

BIO-NANO-ROBOTICS

A truly multidisciplinary field

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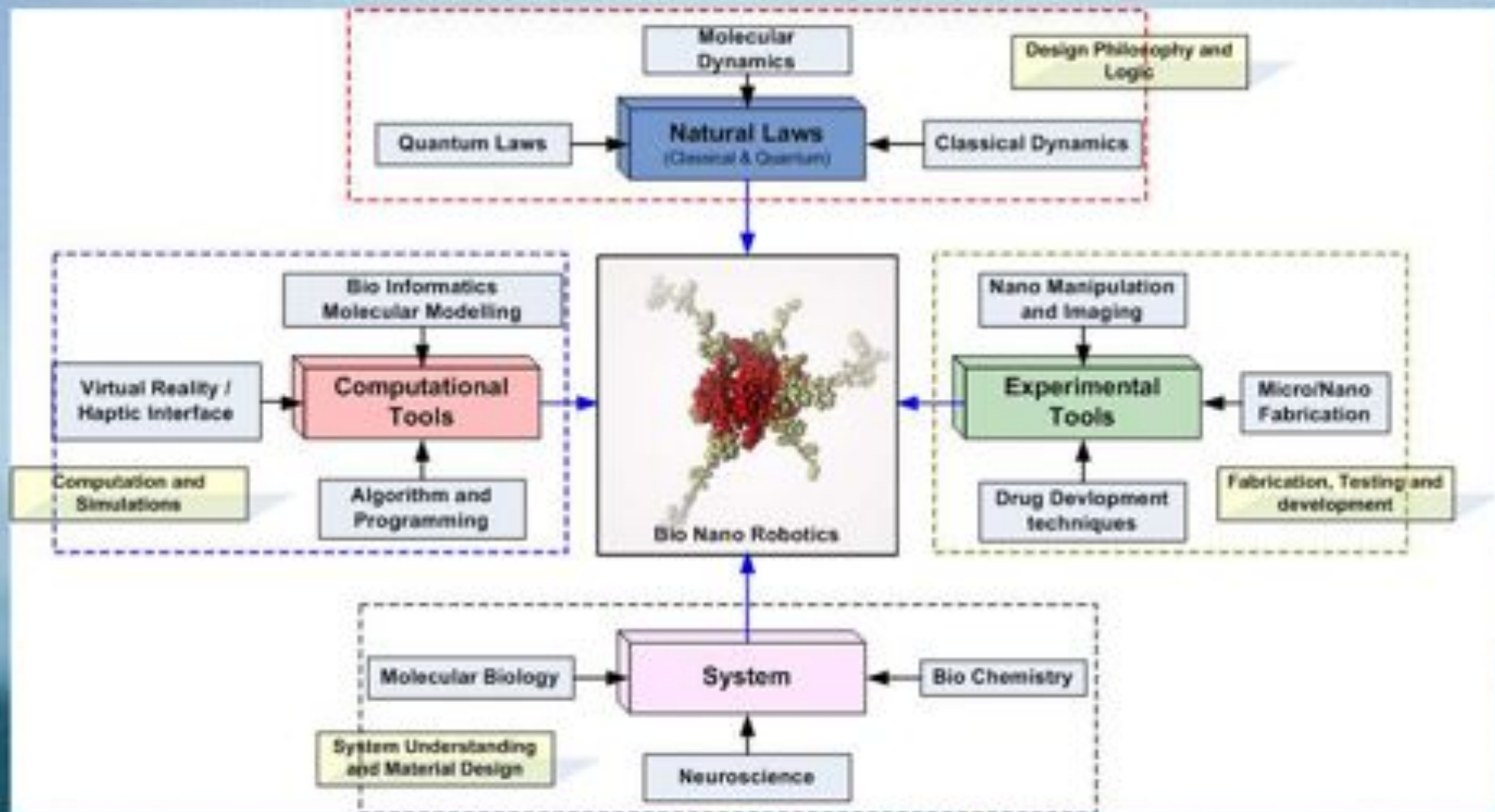
The Concept



- Nanorobots would constitute any “*smart*” structure capable of *actuation, sensing, signaling, information processing, intelligence, and swarm behavior* at nano scale.
- *Bio* nanorobots – Nanorobots designed (and inspired) by harnessing properties of biological materials (peptides, DNAs), their designs and functionalities. These are inspired not only by nature but machines too.

