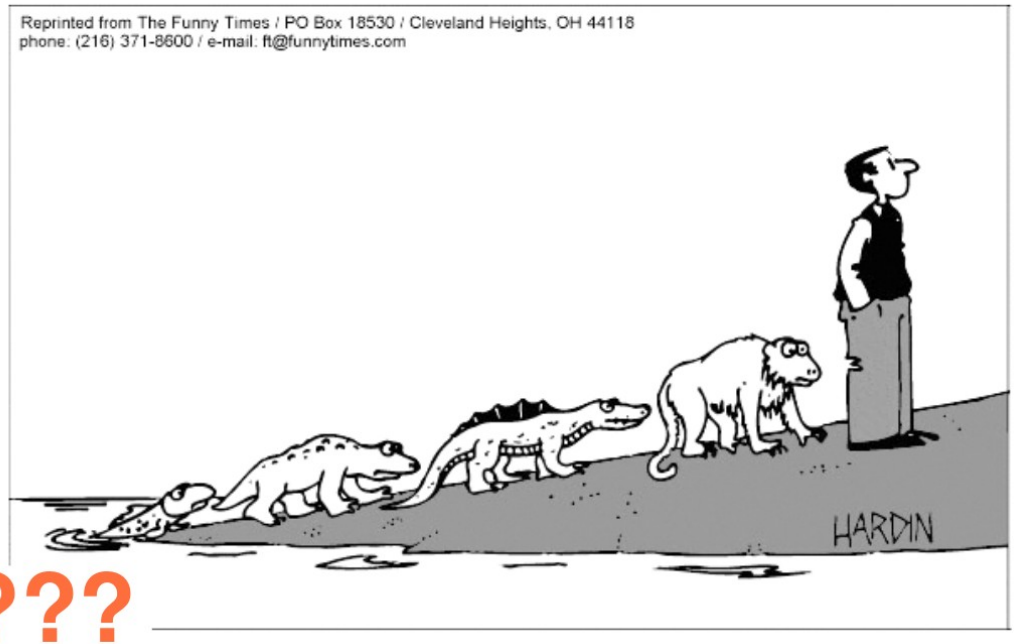
How did we get here?



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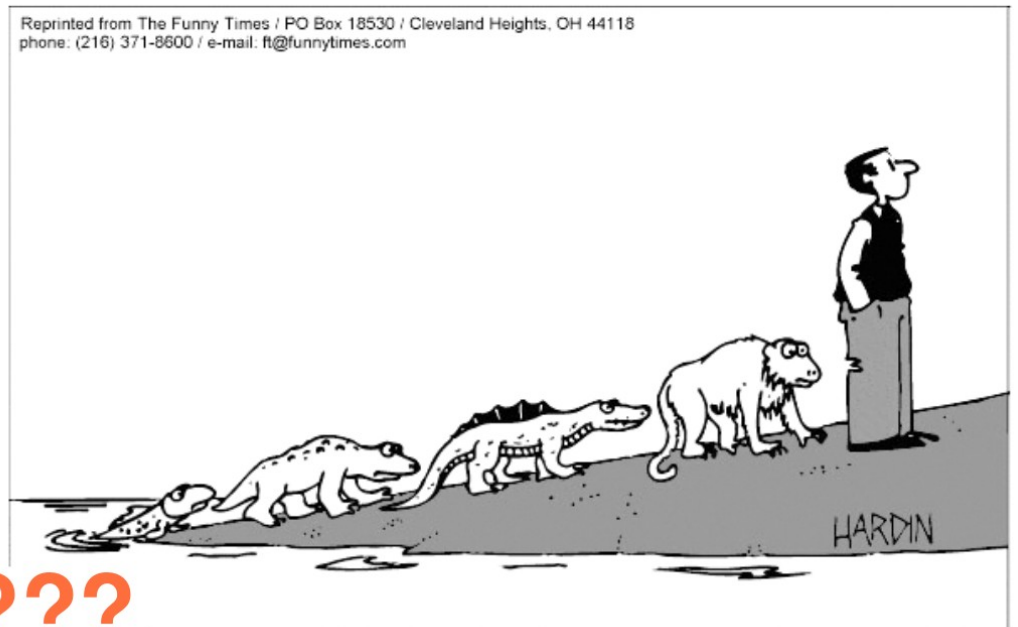

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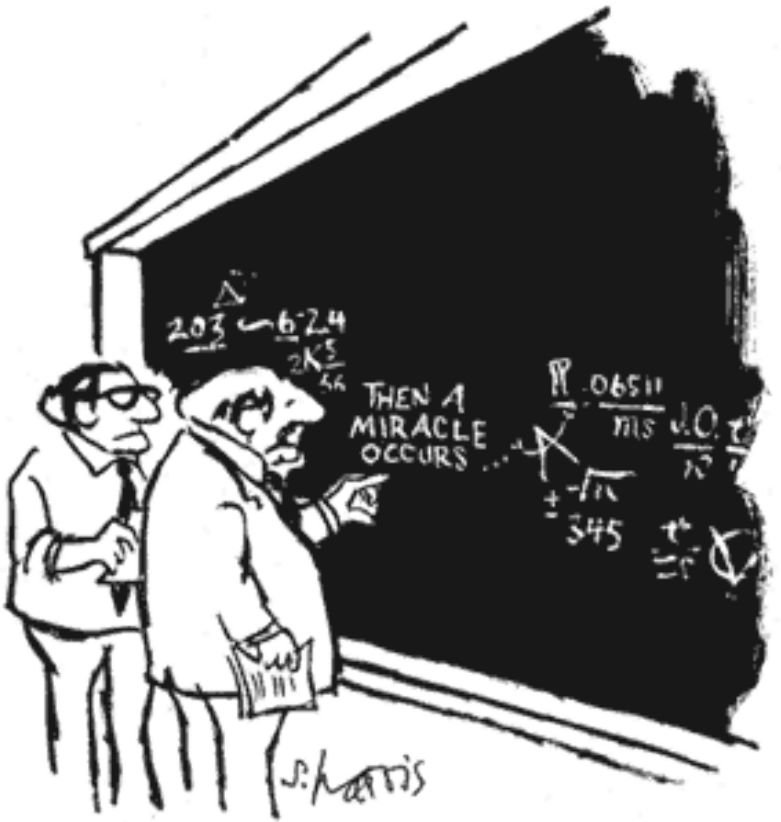
Evolution and the Origins of Life



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

A: Fundamentals of Life

- Definition of Life
- Logic of Molecular Biology
- History of Biology
- Becoming alive
- Soup of Life
- Selection: before and in life
- Three faces of Entropy
- Death and equilibrium
- Missing non-equilibrium
- Structure of Origin of Life
- Modes of non-equilibrium
- Examples of evolution

B: Physics for Chemistry

Polymerization
- Theory of polymerization
- P. by fast cooling
- P. by stacking with 3’-5’-Ph.
- Activation groups
- P. on clay
- P. by thermophoresis
- Phase transitions with DNA
- Sedimentation of DNA
- Drying and its problems
- Elegance of air interface

Replication
- Templated polymerization
- Ligation
- Strand separation problem
- PCR in convection
- Ribo-PCR in convection

C: Evolution Machines

Replication with accumulation
- Case of Ribo-PCR
- Spiegelman problem
- Case of trapped PCR
- Trapped PCR with flow
- Feeding problem
- Replication with heated tRNA
- Replication in driven Fog

Rebustness of evolution
- Error threshold
- Instability of four bases
- Hypercycles with ligation
- Spont. Symmetry breaking
- Spont. sequence selection
- Cooperation within cells

A: Fundamentals of Life

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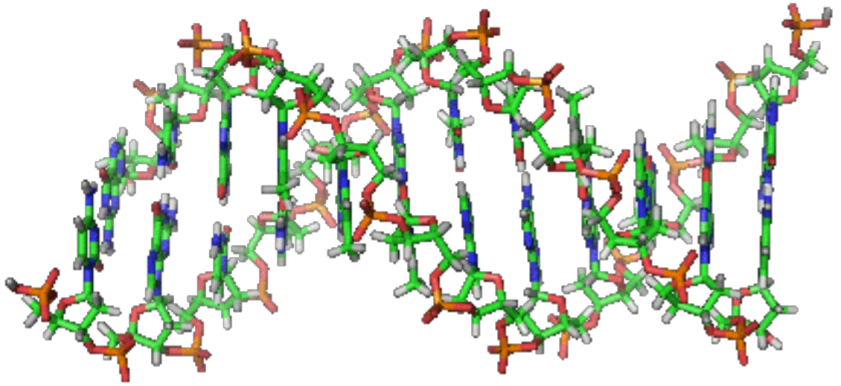
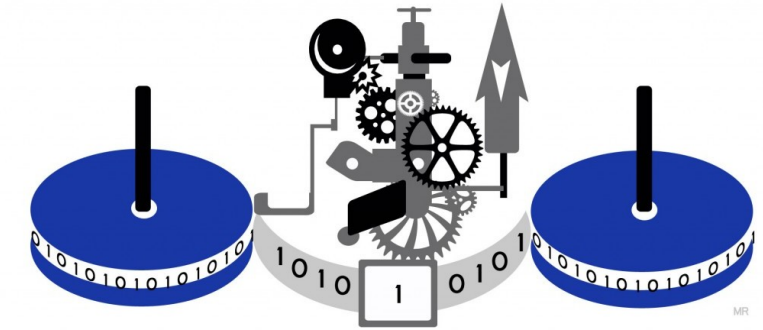
What is life?

