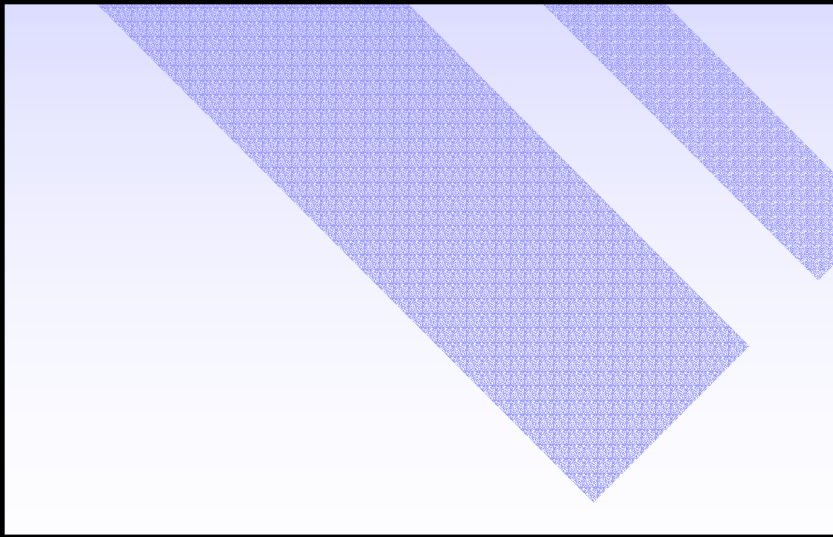
PV-II



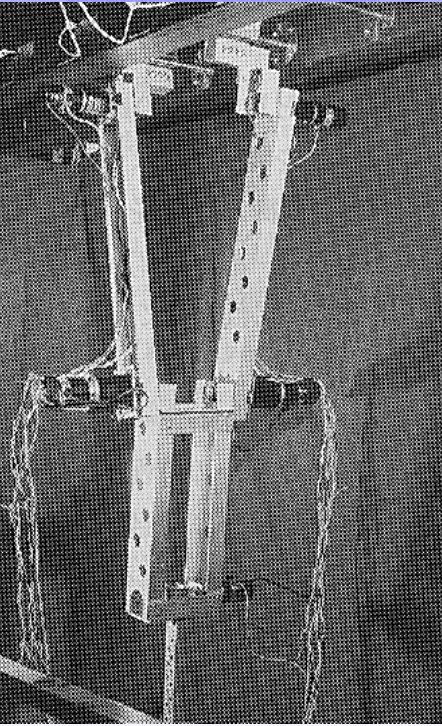
TAITAN IV



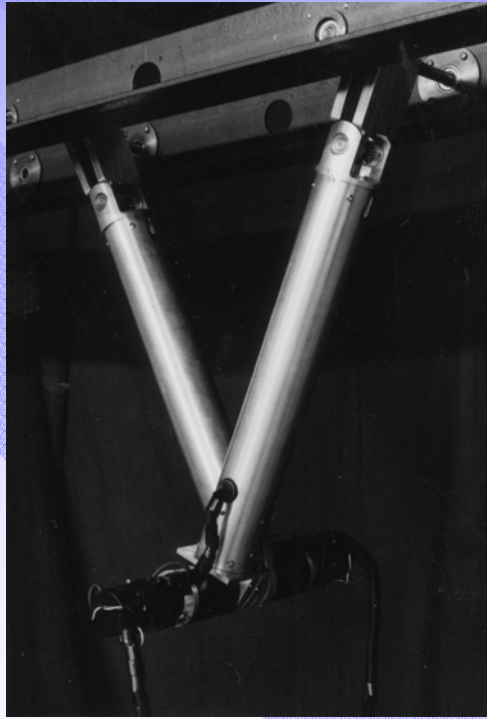
BANRYU



枝渡りロボット: Brachiation Robot



Brachiator I



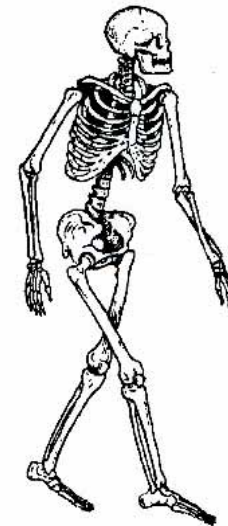
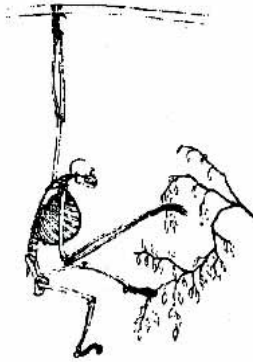
Brachiator II



Brachiator III

靈長類: Primates

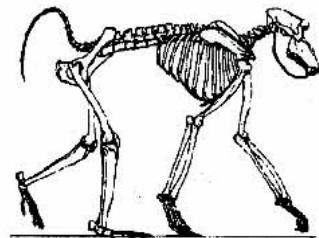
Suspensory



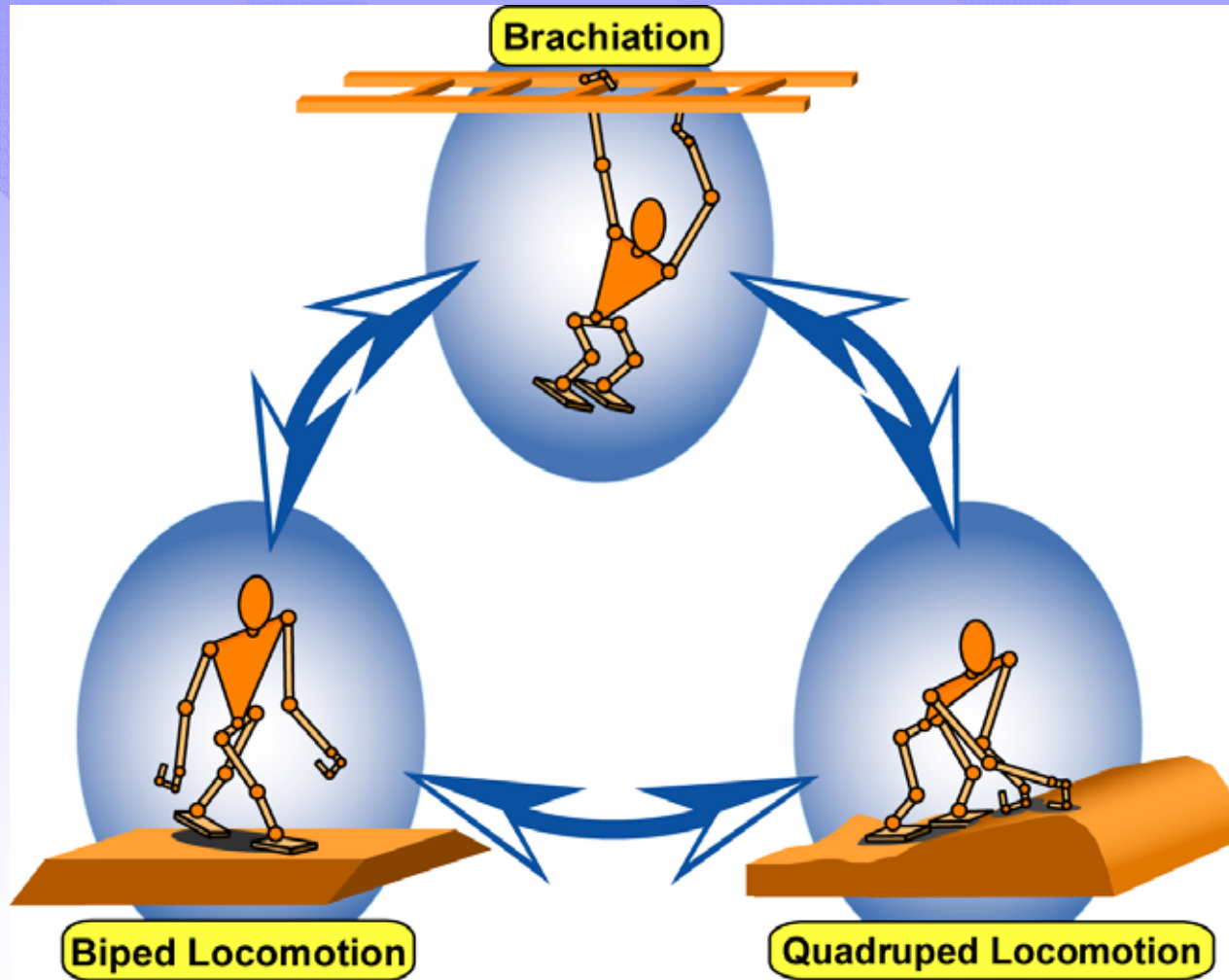
Biped



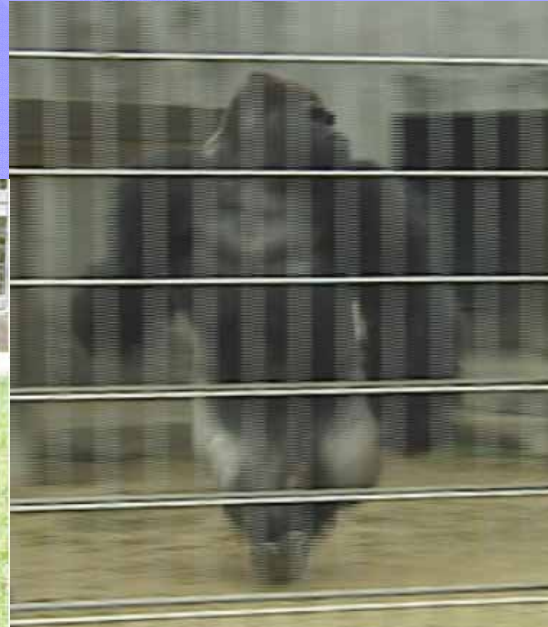
Quadruped



マルチロコモーションロボット: Multi-locomotion Robot

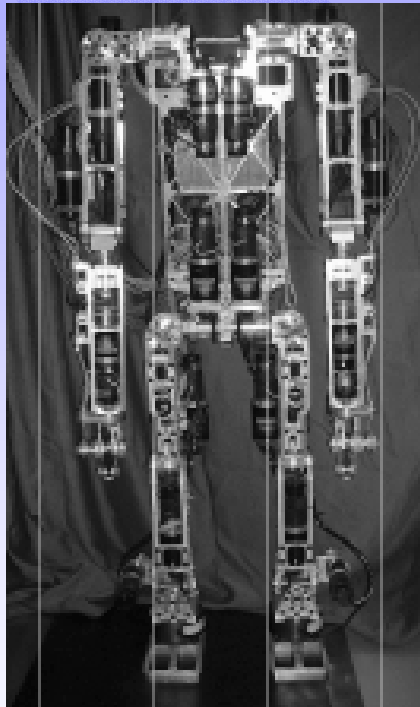


ゴリラ:Gorilla, Gorilla, Gorilla

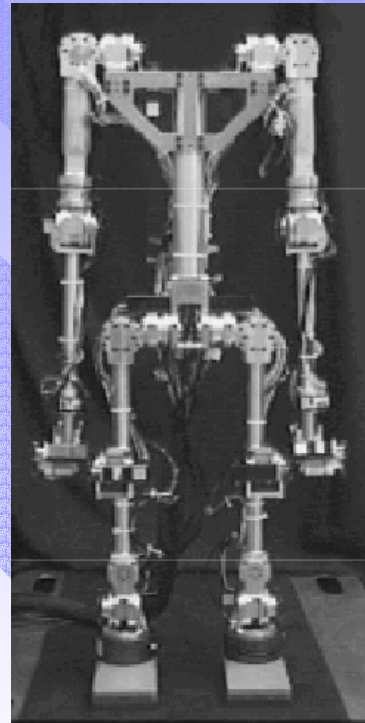


Western Lowland Gorilla

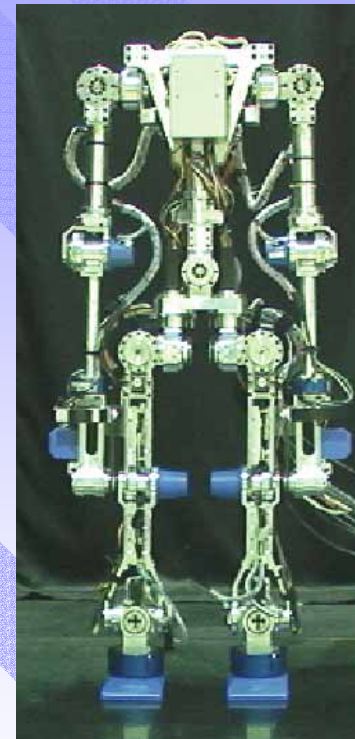
ゴリラロボットプロトタイプ: Prototype of Gorilla Robot