Collaboration

A truly multidisciplinary field

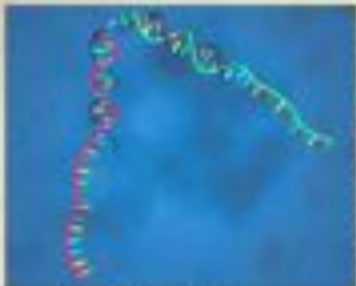


The Roadmap

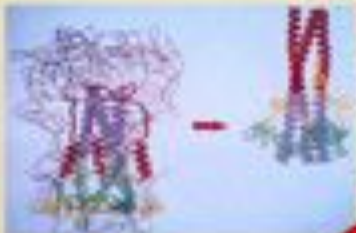
Increasing Capability of Bio Nano Systems



Bio Sensors

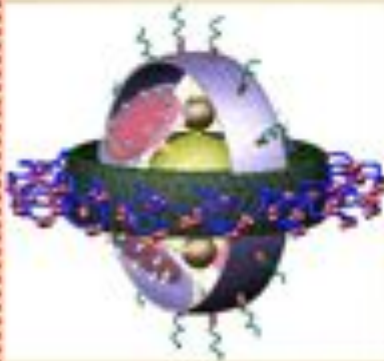


DNA Joints



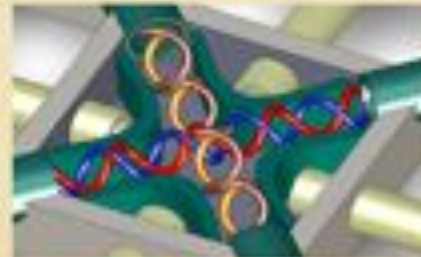
HA a-helix

Bio nano components



A bio nano robot
Representative Assembly of bio components

Assembled bio nanorobots



A bio nano computational cell

Distributive intelligence programming & control

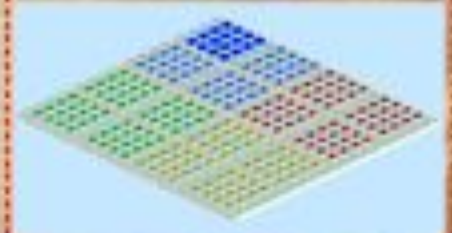


Bio nano swarms

Automatic fabrication and information processing



A Bio nano information processing component



Conceptual automatic fabrication floor

STEP 1

STEP 2

STEP 3

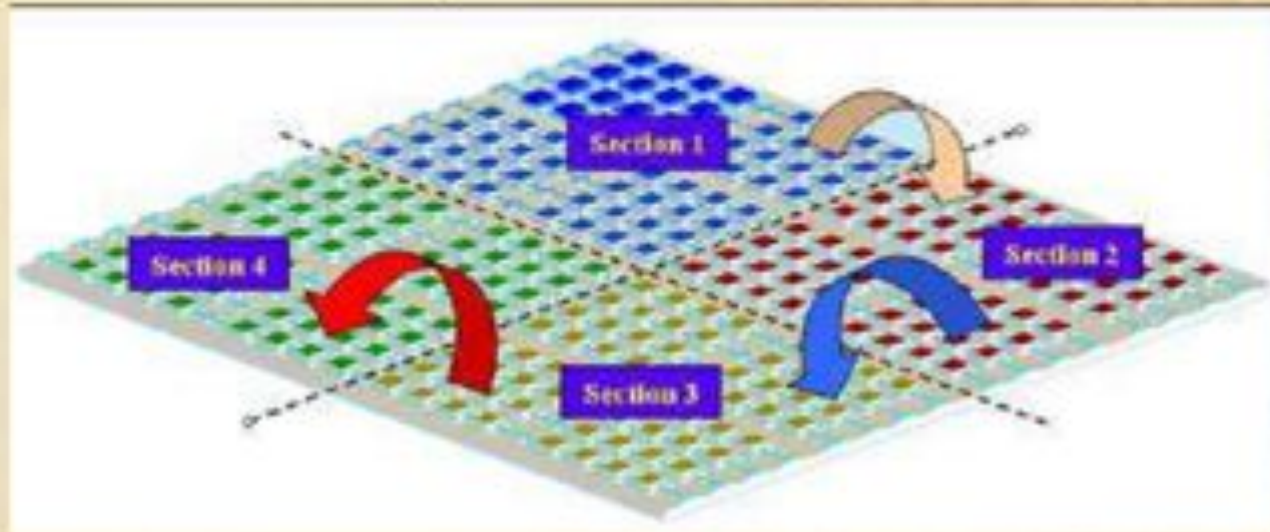
STEP 4

Research Progression

Automatic Fabrication

Automatic fabrication methodologies of such bio-nano robots *in vivo* and *in vitro*.

Floor concept of assembling bionanorobot:

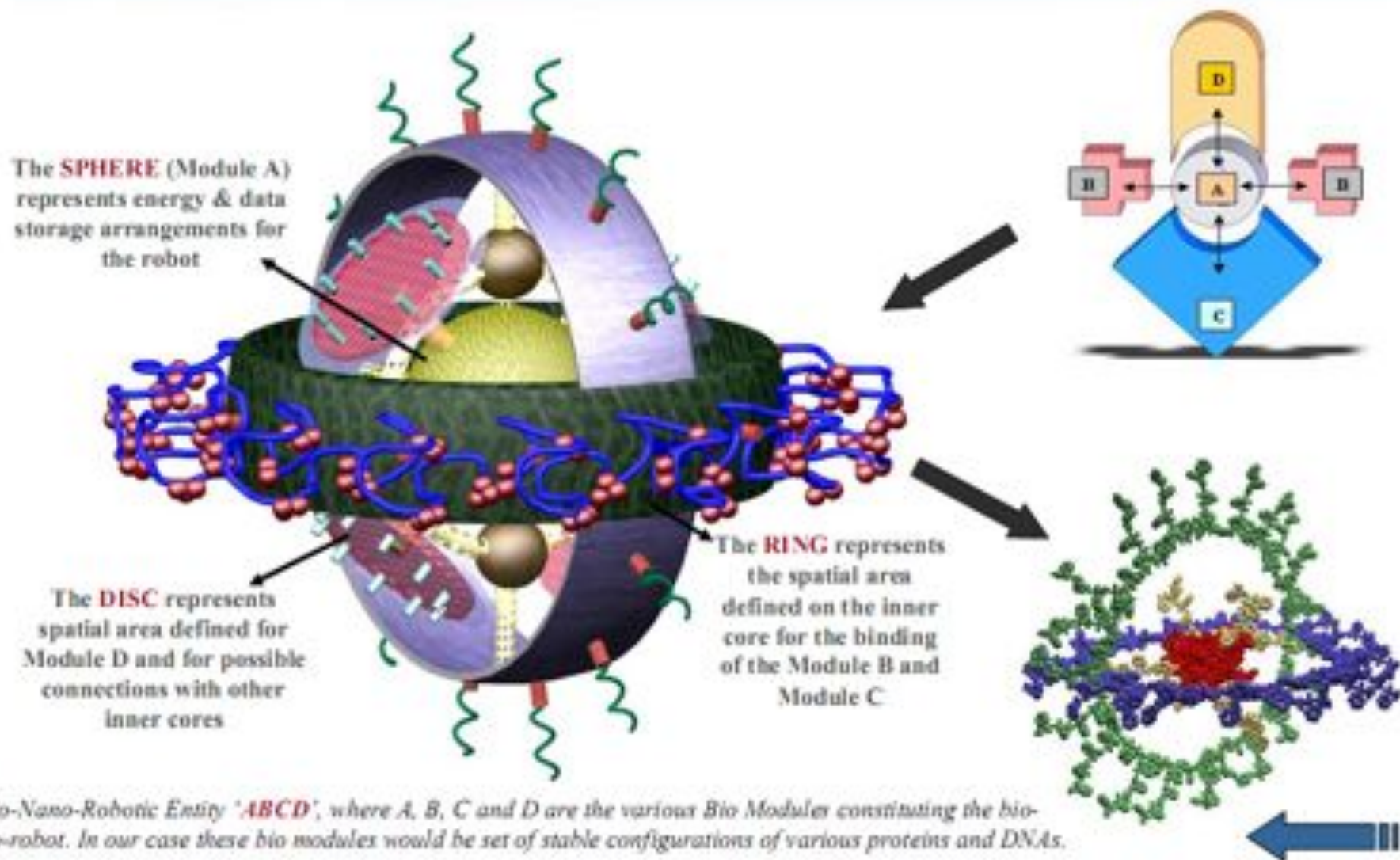


Different colors represent different functions in automatic fabrication mechanism. The arrows indicate the flow of components on the Floor layout. **Section 1**: Basic Stimuli storage – Control Expression; **Section 2**: Bio molecular component manufacturing (actuator / sensor); **Section 3**: Linking of bio-nano components; **Section 4**: Fabrication of Bio-nano robots (assemblage of linked bio-nano components)