What is life?

Nasa working definition of Life:
A self-sustained chemical system
capable of undergoing Darwinian Evolution

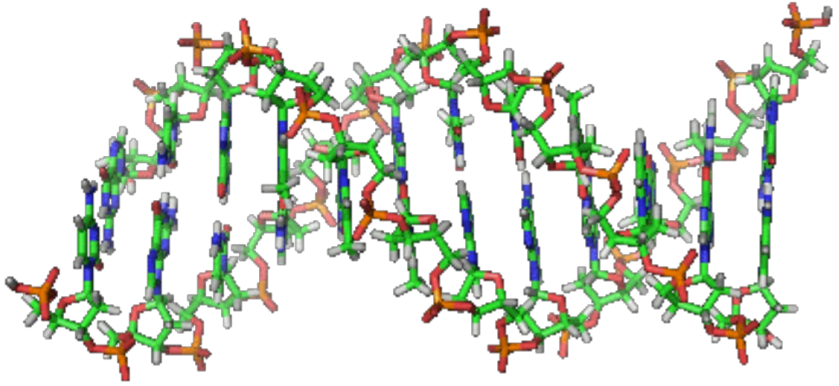
Logic of Molecular Biology

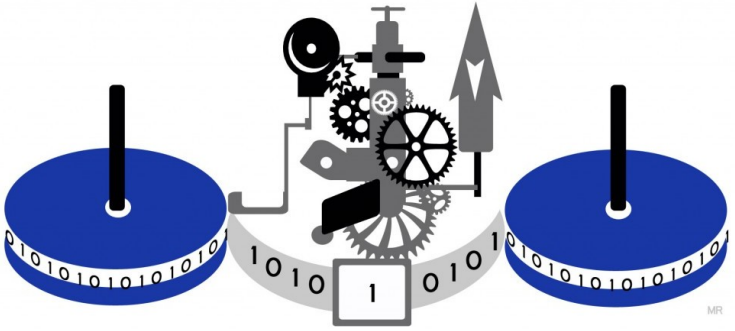




Storage of information very similar to Turing machine => Computer

Logic of Molecular Biology





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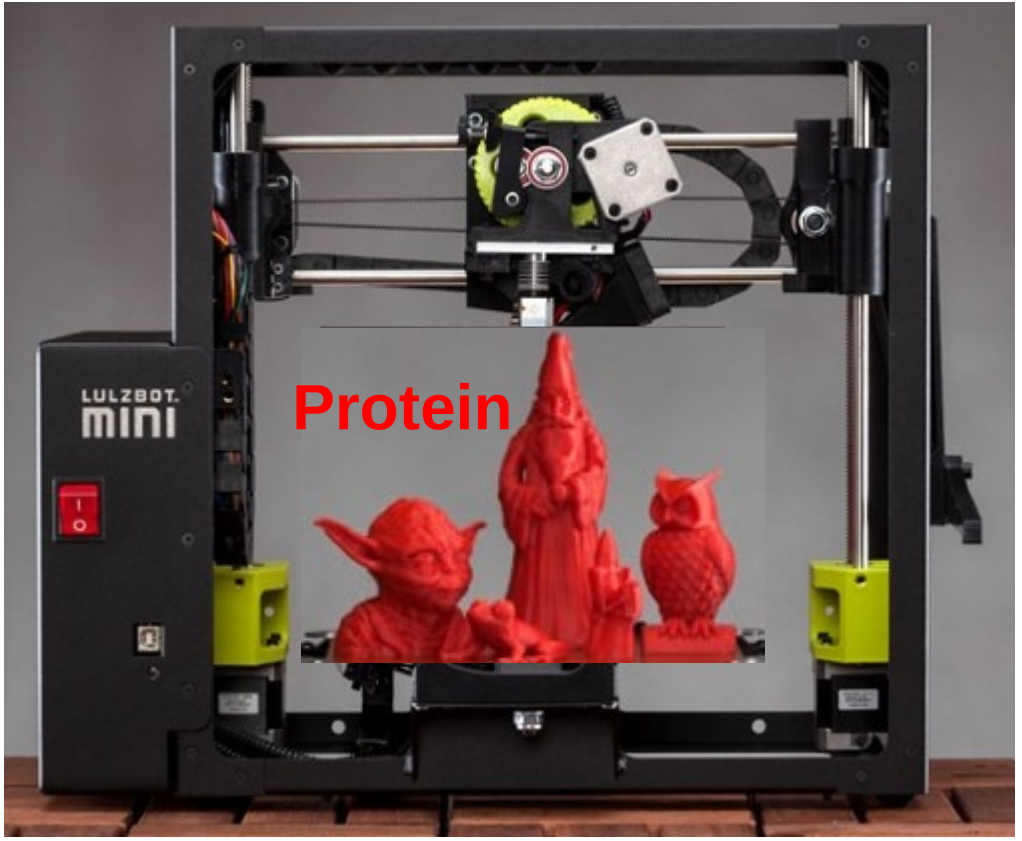
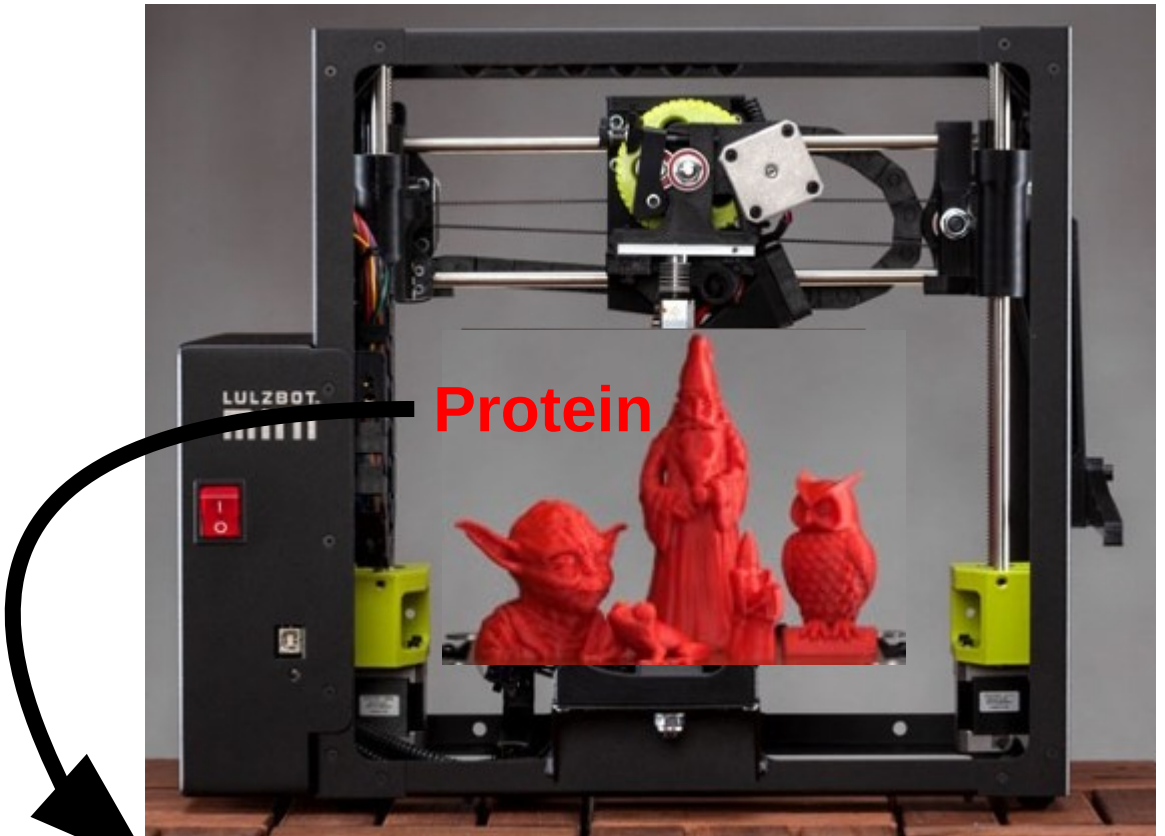