Gorilla Robot I
(2000)

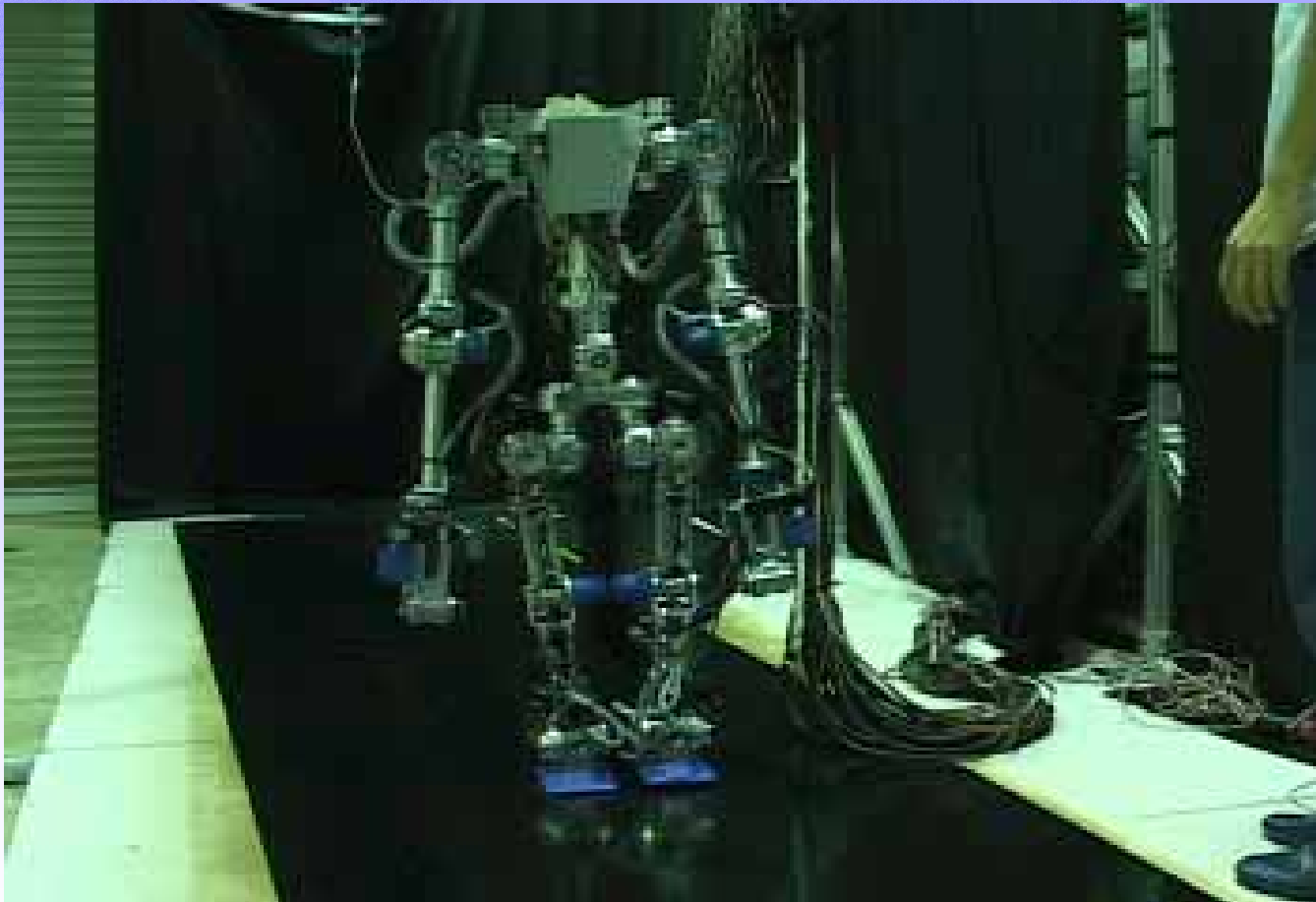


Gorilla Robot II
(2001)



Gorilla Robot III
(2002)