Design Philosophy and Architecture

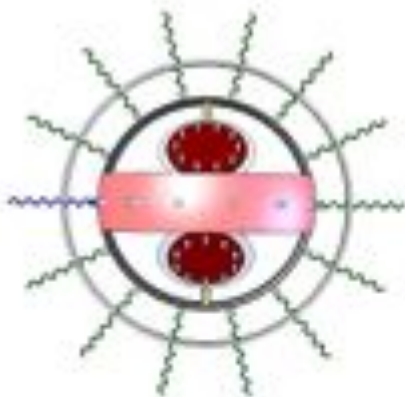
A. Modular Organization





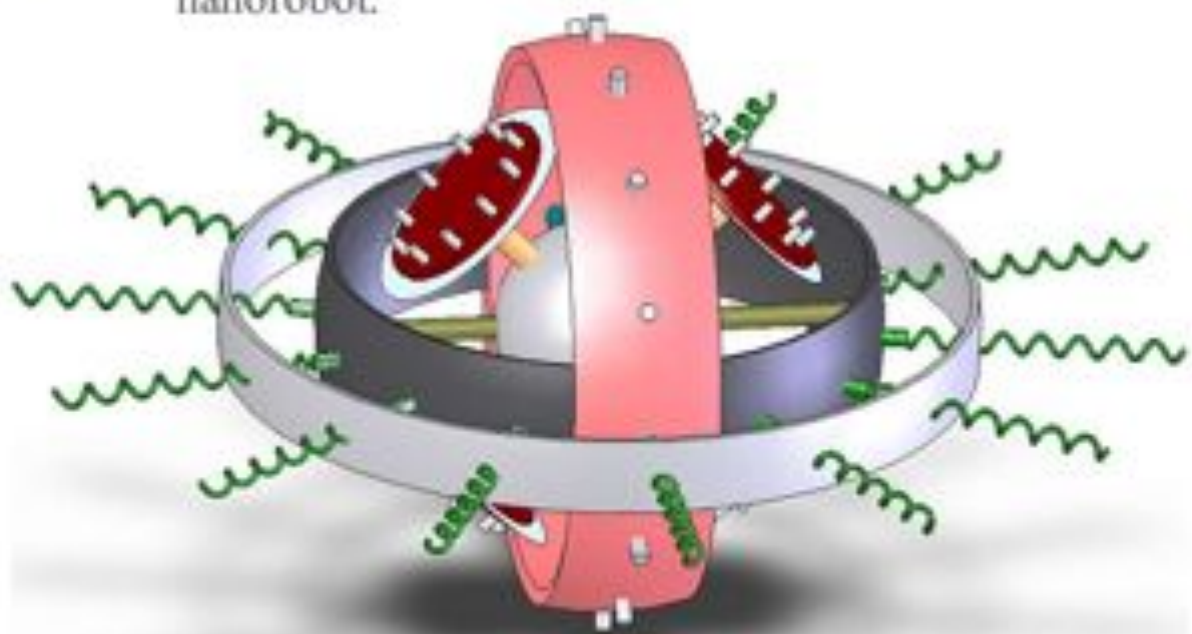
Design Philosophy and Architecture

B. The Universal Template



A basic template which could be at run-time modified and subjected to have specific functionality is the goal of the bio nano STEM cells.

Sensing capability enhanced Bio nanorobot.