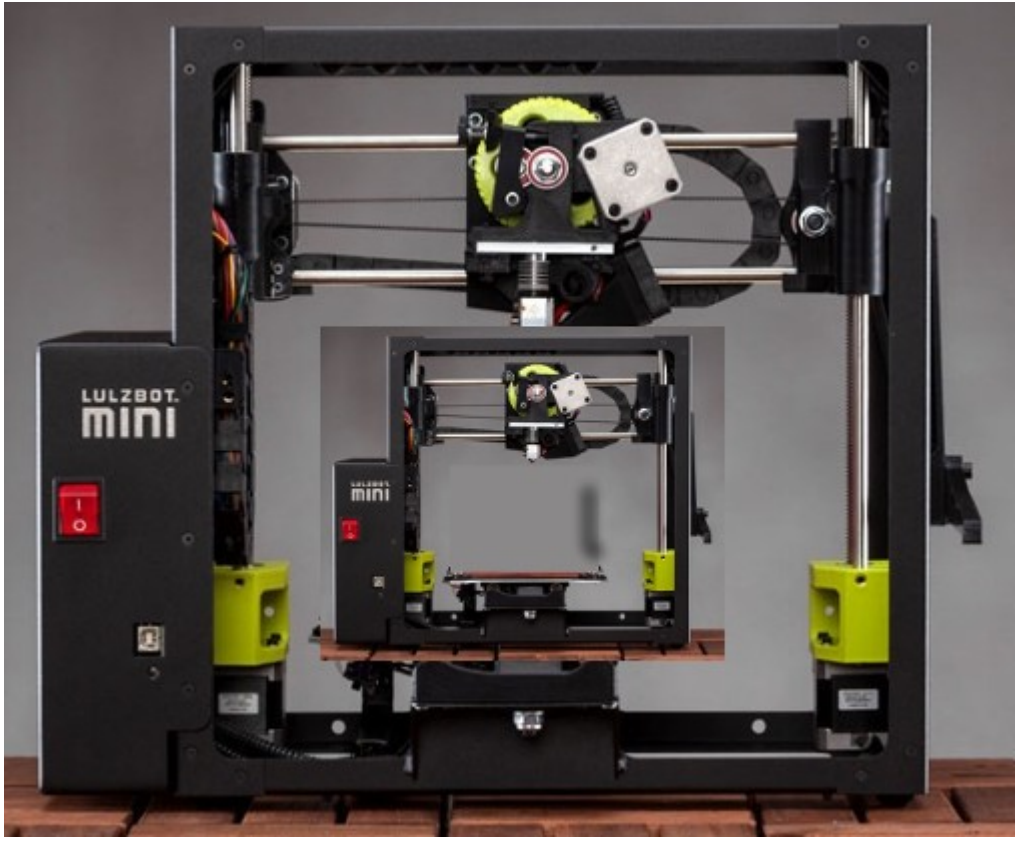
DNA+RNA

Logic of Molecular Biology

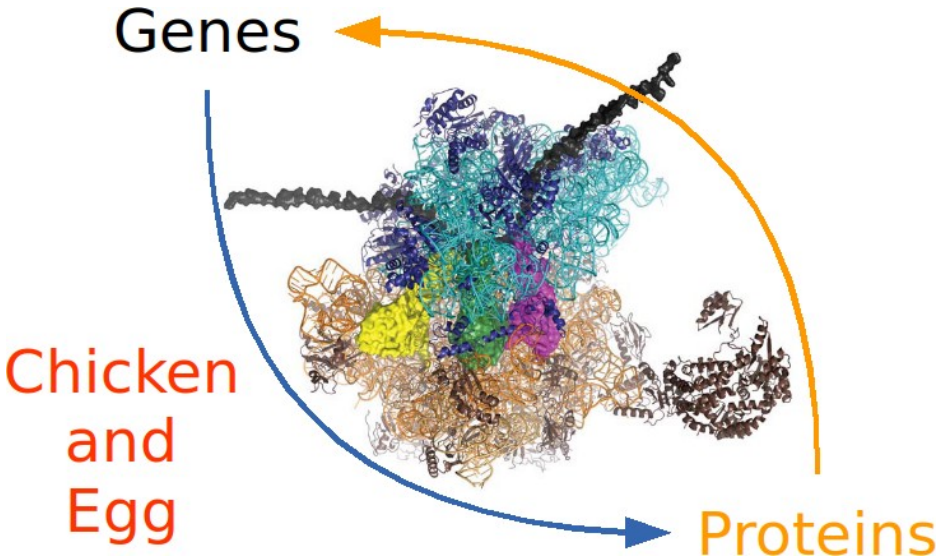


Logic of Molecular Biology

How to make a machine that makes itself?



