Life's Complexity Pyramid

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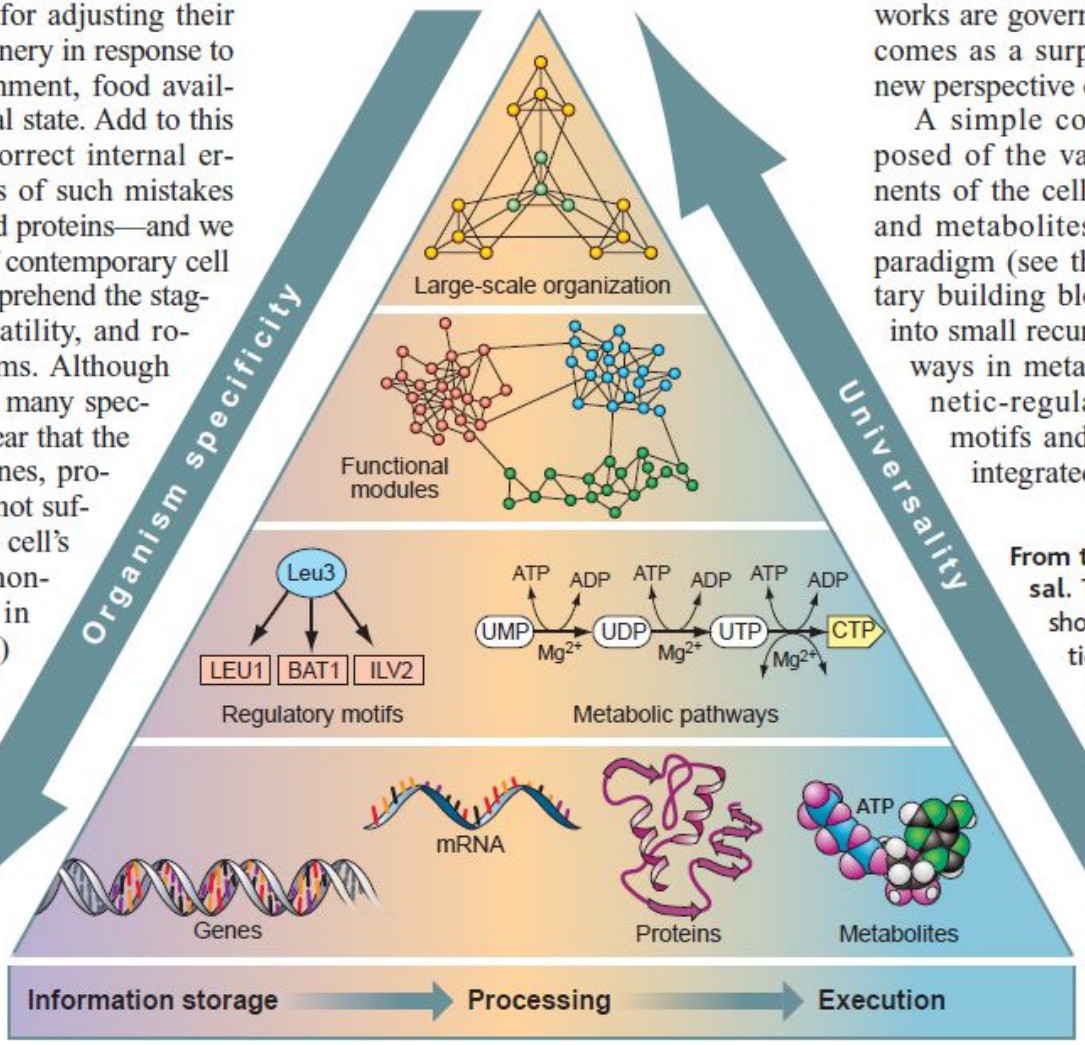
Cells and microorganisms have an impressive capacity for adjusting their intracellular machinery in response to changes in their environment, food availability, and developmental state. Add to this an amazing ability to correct internal errors—battling the effects of such mistakes as mutations or misfolded proteins—and we arrive at a major issue of contemporary cell biology: our need to comprehend the staggering complexity, versatility, and robustness of living systems. Although molecular biology offers many spectacular successes, it is clear that the detailed inventory of genes, proteins, and metabolites is not sufficient to understand the cell's complexity (*1*). As demonstrated by two papers in this issue—Lee *et al.* (*2*) on page 799 and Milo *et al.* (*3*) on page 824—viewing the cell as a network of genes and proteins offers a viable strategy for addressing the complexity of living systems.