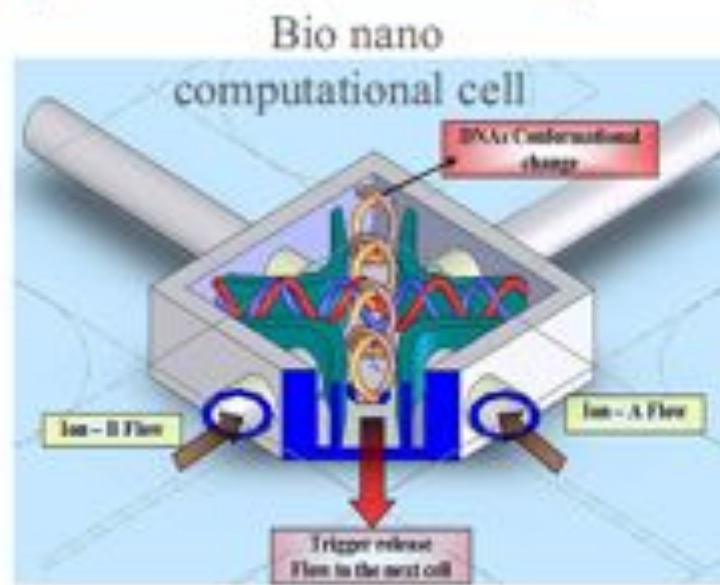
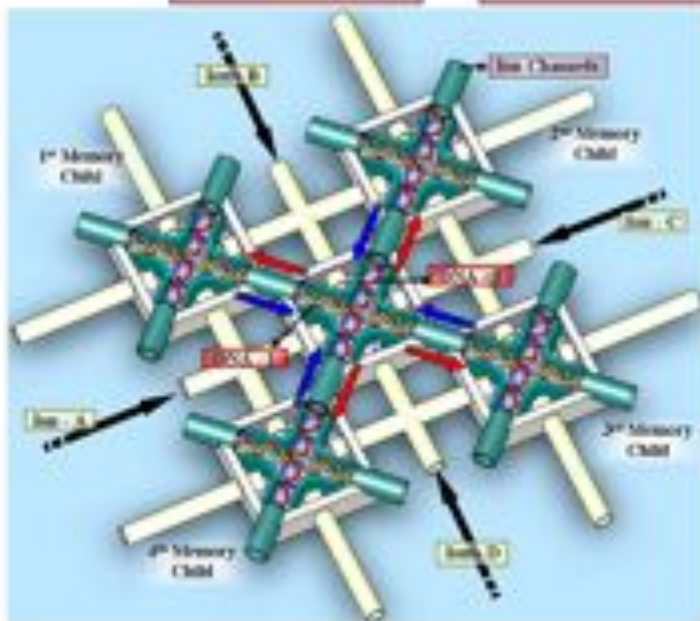
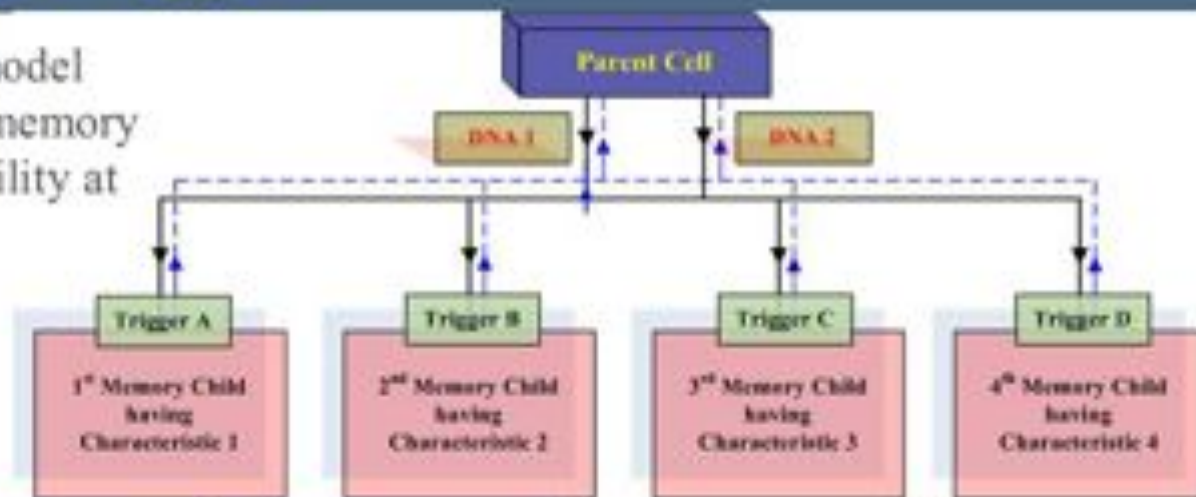