Logic of Molecular Biology



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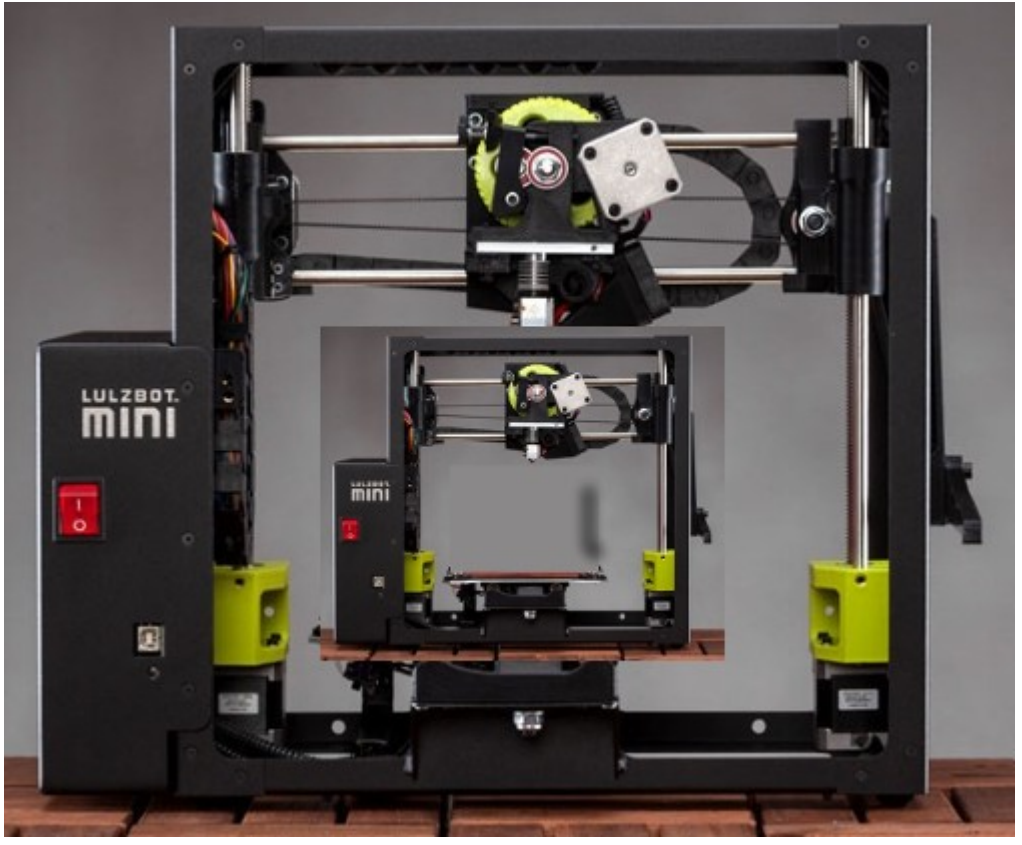
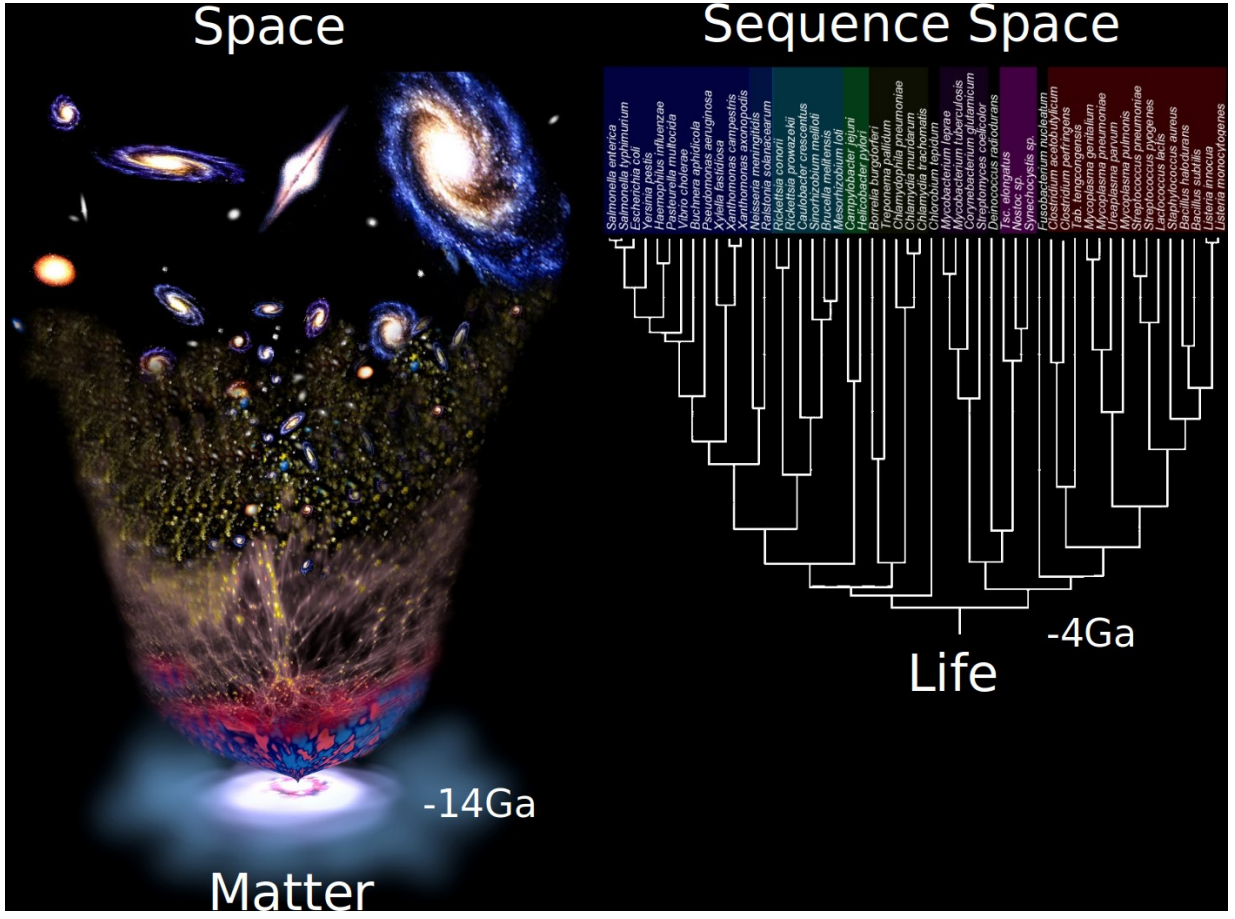


History of Biology



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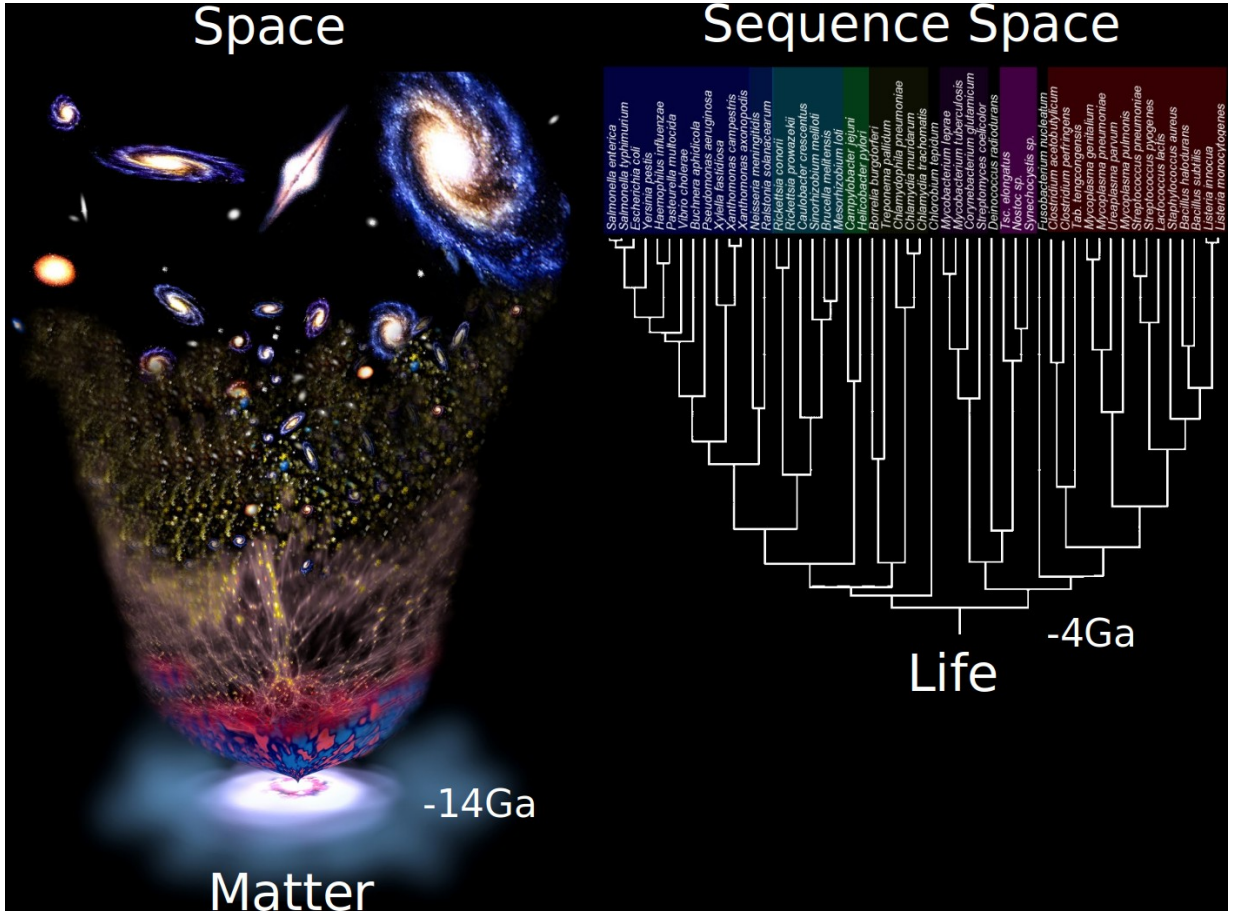