実験: Lateral Motion



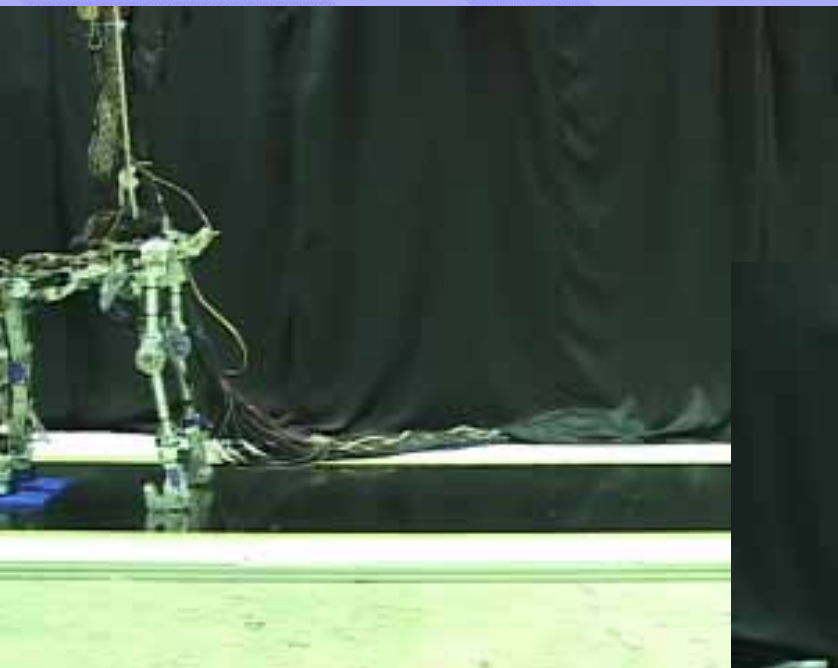
実験: Sagittal Motion



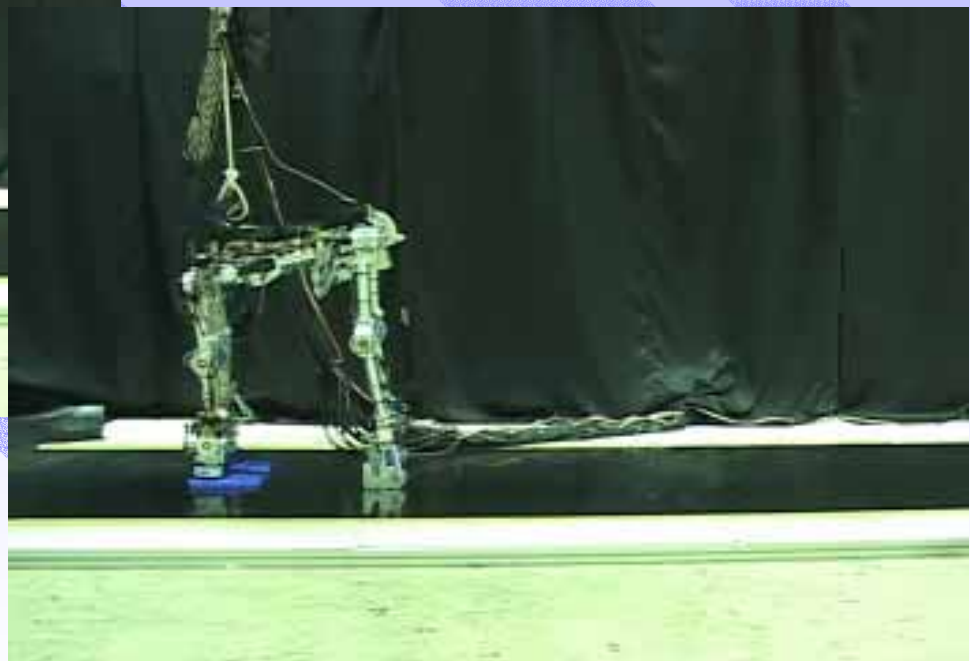
実験: Brachiation



実験: Trot Gait

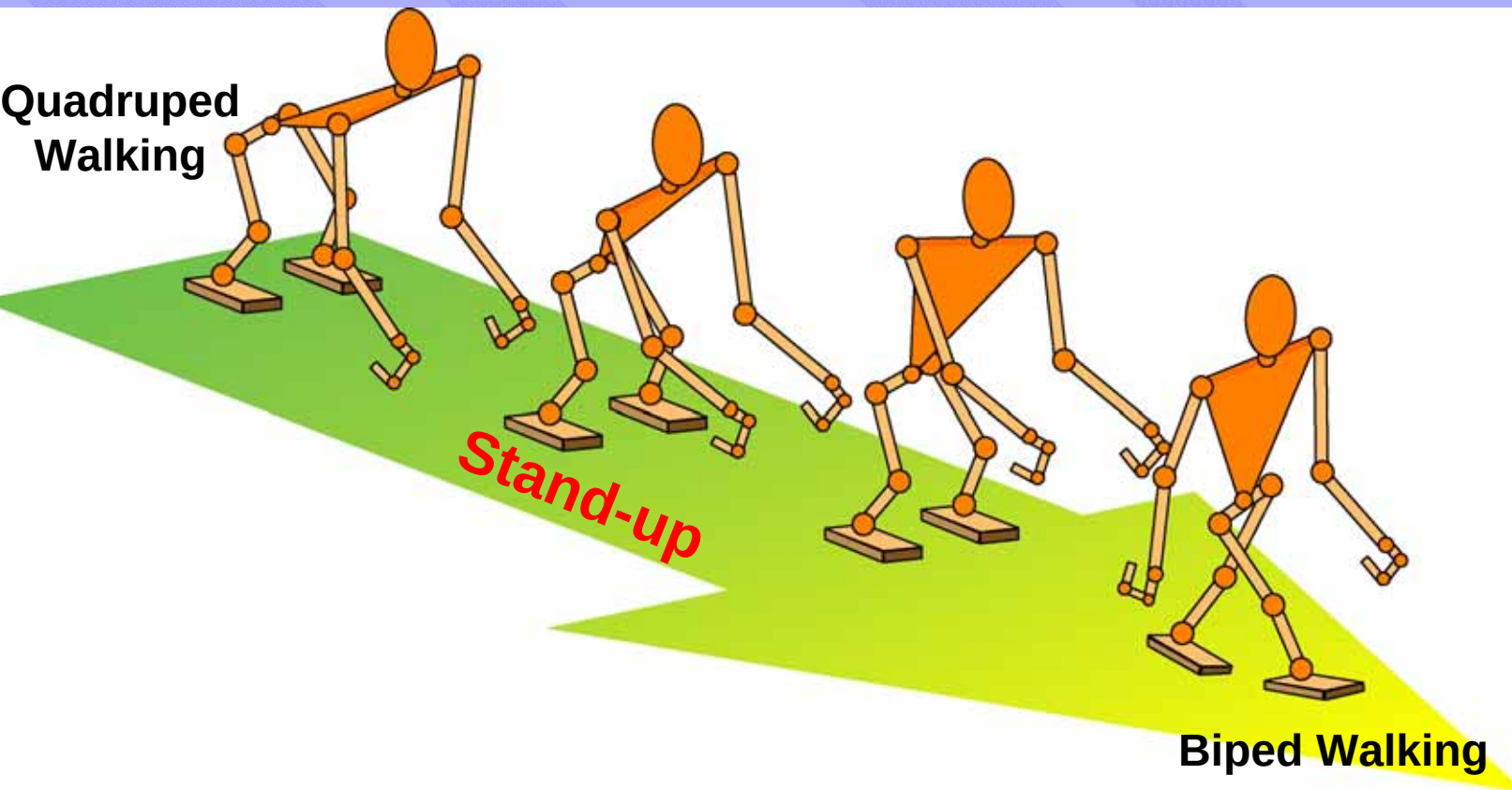


m/s]

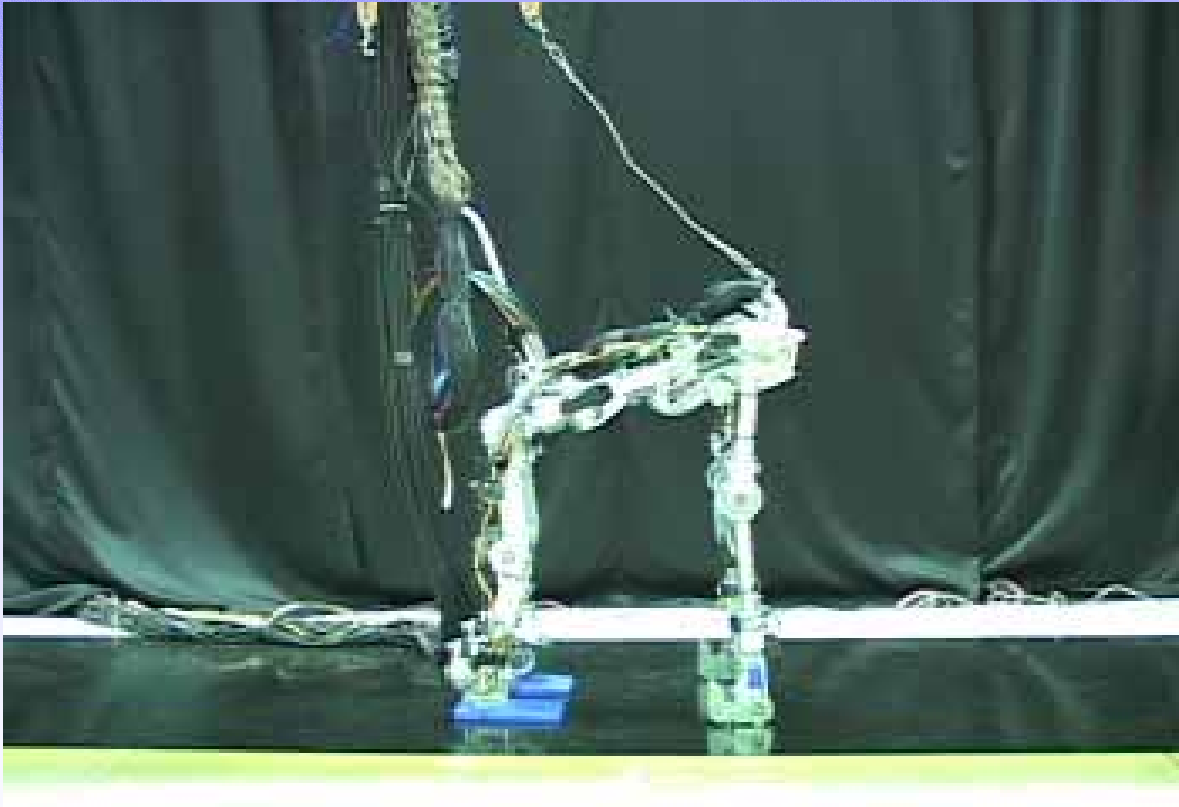


0.10[m/s]

立ち上がり : Stand-up Motion

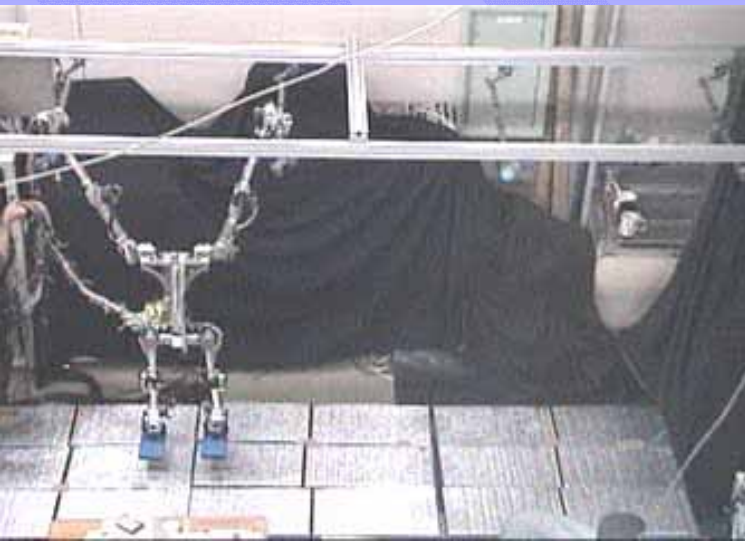


実験: Experimental Result

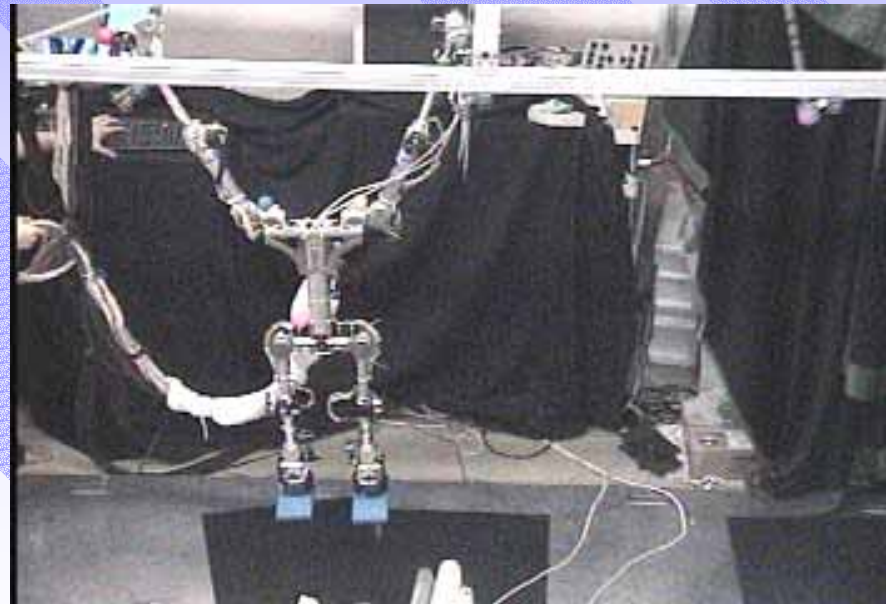
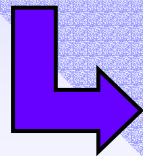


(A)→(B) : 1.0[s] (B) →(C):1.0[s] (C)→(D) : 1.0[s]