According to the



within large networks (*6, 7*).
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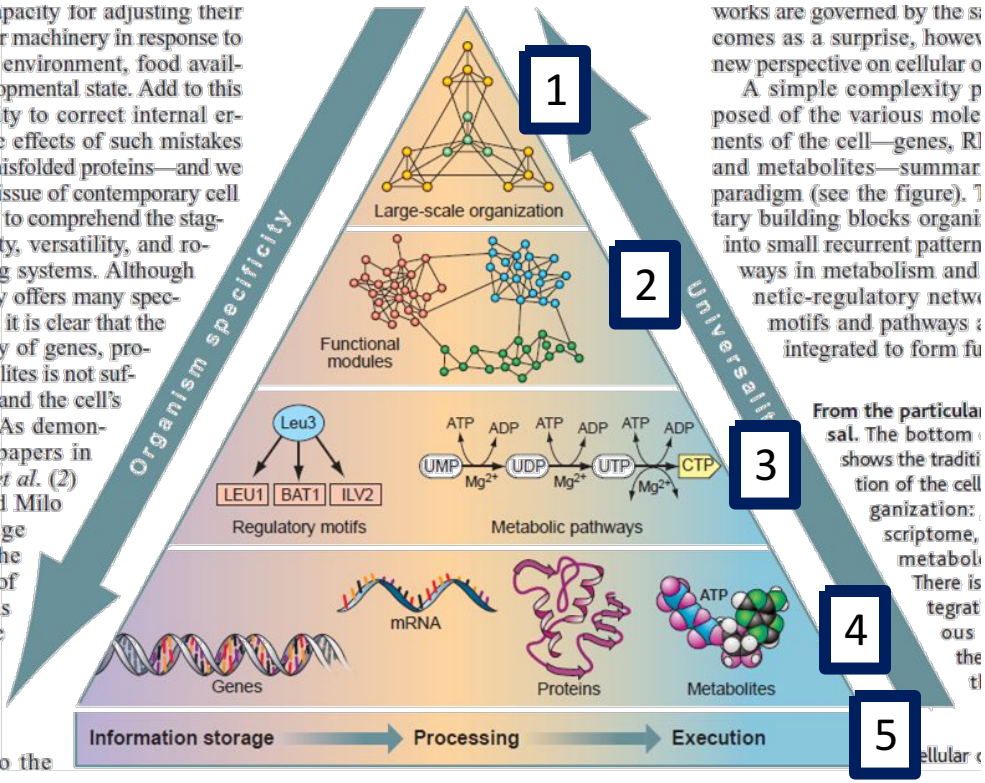
Hierchical levels of cell complexity



1) **Large-scale organisation**

2) **Functional modules**

3) **Regulatory motifs, metabolic pathways**

4) **Molecules: genes, mRNAs, proteins, metabolites**

5) **Overall: Information storage, Processing, Execution**

The **cell** is the basic structural, functional and biological unit of all known living organisms

Cells are the smallest unit of life that is classified as a living thing, and are often called the "building blocks of life".

http://en.wikipedia.org/wiki/Cell_%28biology%29

Experimental techniques/methods for detecting:

1) **Large-scale organisation**
2) **Functional modules**
3) **Regulatory motifs, metabolic pathways**
4) **Molecules: genes, mRNAs, proteins, metabolites**
5) **Overall: Information storage, Processing, Execution**