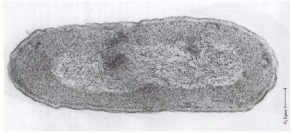

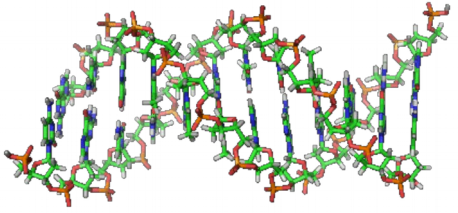

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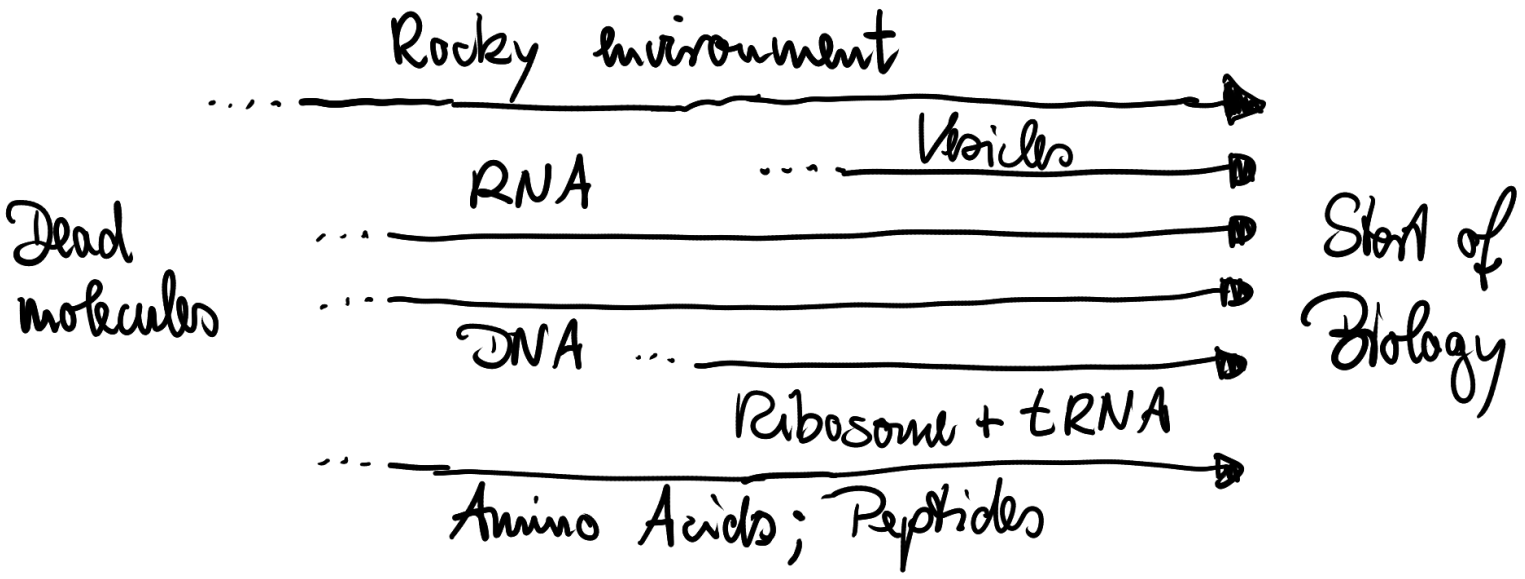
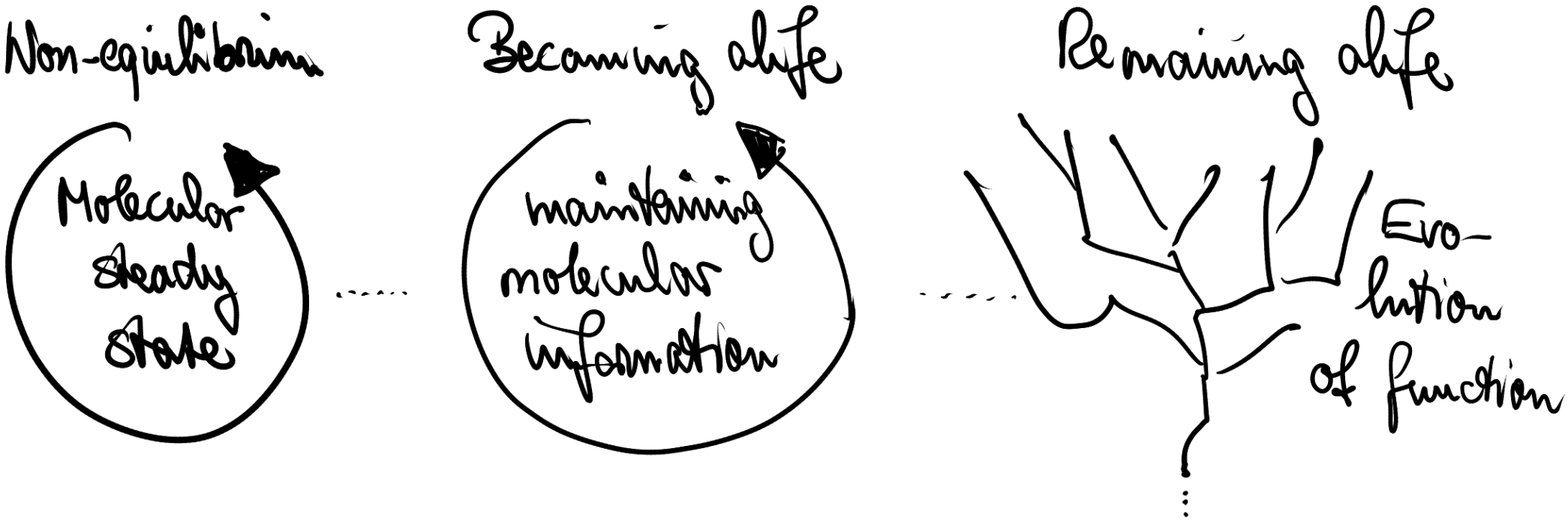
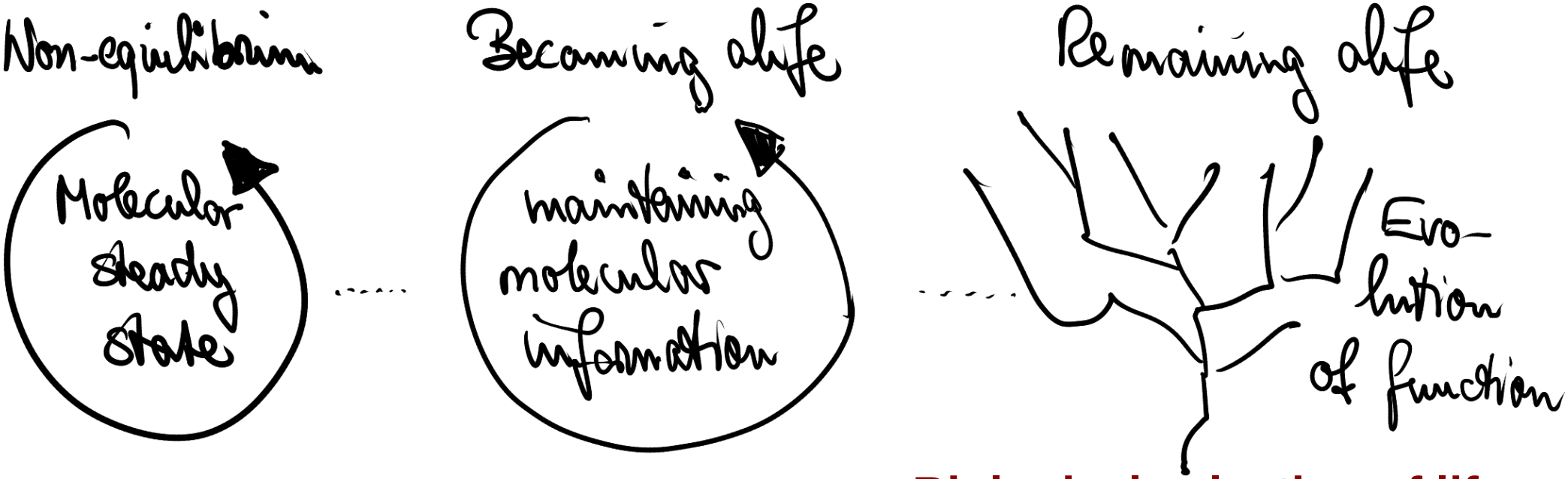