動作学習: Motion Learning

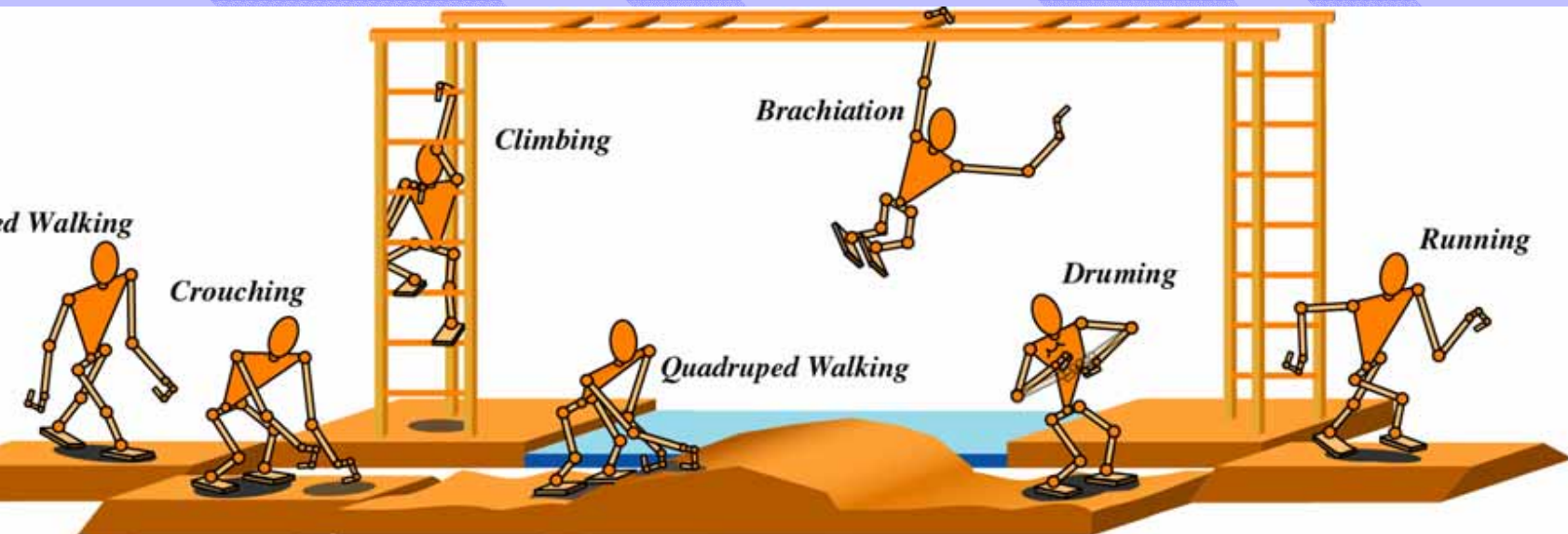


before learning



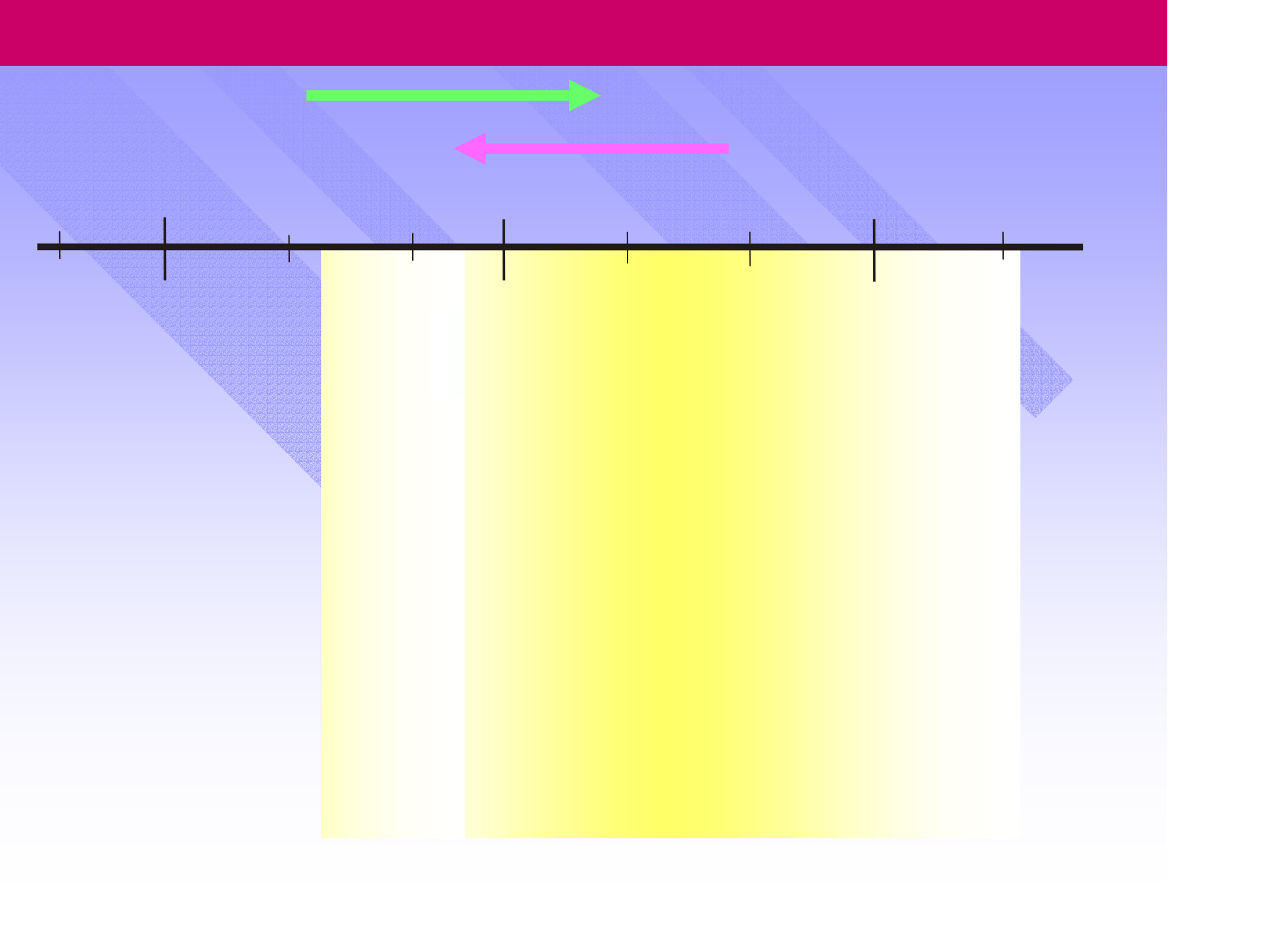
After learning

インテリジェント制御: Intelligent Control



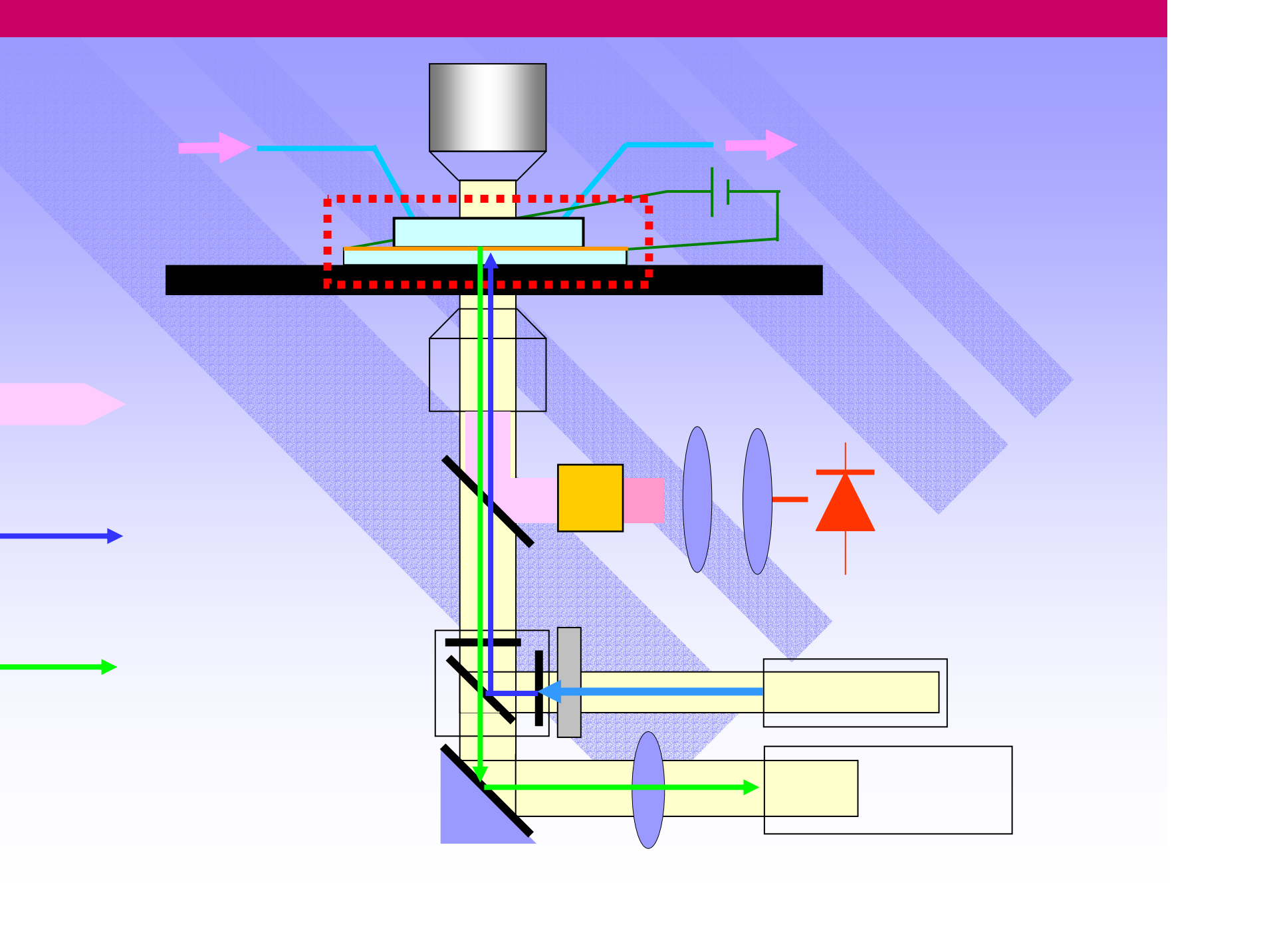
A microscopic view of numerous spherical cells, likely yeast or bacteria, against a greenish-yellow background. The cells are in various stages of focus, with some appearing sharp and others blurred.