Data analysis

Model building/model validation

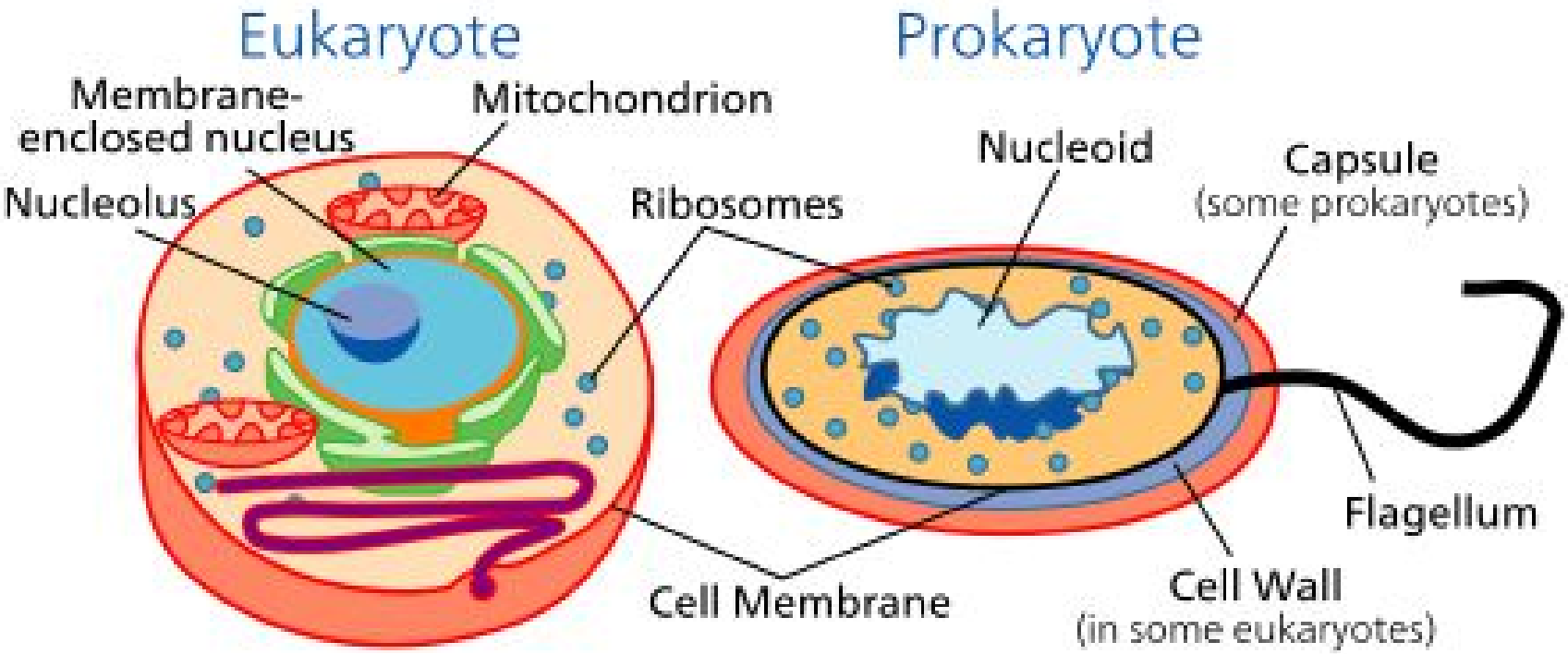
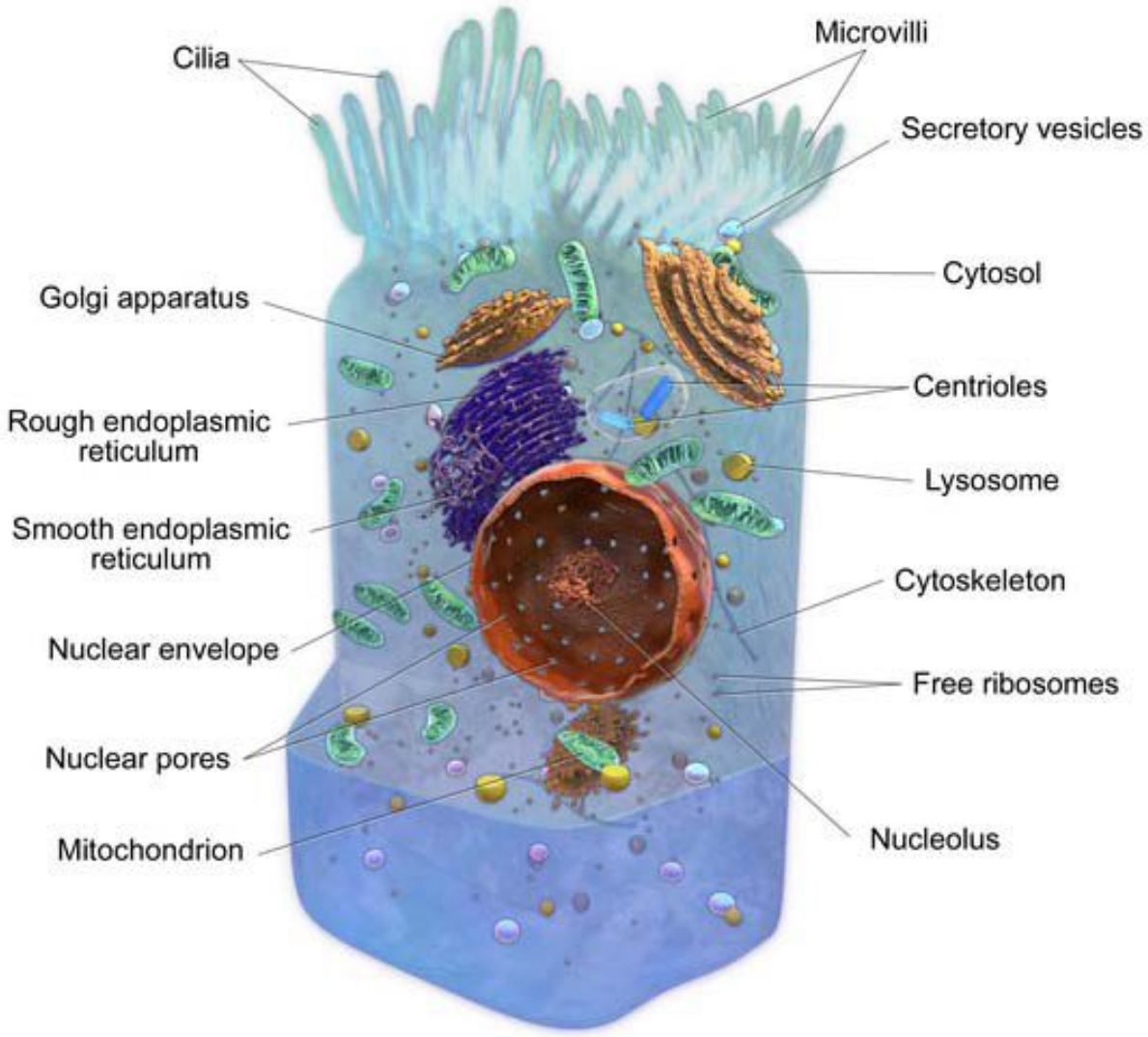

Eukaryote
Prokaryote
Membrane-enclosed nucleus
Mitochondrion
Nucleolus
Ribosomes
Nucleoid
Capsule
(some prokaryotes)
Flagellum
Cell Membrane
Cell Wall
(in some eukaryotes)