Becoming alive

Becoming alive



Selection before and within life

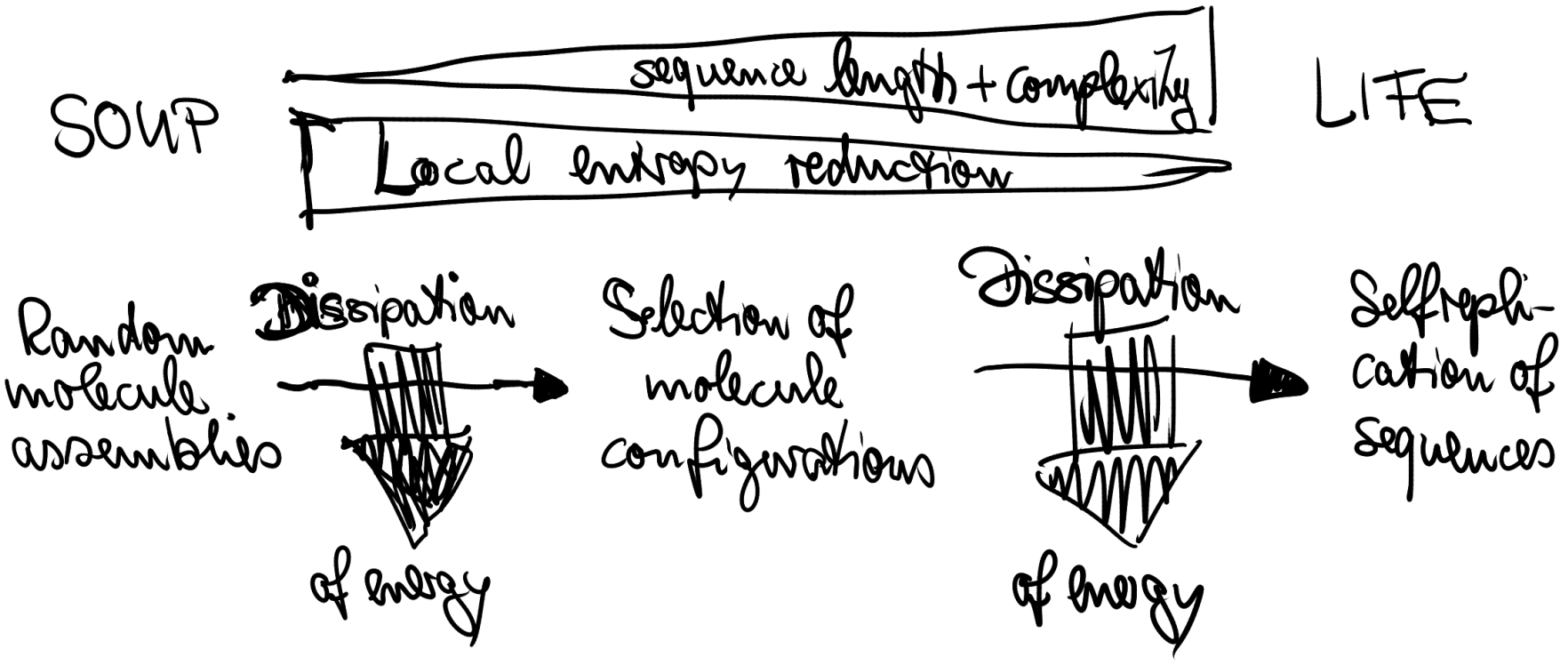


Physical selection from non-equilibrium boundary conditions

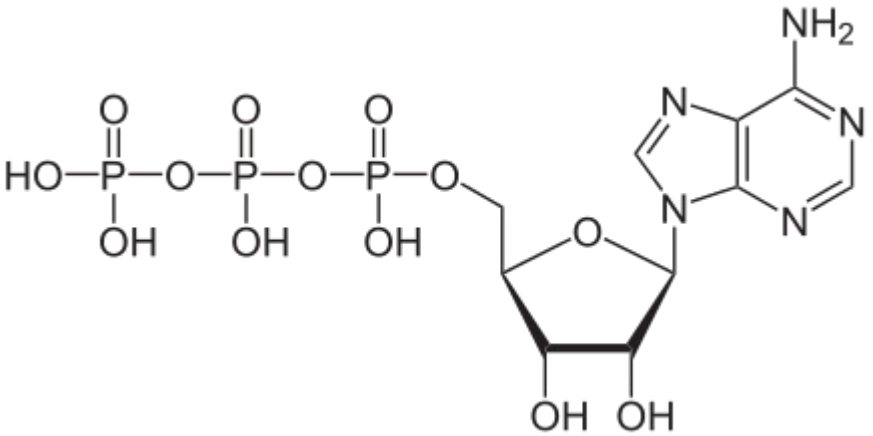
Biological selection of life against life for better adaptation to environment

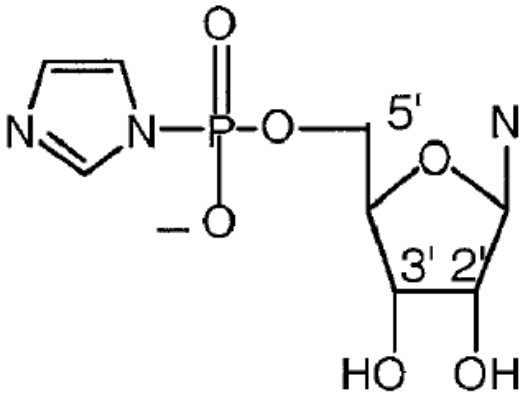
Soup of life

Soup of life


SOUP
sequence length + complexity
Local entropy reduction
LIFE
Random molecule assemblies
Dissipation of energy
Selection of molecule configurations
Dissipation of energy
Self-replication of sequences

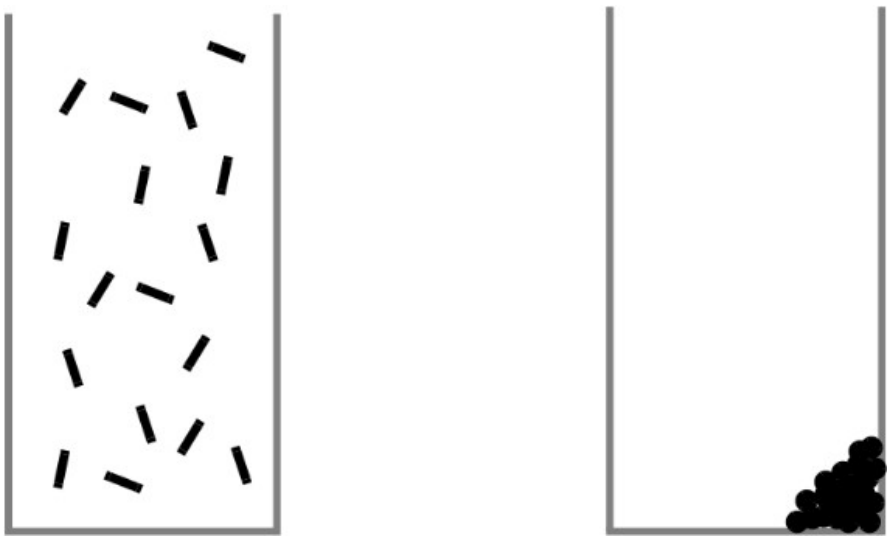
Three faces of entropy





Molecular Entropy: ATP vs AMP, activation, nucleophiles, leaving group

Three faces of entropy



Localization Entropy: chances to find molecules, probability of reaction, leaving group