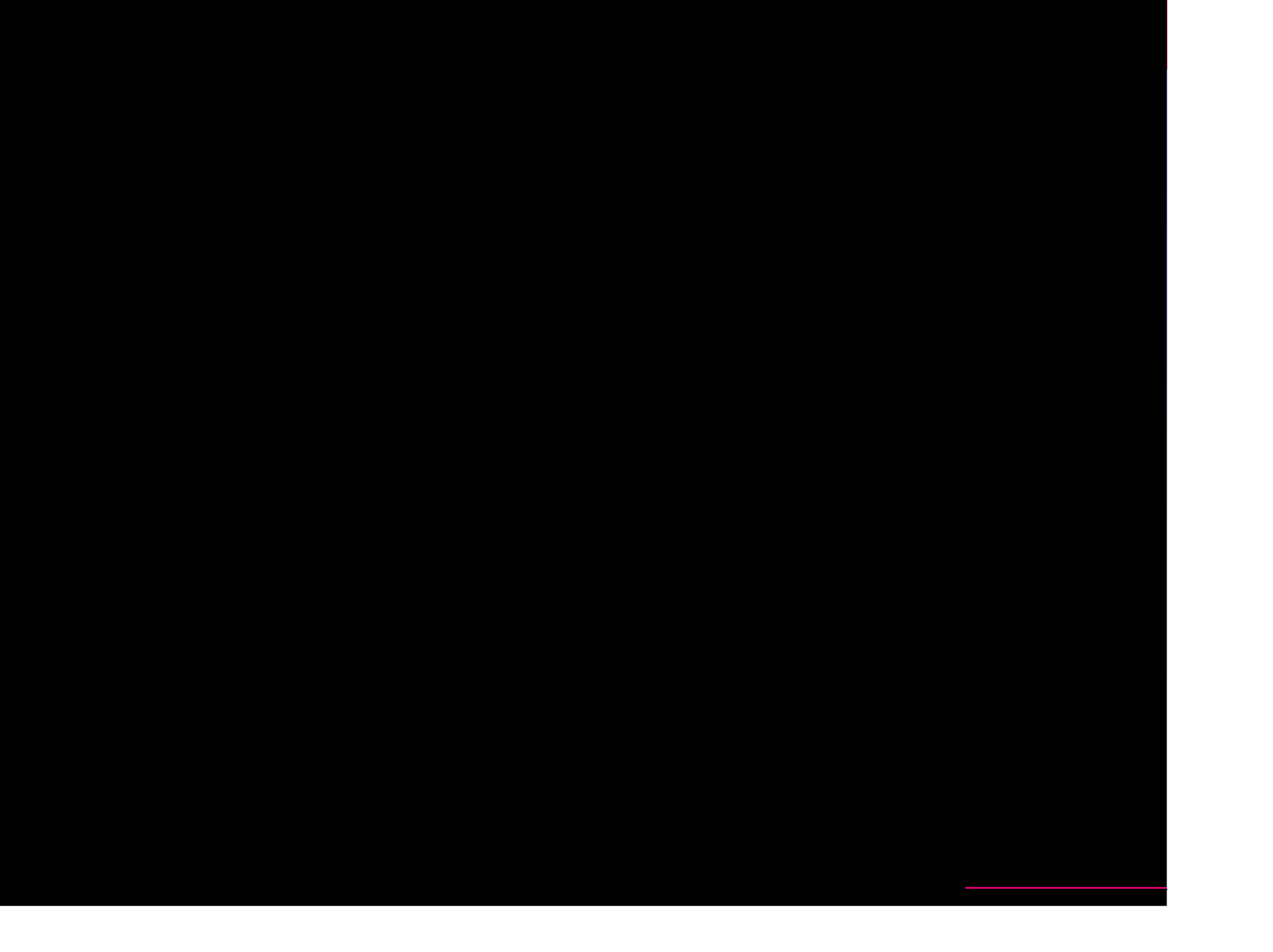
マイクロロボット： Micro-bio Mechatronics

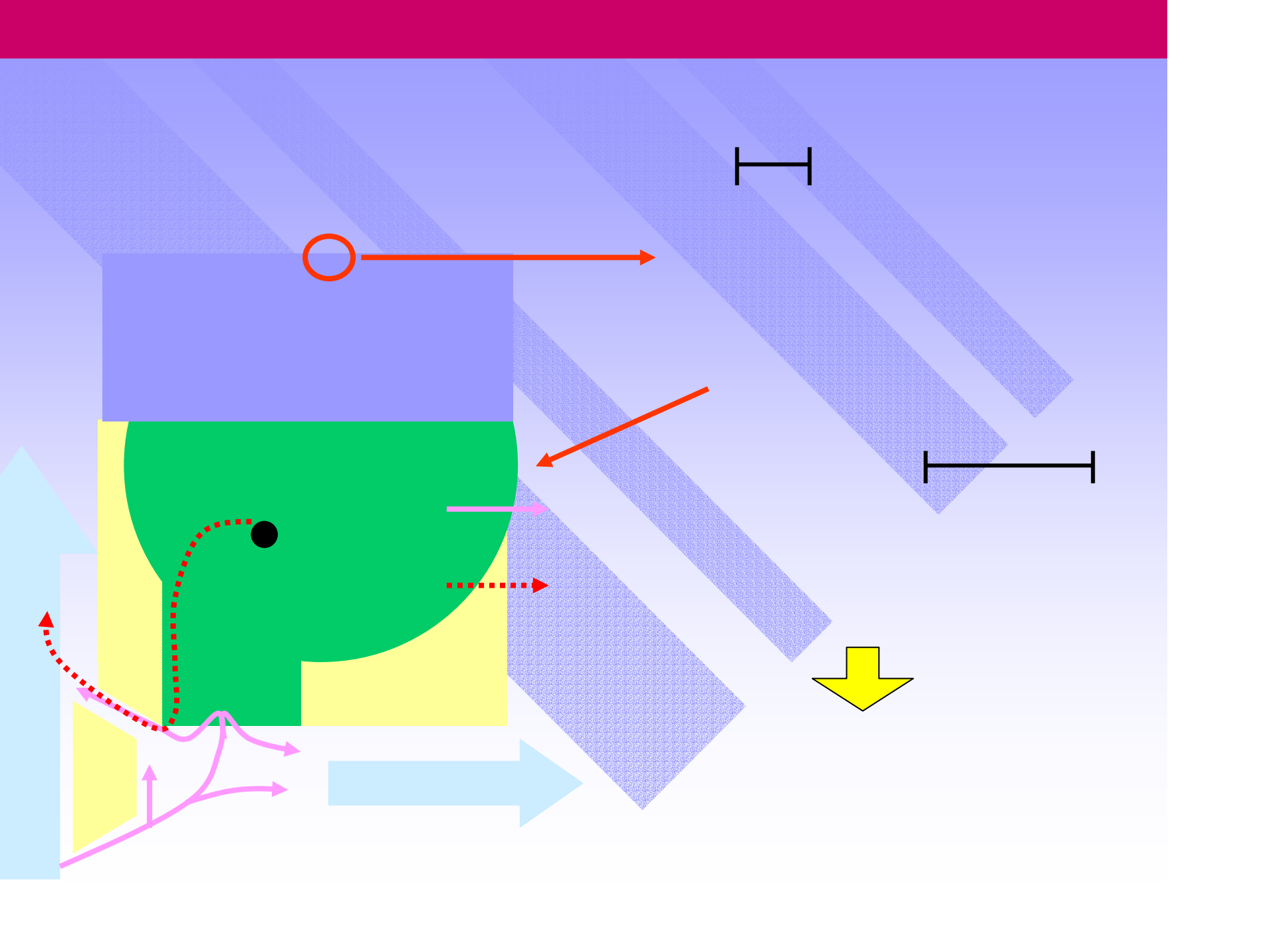


- The Dance of Yeasts -

Synchronized Laser Micro-Manipulation
for 6 Yeasts.