Table 1: Comparison of features of prokaryotic and eukaryotic cells

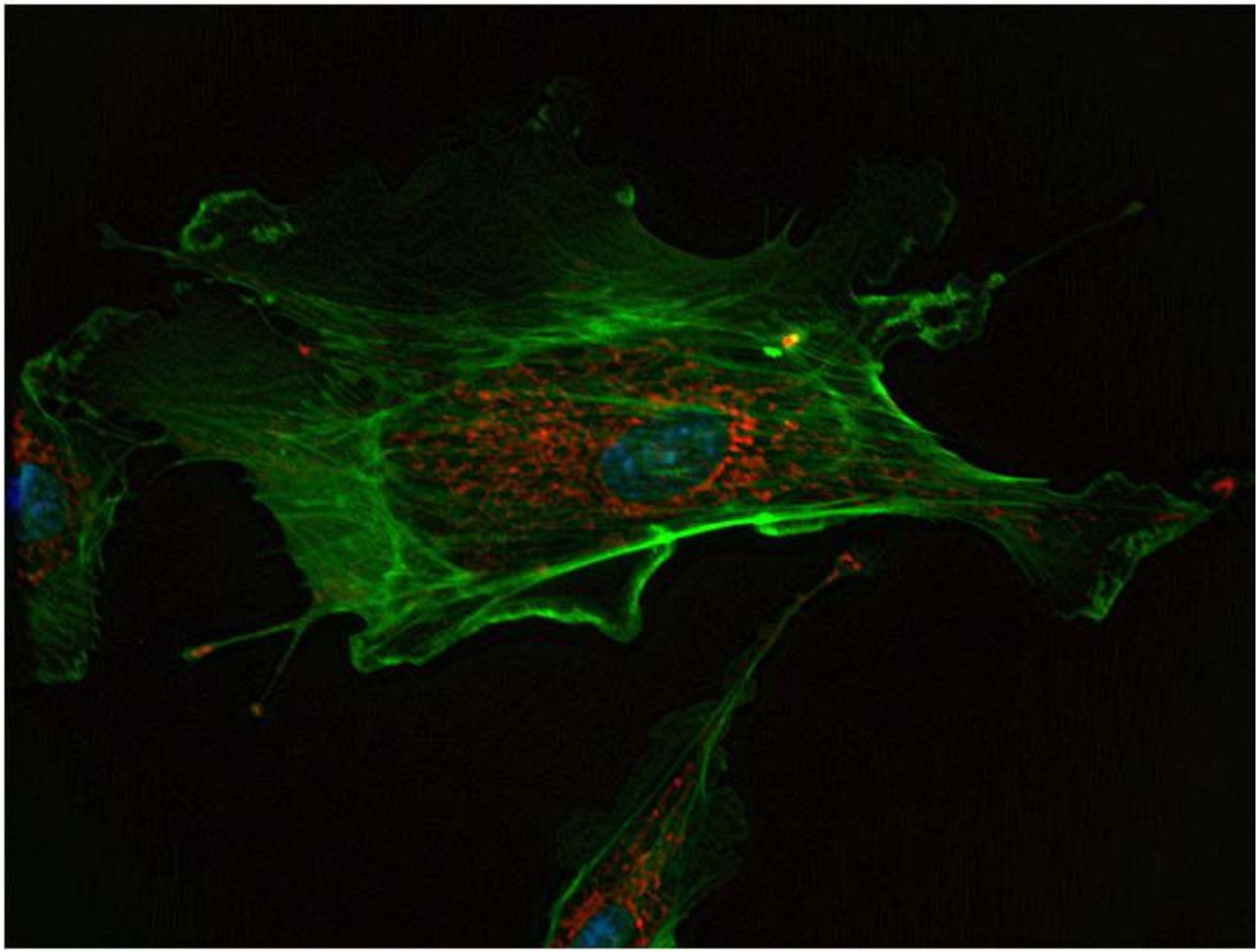
	Prokaryotes	Eukaryotes
Typical organisms	bacteria, archaea	protists, fungi, plants, animals
Typical size	~ 1–5 µm[10]	~ 10–100 µm[10]
Type of nucleus	nucleoid region; no true nucleus	true nucleus with double membrane
DNA	circular (usually)	linear molecules (chromosomes) with histone proteins
RNA/protein synthesis	coupled in the cytoplasm	RNA synthesis in the nucleus protein synthesis in the cytoplasm
Ribosomes	50S and 30S	60S and 40S
Cytoplasmic structure	very few structures	highly structured by endomembranes and a cytoskeleton
Cell movement	flagella made of flagellin	flagella and cilia containing microtubules; lamellipodia and filopodia containing actin
Mitochondria	none	one to several thousand (though some lack mitochondria)
Chloroplasts	none	in algae and plants
Organization	usually single cells	single cells, colonies, higher multicellular organisms with specialized cells
Cell division	Binary fission (simple division)	Mitosis (fission or budding) Meiosis