Three faces of entropy

$$H(X) = -\sum_{i=1}^{n} p_i \log_2 p_i$$

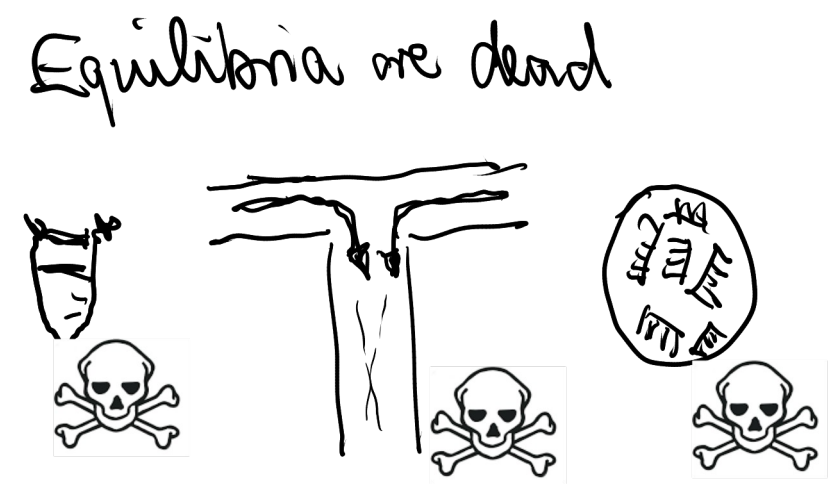
ATTTTTATATATAAAATATATATA

Sequence Entropy: information stored in DNA or RNA to be replicated

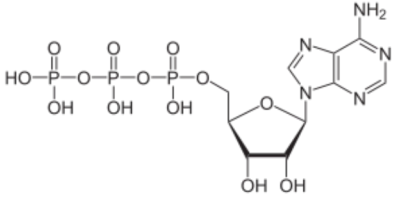
Death of equilibrium

Death of equilibrium

Death of equilibrium



Assumed nonequilibrium



Modes of non-equilibrium

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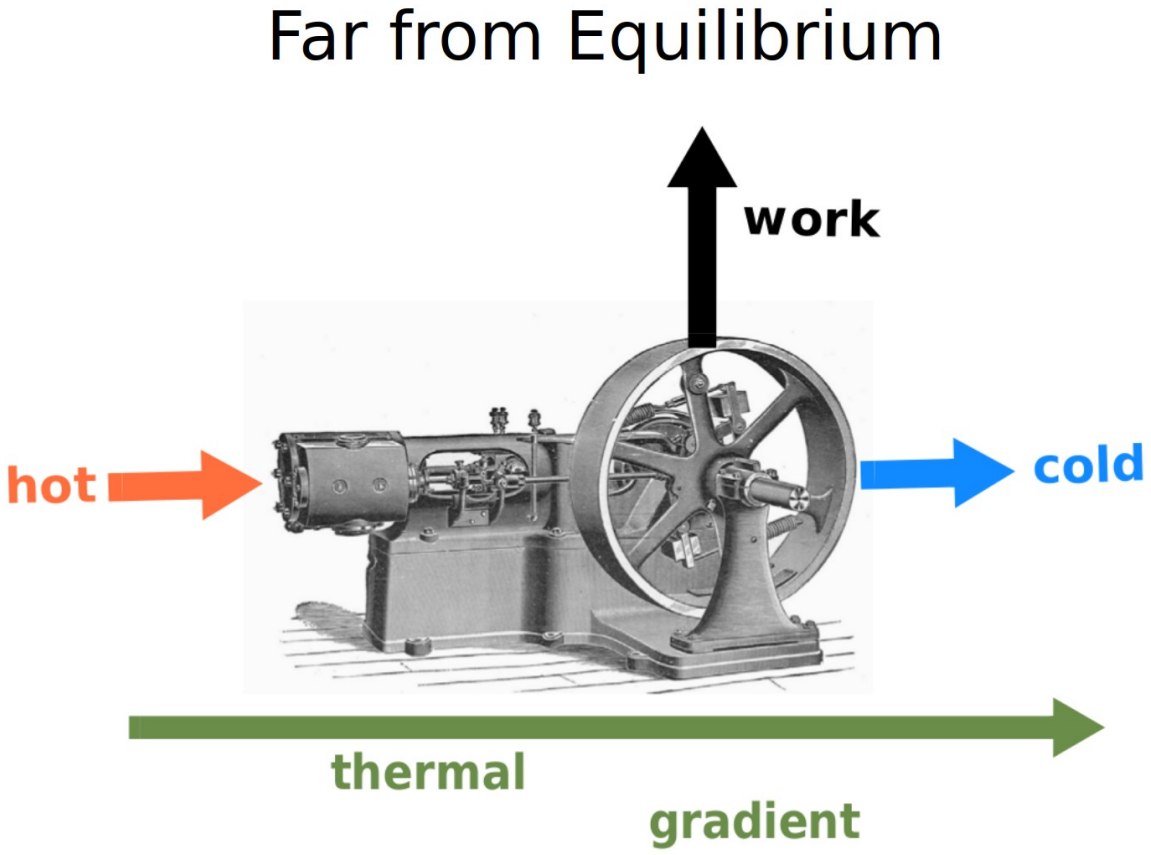

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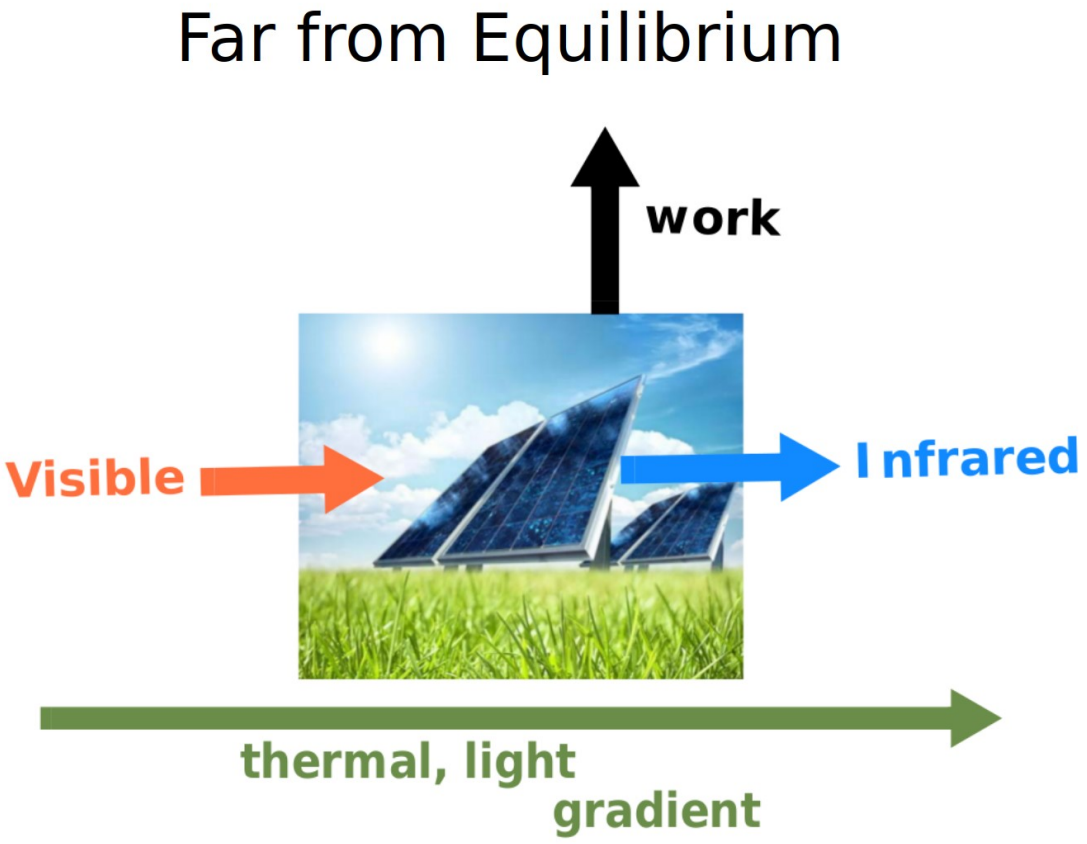

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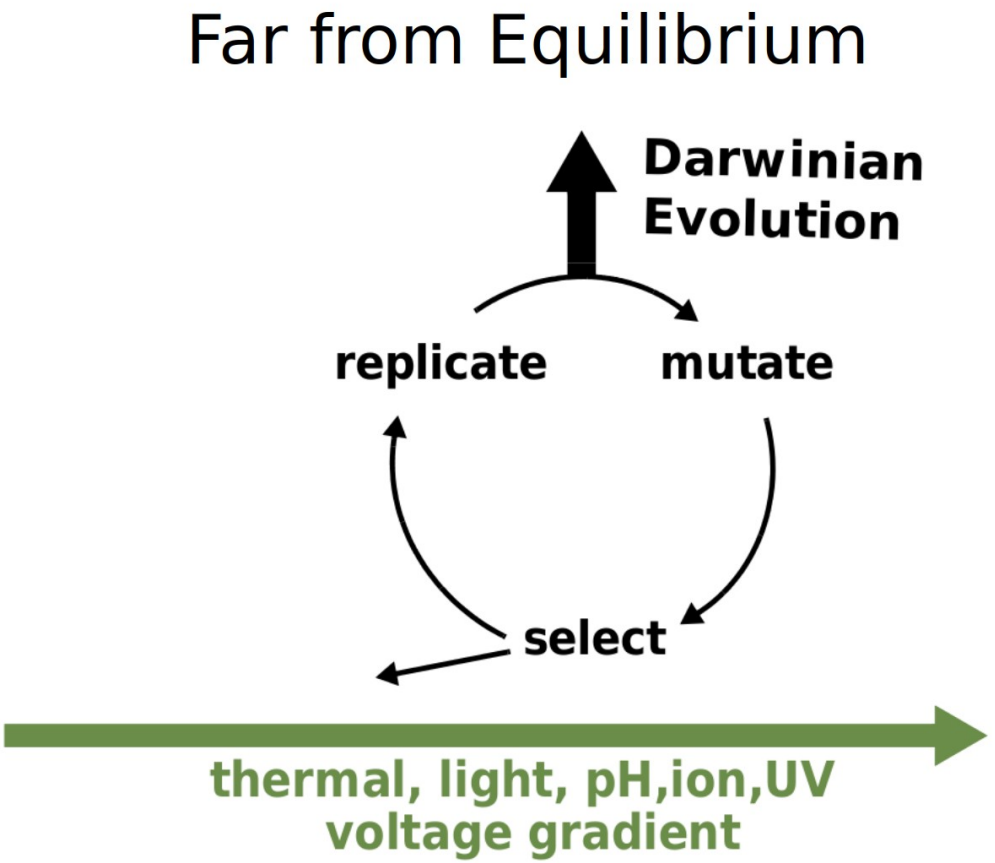