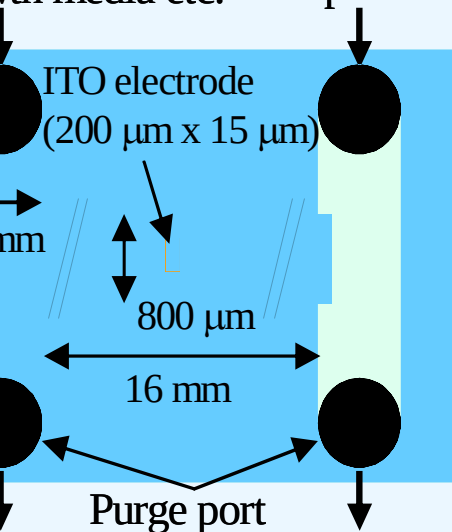




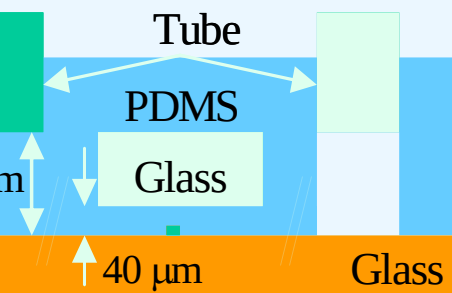


On-chip Separation and Reaction Using Thermal Gelation

Reagent, dyes,
with media etc. Sample solution



(a) Top view

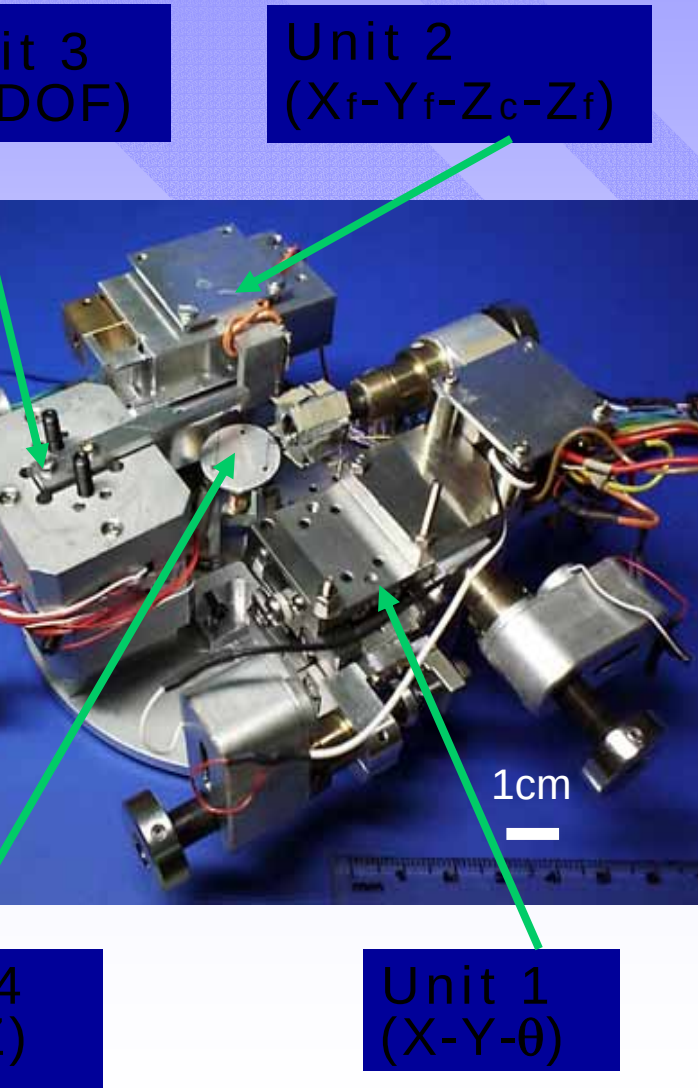


(b) Side view

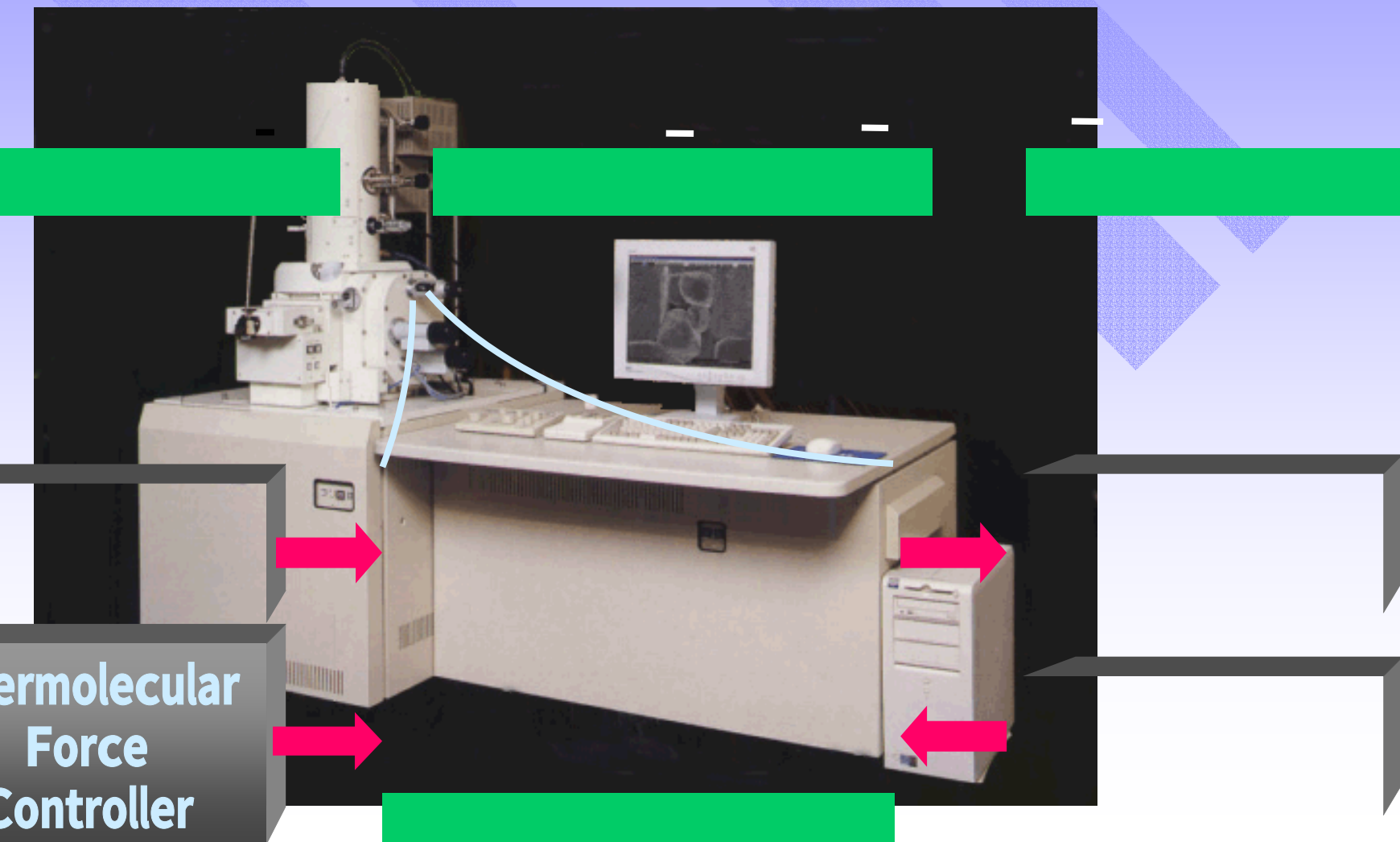
US\$5.00-



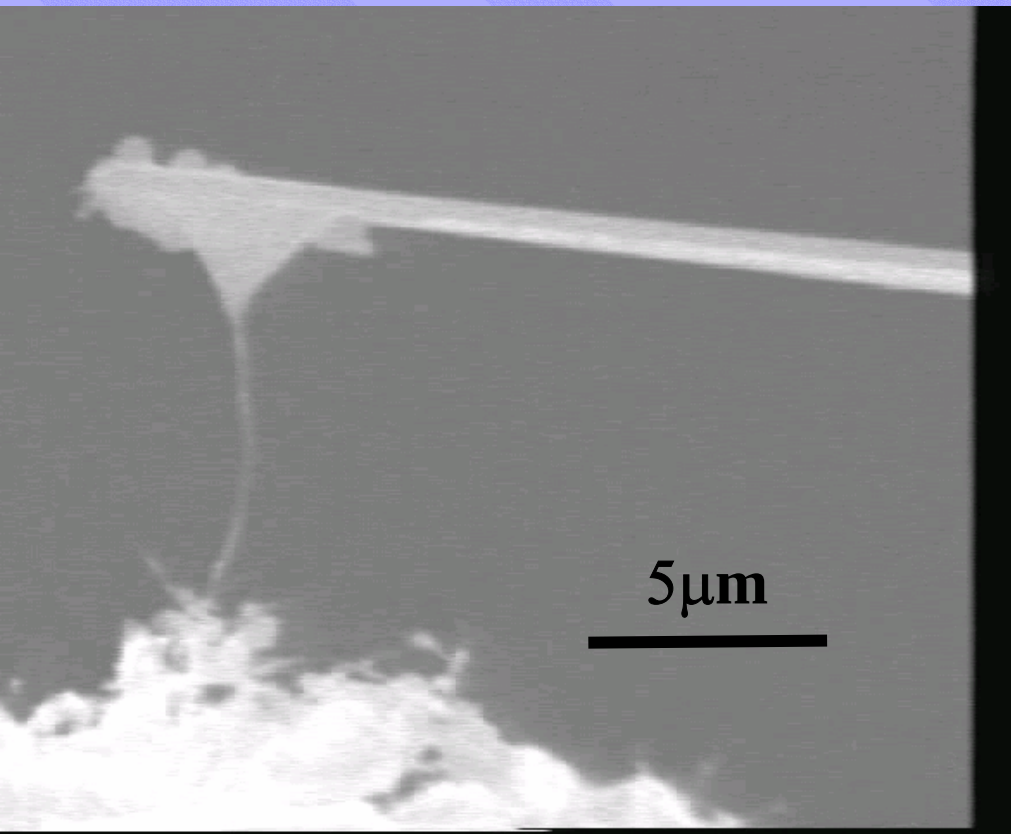
Nanorobotic Manipulators



- **DOFs:** Total: 16-DOFs
Unit1: 3-DOF (coarse), Unit2: 1-DOF (coarse), 3-DOF (fine), Unit3: 6-DOF (ultrafine), Unit 4: 3-DOF(fine)
- **Actuators:** 4 PicomotorsTM (Units 1& 2), 9 PZTs (Unit 2& 3), 7 NanomotorsTM (Unit 2 & 4)
- **Endeffectors:** 3-4 AFM cantilevers
- **Working space:**
18mmX18mmX12mmX360° (coarse, fine),
26μmX22μmX35μm (ultrfine)
- **Positioning resolution:** 30nm(coarse),
2mrad (coarse), 2nm(fine), sub-nm
(ultra fine)
- **Sensing system:** FESEM and AFM
cantilever



Flexural Rigidity Measurement by Buckling an MWNT



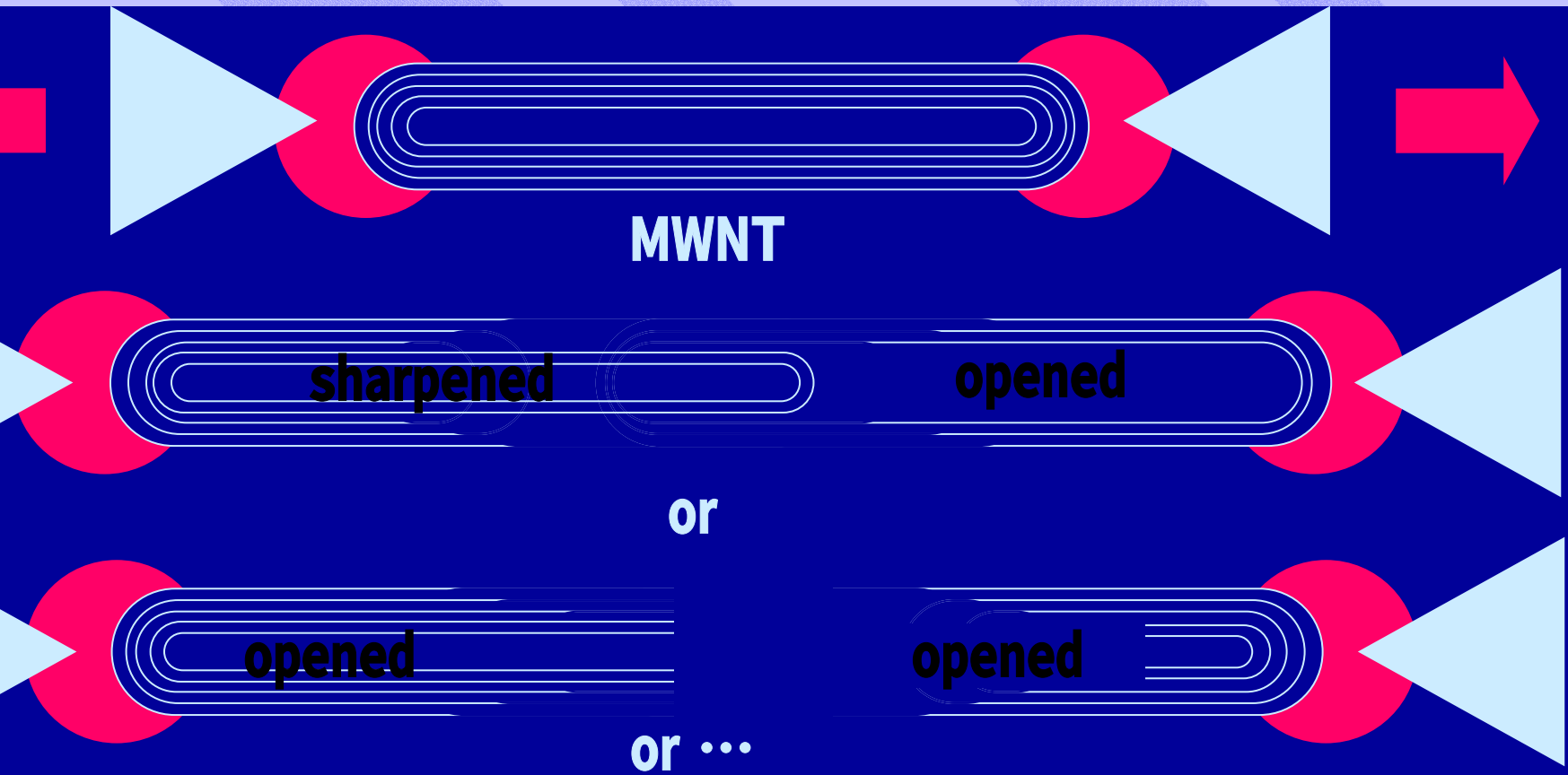
A single MWNT with estimated dimensions of $\sim \phi 30nm \times 6.9\mu m$ was bent with an AFM cantilever ($k=0.03N/m$). Flexural rigidity is obtained:

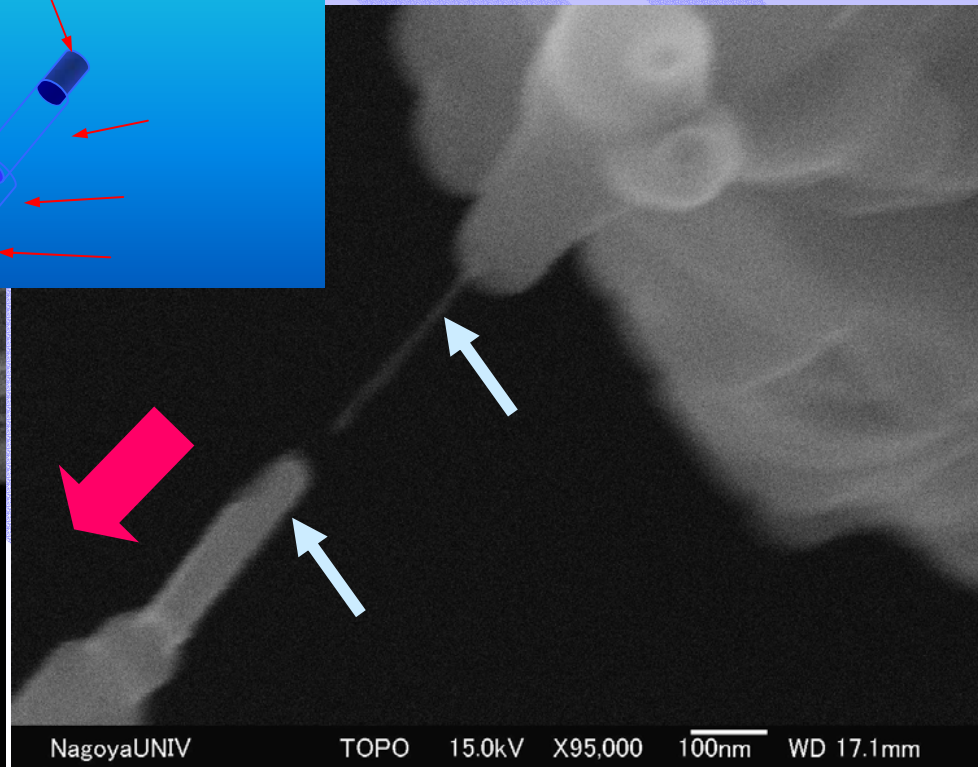
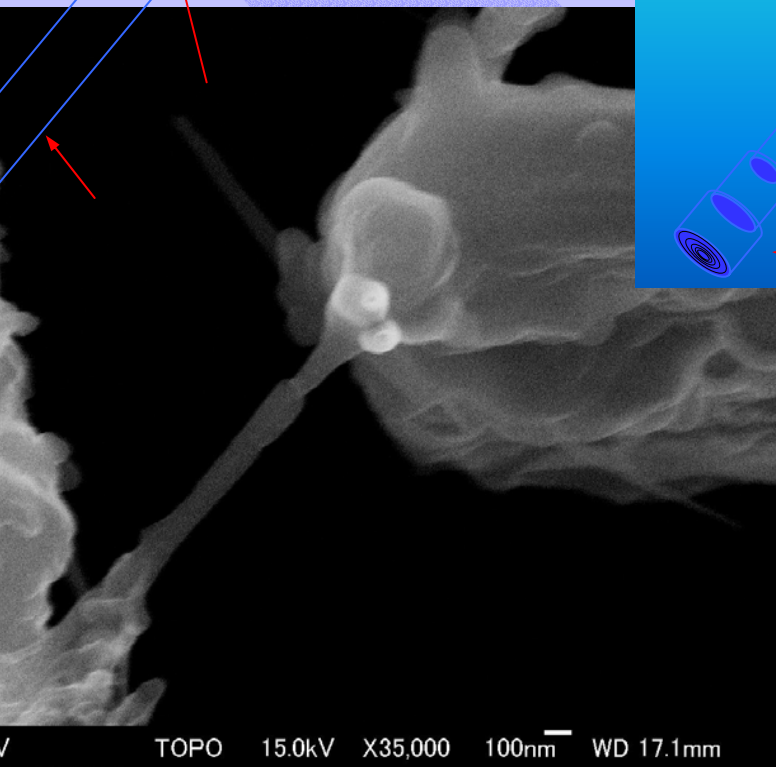
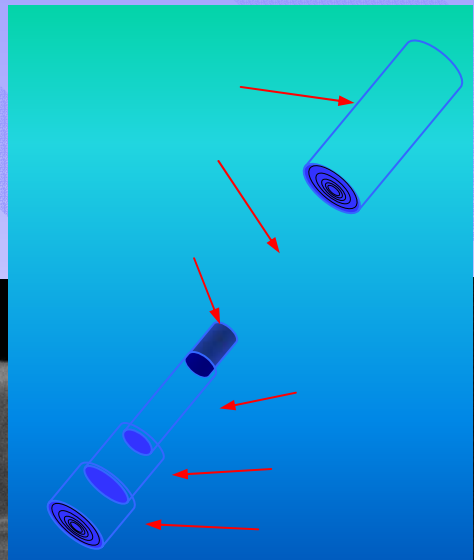
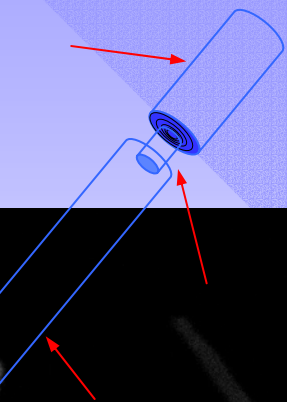
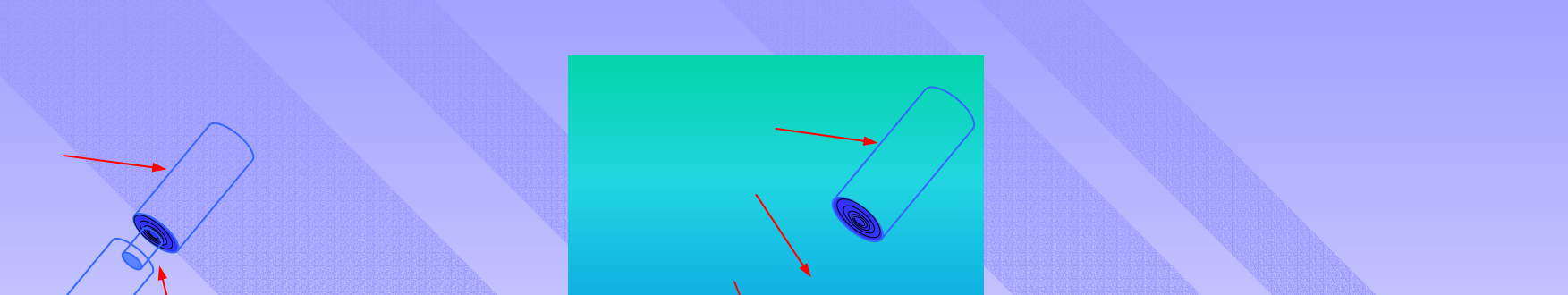
$$EI_z = 8.641 \times 10^{-20} Nm^2$$

. Dong, F. Arai, and T. Fukuda, 3D Nanorobotic Manipulations of Multi-Walled Carbon Nanotubes, Proc. of IEEE Int'l Conf. on Robotics and Automation (ICRA2001), 632-637 (2001).

Destructive Fabrication

By destructing undesired parts, desired shape can be constructed.

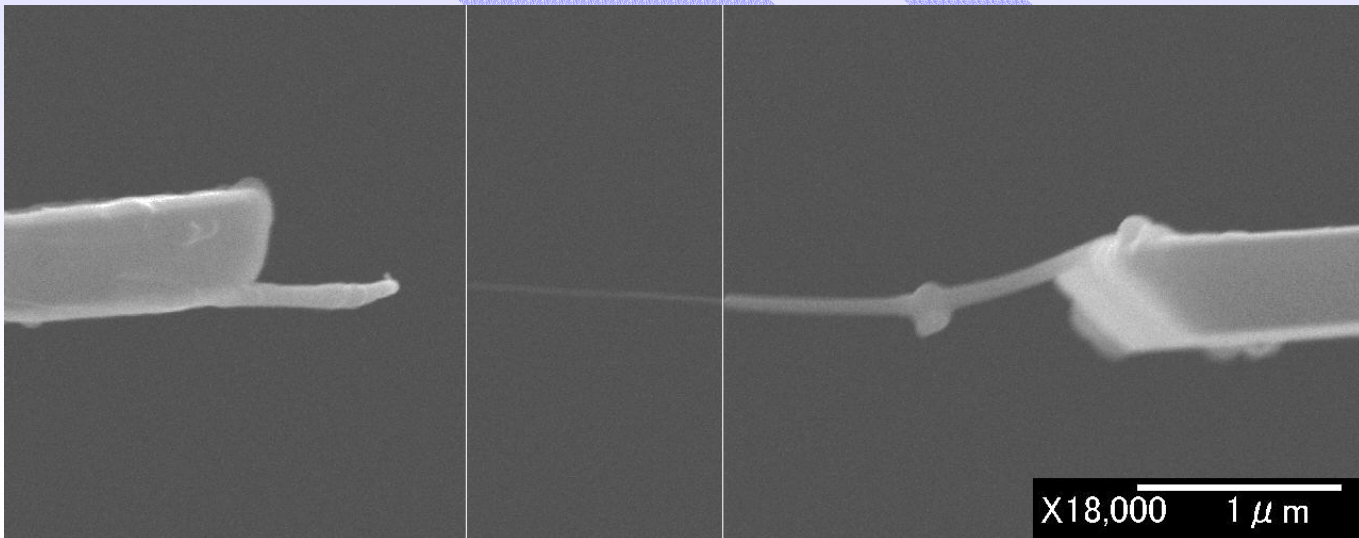
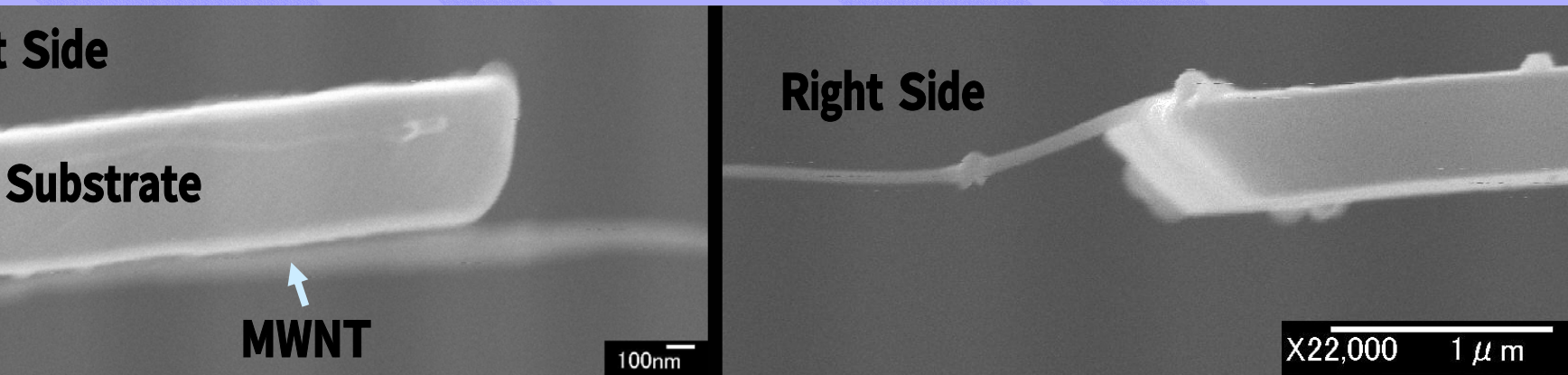