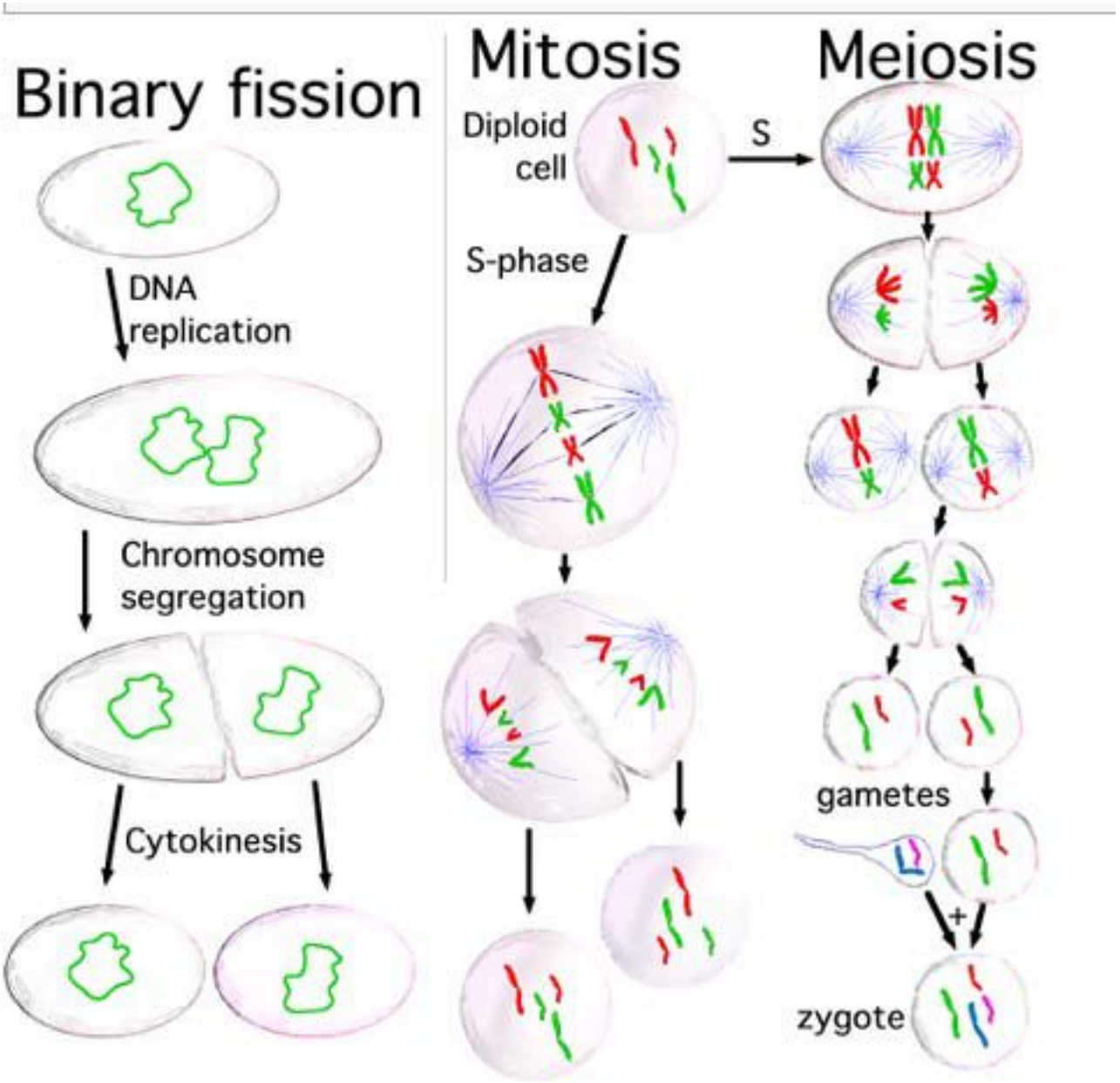
Many compartments……



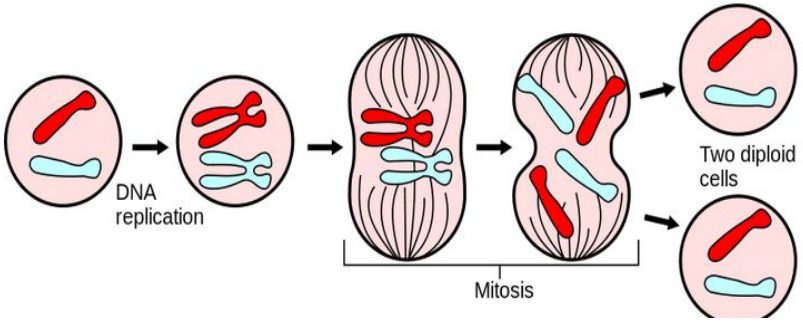
http://www.youtube.com/watch?v=1Z9pqST72is

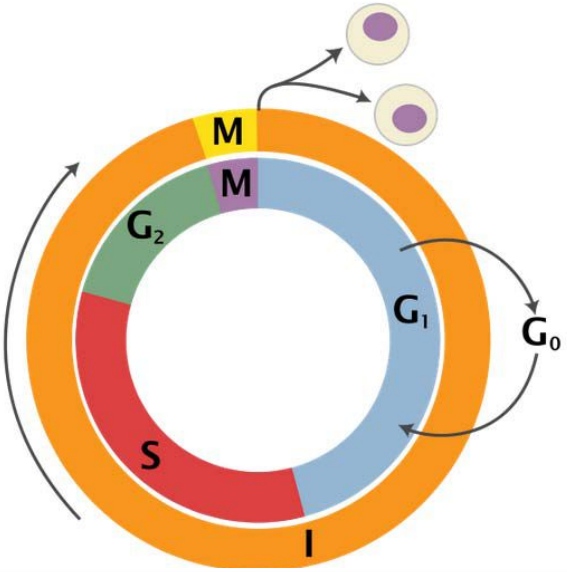
Looking inside a cell…….