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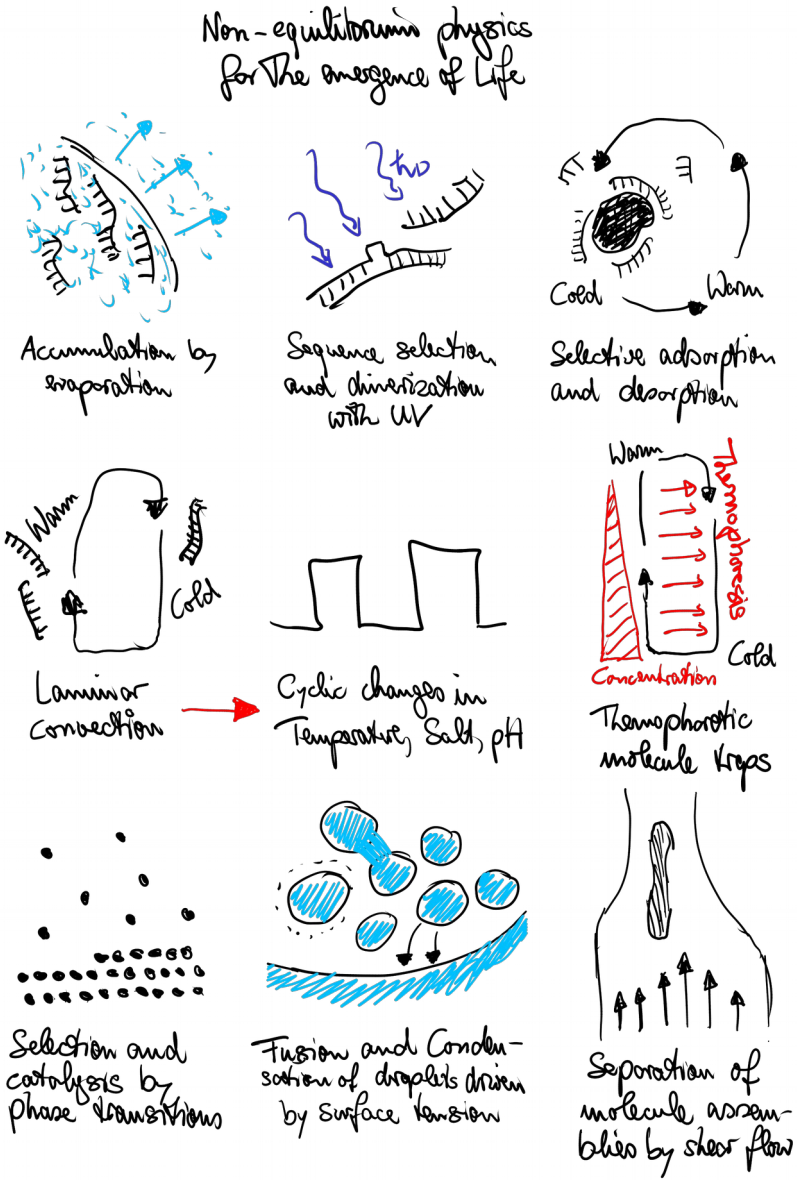

Structure of Origin of Life

Nucleotides (possibly stored)

Chemical conditions:
- Polymerization
- Ligation
- Activation

Physical non-equilibrium:
- Strand separation
- Maintaining accumulation
- Feeding and
  Waste removal

Some upcoming molecular machines

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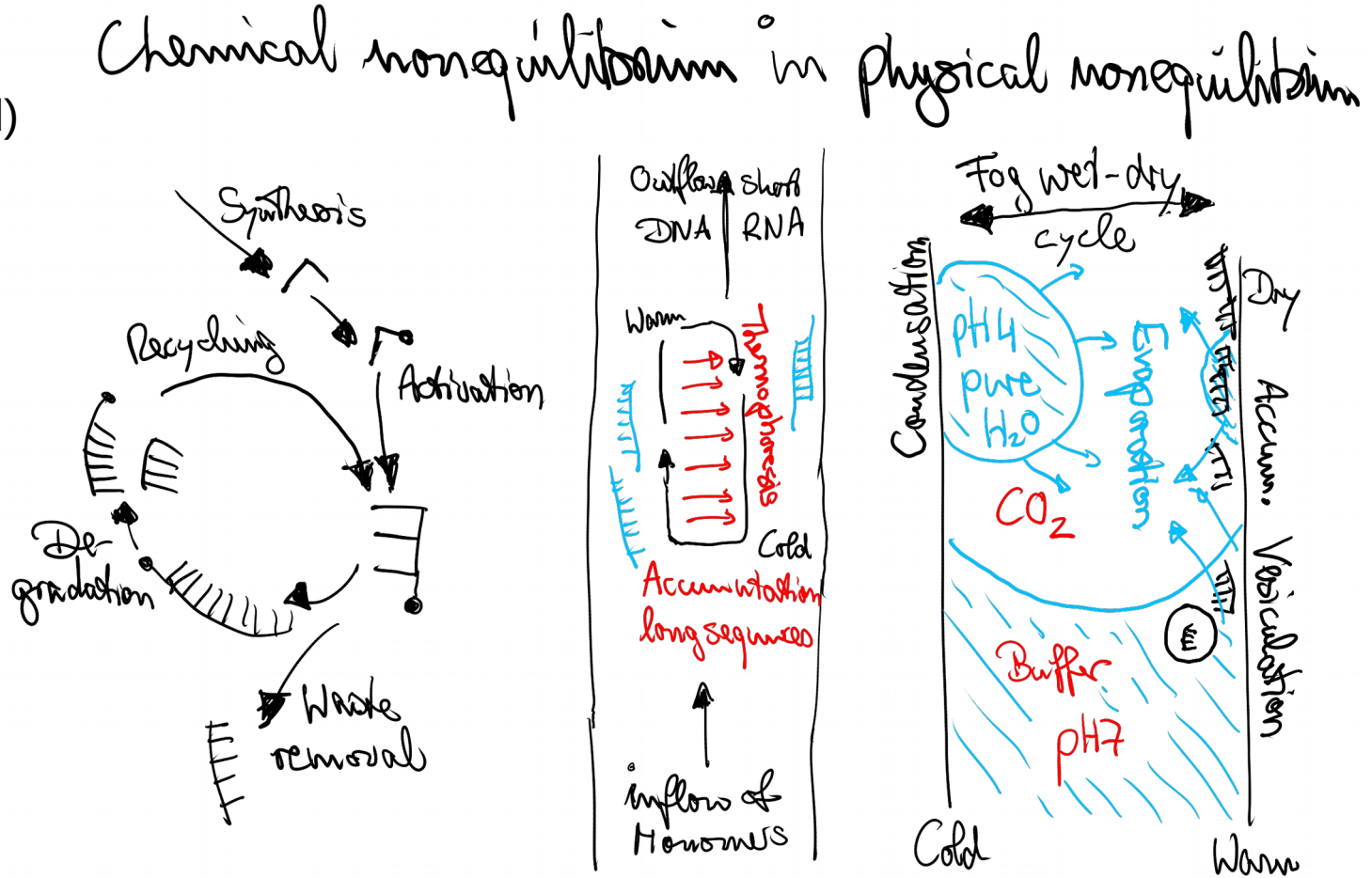

Some upcoming molecular machines