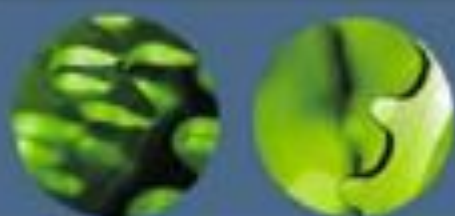


Design Philosophy and Architecture

C. Memory Storage and Programming

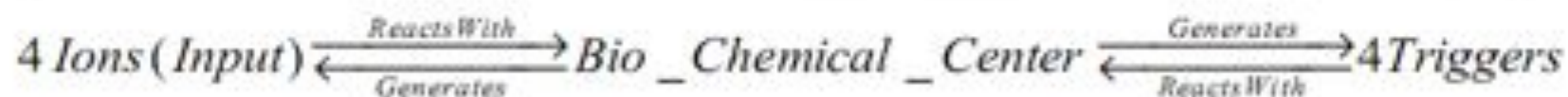
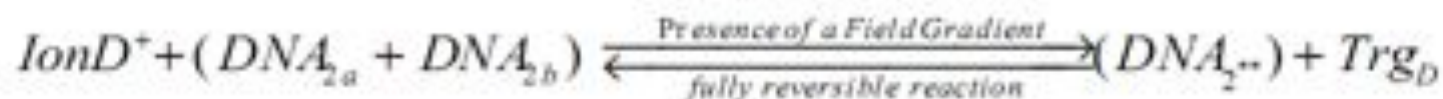
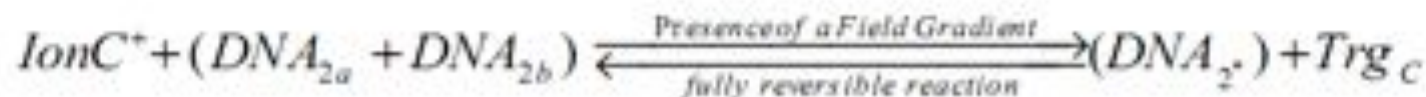
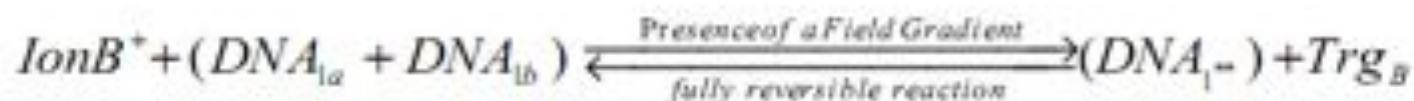
A proposed model designed for memory storage capability at nano scale