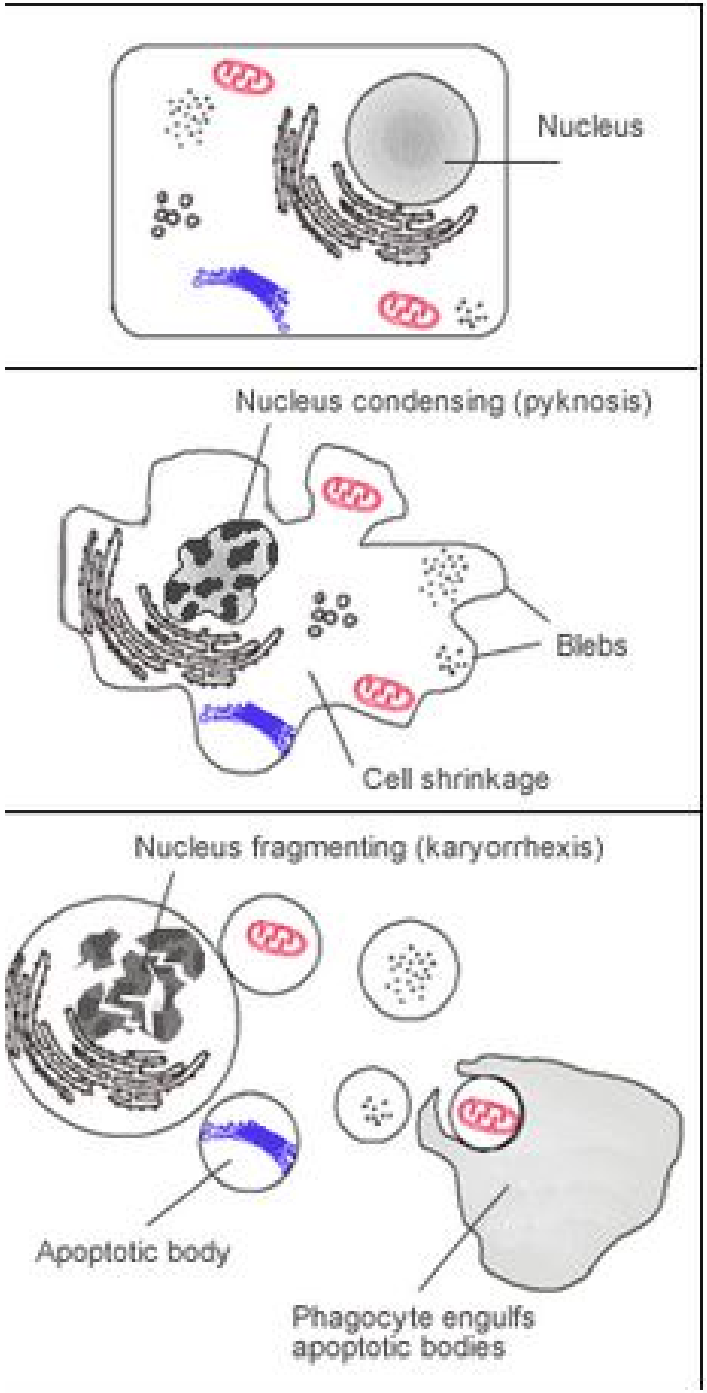
Cell division





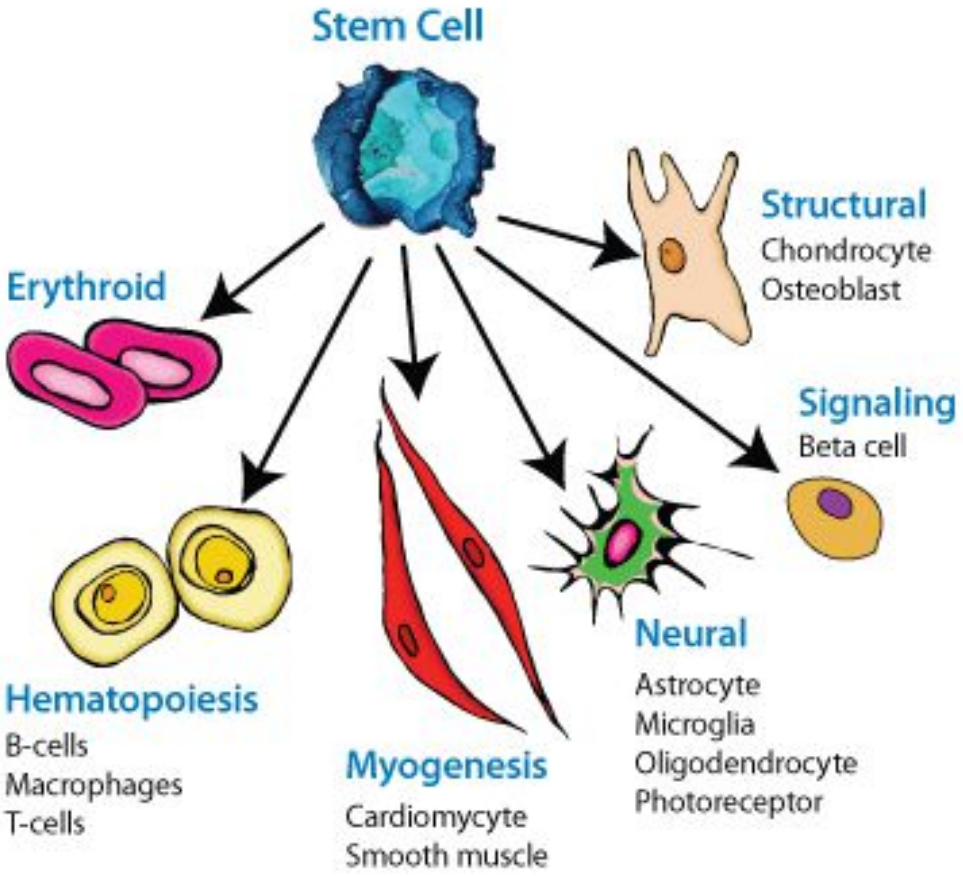
Cell Cycle

State	Description	Abbreviation	
quiescent/ senescent	Gap 0	G_0	A resting phase where the cell has left the cycle and has stopped dividing.
Interphase	Gap 1	G_1	Cells increase in size in Gap 1. The *G_1 checkpoint* control mechanism ensures that everything is ready for DNA synthesis.
	Synthesis	S	DNA replication occurs during this phase.
	Gap 2	G_2	During the gap between DNA synthesis and mitosis, the cell will continue to grow. The *G_2 checkpoint* control mechanism ensures that everything is ready to enter the M (mitosis) phase and divide.