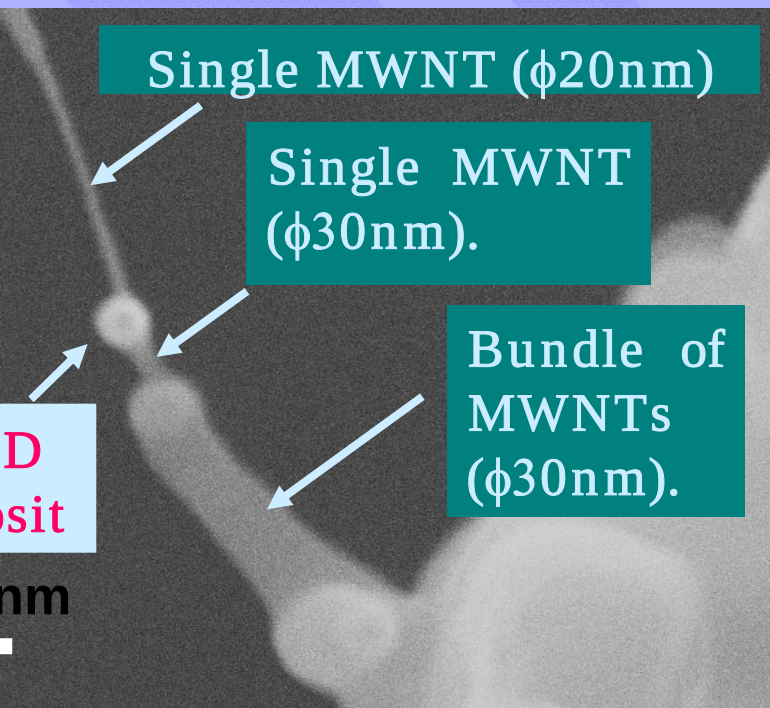
/ TOPO 15.0kV X35,000 100nm WD 17.1mm

NagoyaUNIV TOPO 15.0kV X95,000 100nm WD 17.1mm

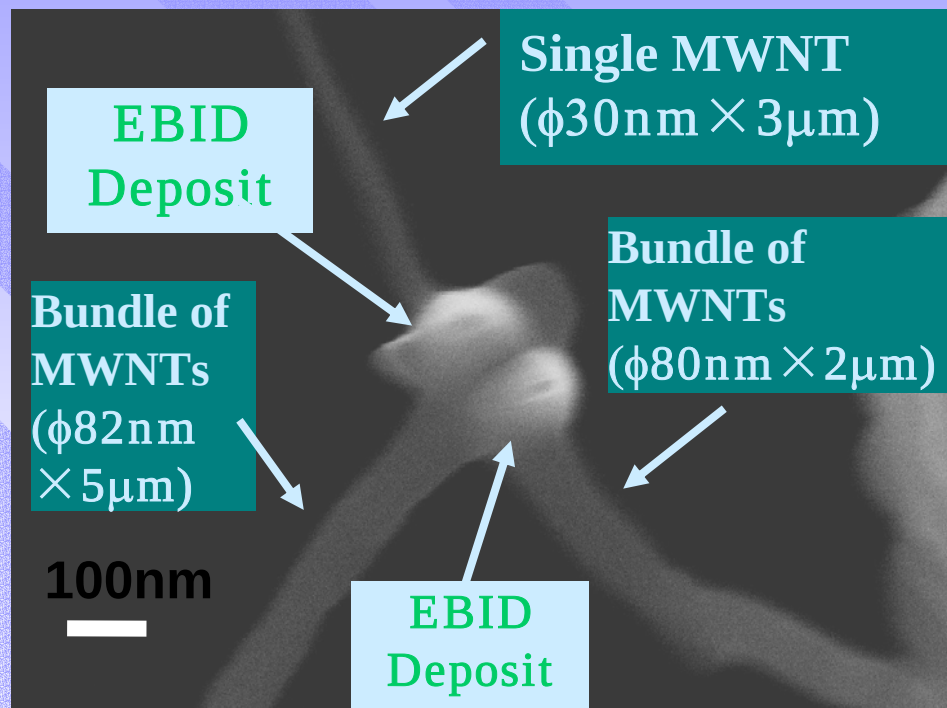
Constructive Pulling a Pre-stressed CNT Forming on a Surface



Joining CNTs with EBID

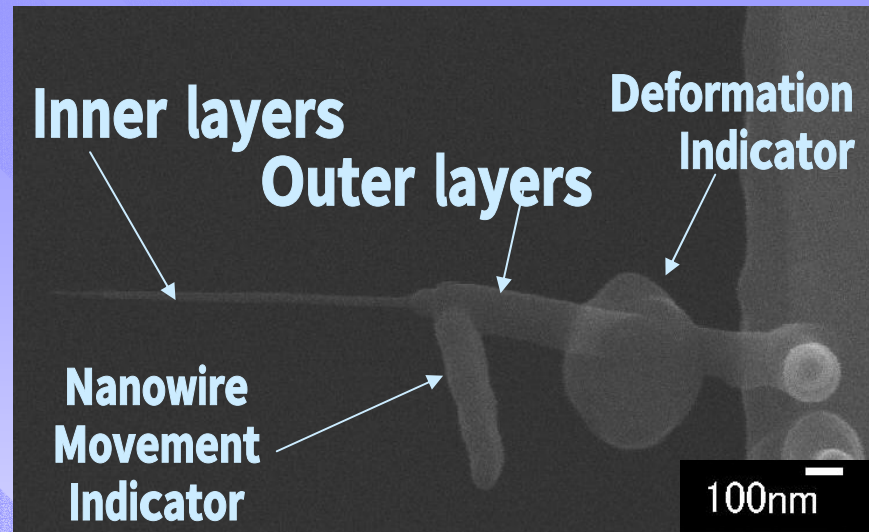
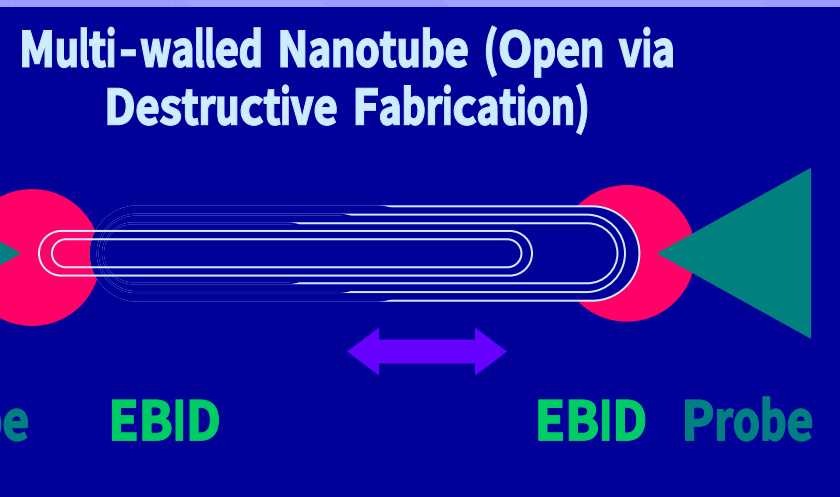


MWNT I-Junction

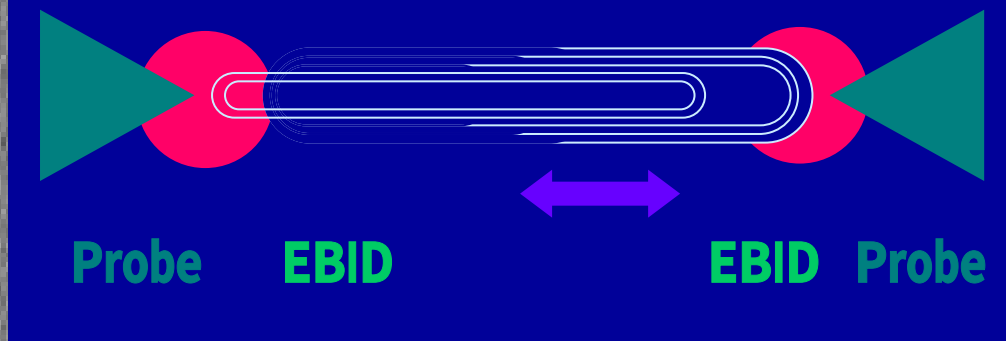


MWNT Y-Junction

MWNT Bearing



Multi-walled Nanotube (Open via Destructive Fabrication)



**3D NRM
of CNTs
inside
HRTEM**

**Automatic
NRM**

***In situ*
Inter-/Intra-
Molecule PC
of CNTs**

**NEMS
Manipulator
with Multi-
CNT Probes**

**3D NRM
of CNTs**
Pick/Place
Bend/Buckle
Pull/Push
...

***In situ* PC
of CNTs**
EI/E
Elasticity/Plasticity
Conductivity
...

**Molecule
Identification**

**CNT NEMS
Pure C NEs**

**ND
with CNTs**
Mass Flow Sensor
Bearing
Scissors
...

Nano Lab

**NF
of CNTs**
Destructive Fab.
Kinky
Shape Modif.
...

**Controlled
Preparation
of Dangling
Bonds**

**NEMS
Exponential
Assembler**

**NA
of CNTs**
vdW
EBID
Mechanochem.
...

**NF
with CNTs**
EBID
CNT Emitter
Parallel EBID
...

**Deposit
Atoms with
Dangling
Bonds**

**Controlled
Bond
Formation
Inside CNTs**

**Directed
Self-
Assembly**

**Single
Molecule
Deposition
by Multi-
Electron**

**PC=Property
Characterization,
NA=Nano Assembly,
ND=Nano Device,
NF=Nano Fabrication**

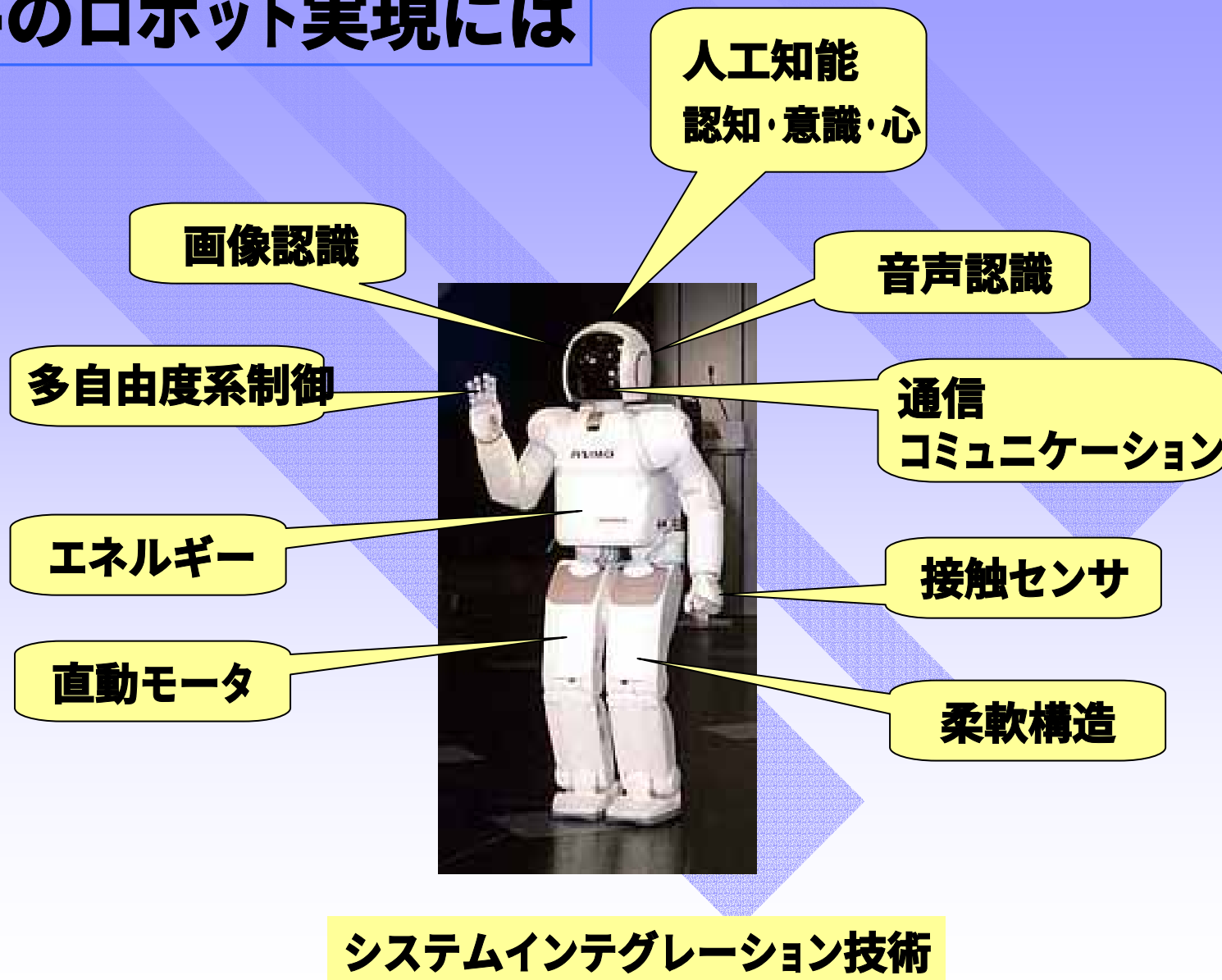
知能ロボット

学習 (Learning) : **環境や条件, 動作や行動を学習し,**

適応 (Adaptation) : **環境や仕事に対して適応し,**

進化 (Evolution) : **システム構造や能力を進化させる**

夢のロボット実現には



ご清聴ありがとうございました