C. Memory Storage and Programming

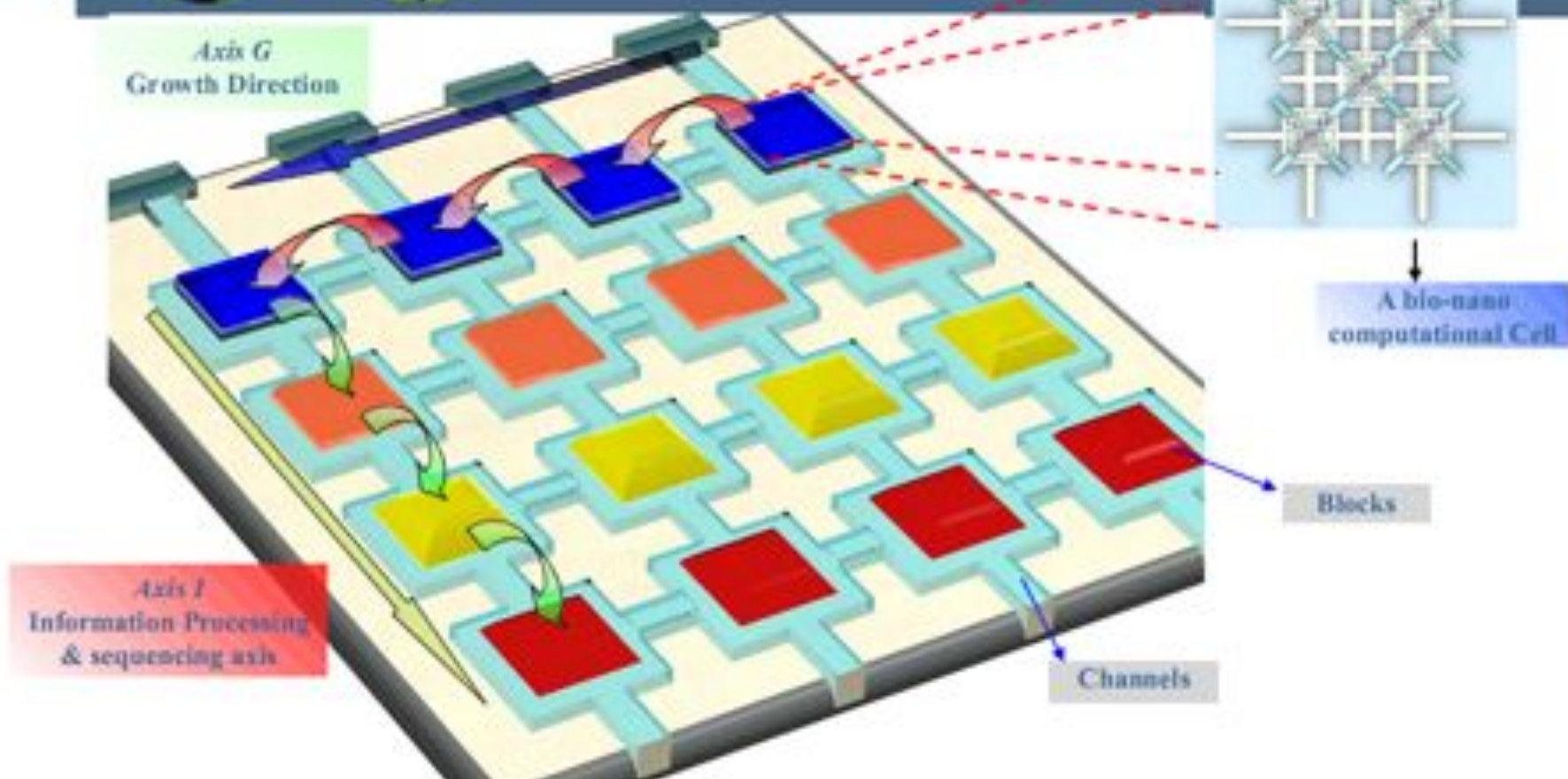
The working principle is illustrated in the following equations





Design Philosophy and Architecture

D. Bio Nano Intelligence



A model is being proposed which describes programming, learning and hence evolving as one combination of events which can quantitatively describe intelligence. Ionic strength and their variations could be few of the important variables responsible for the behavior of a bio-nano robotic system.



Control of Bionano Robotic Systems

Internal Control

Passive control - depends upon the mechanism of bio chemical sensing and selective binding of various bio molecules with various other elements.

Active control - 'active' control mechanism has to be designed for the nanorobots such that they can vary their behavior based on situations they are subjected to, similar to the way macro robots perform.

This requires the nanorobot to be programmable and have an ability for memory storage. Professor Ehud Shapiro's lab has devised a biomolecular computer which could be an excellent method.

External Control

This type of control mechanism employs affecting the dynamics of the nanorobot in its work environment through the application of external potential fields.

Researchers (Prof Sylvain Martel) are using MRI as an external control mechanism for guiding the nano particles.

An MRI system is capable of generating variable magnetic field gradients which can exert force on the nanorobot in the three dimensions and hence control its movement and orientation. But this method has some limitations on very accurate precision of the control.

Applications

Some important application of Bio-Nano-Robots are as follows:

- I. Space
- II. Medical
- III. Military

Space Applications

Current research is focused on two main space based applications:

- Networked TerraXplorers (NTXp)
 - Mapping and sensing of vast planetary terrains
- All Terrain Astronaut Bionano Gears (ATB)
 - Enhanced health management and protection system for astronauts