Cell division	Mitosis	M	Cell growth stops at this stage and cellular energy is focused on the orderly division into two daughter cells. A checkpoint in the middle of mitosis (*Metaphase Checkpoint*) ensures that the cell is ready to complete cell division.

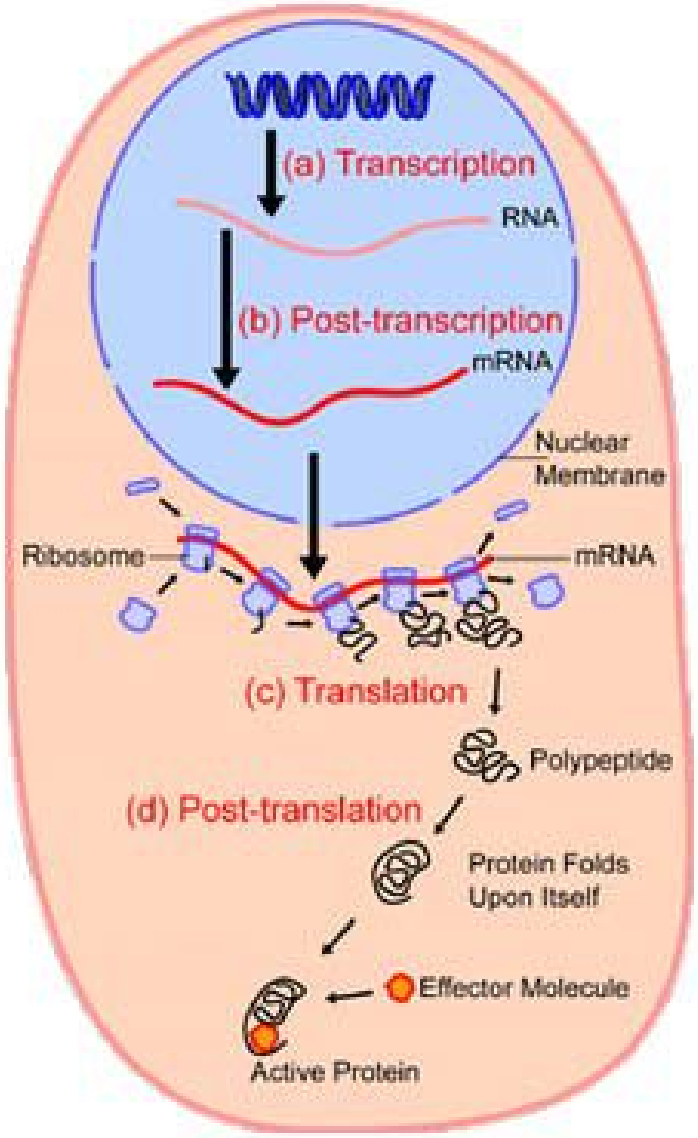


Apoptosis

Apoptosis is the process of programmed cell death (PCD) that may occur in multicellular organisms.
Biochemical events lead to characteristic cell changes (morphology) and death. These changes include blebbing, cell shrinkage, nuclear fragmentation, chromatin condensation, and chromosomal DNA fragmentation.

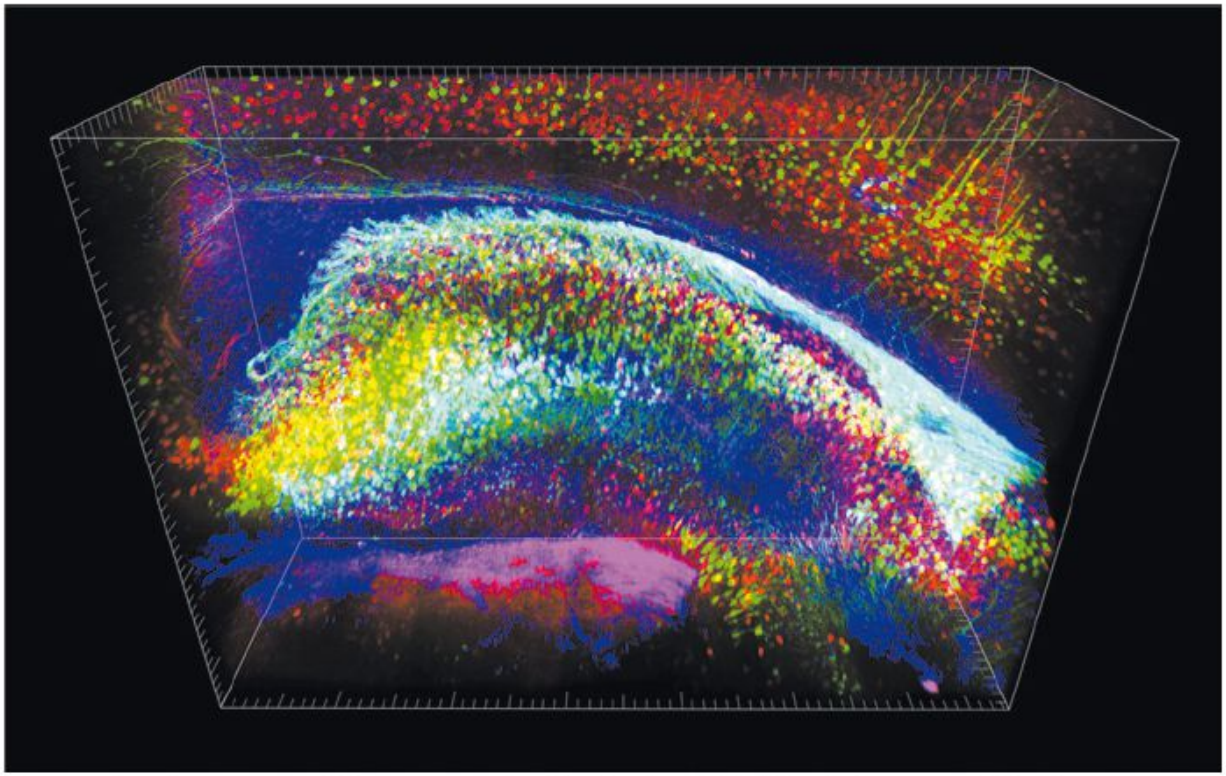


In developmental biology, cellular differentiation is the process by which a less specialized cell becomes a more specialized cell type



Large scale organization:

Protein synthesis, one among the different biological processes occurring inside the cell.



KWANGHUN CHUNG & KARL DEISSEROTH, HHMI/STANFORD UNIV.

Neurons in an intact mouse hippocampus visualized using CLARITY and fluorescent labelling.

NEUROSCIENCE

See-through brains clarify connections

Technique to make tissue transparent offers three-dimensional view of neural networks.

through 0.5-millimetre-thick slabs of formalin-preserved autopsied human brain — orders of magnitude thicker than slices currently imaged.

"The work is spectacular. The results are unlike anything else in the field," says Van Wedeen, a neuroscientist at the Massachusetts General Hospital in Boston and a lead investigator on the US National Institutes of Health's Human Connectome Project (HCP), which aims to chart the brain's neuronal communication networks. The new technique, he says, could reveal important cellular details that would complement data on large-scale neuronal pathways that he and his colleagues are mapping in the HCP's 1,200 healthy participants using magnetic resonance imaging.

Francine Benes, director of the Harvard Brain Tissue Resource Center at McLean Hospital in Belmont, Massachusetts, says that more tests are needed to assess whether the lipid-clearing treatment alters or damages the fundamental structure of brain tissue. But she and others predict that CLARITY will pave the way for studies on healthy brain wiring, and on brain disorders and ageing.

Researchers could, for example, compare circuitry in banked tissue from people with neurological diseases and from controls whose brains were healthy. Such studies in living people are impossible, because most neuron-tracing methods require genetic engineering or injection of dye in living animals. Scientists might also revisit the many specimens in repositories that have been difficult to analyse because human brains are so large.

NATURE | ARTICLE

日本語要約

Structural and molecular interrogation of intact biological systems

Kwanghun Chung, Jenelle Wallace, Sung-Yon Kim, Sandhiya Kalyanasundaram, Aaron S. Andalman, Thomas J. Davidson, Julie J. Mirzabekov, Kelly A. Zalocusky, Joanna Mattis, Aleksandra K. Denisin, Sally Pak, Hannah Bernstein, Charu Ramakrishnan, Logan Grosenick, Viviana Gradinaru & Karl Deisseroth

Affiliations | Contributions | Corresponding author

Nature **497**, 332–337 (16 May 2013) | doi:10.1038/nature12107

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Abstract

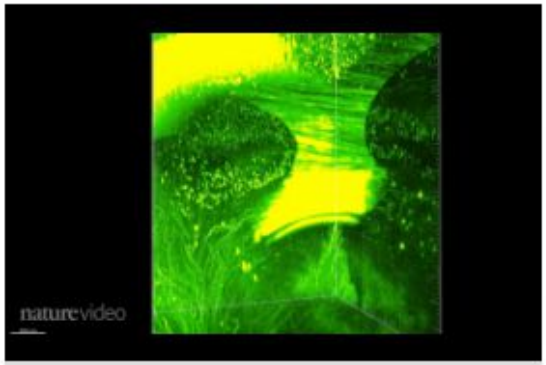
Editor's summary

العربية

High-resolution imaging of biological tissue has traditionally required sectioning, which for tissues like the brain means the loss of long-range connectivity. Now Karl Deisseroth and colleagues have ...

Related video

See-through brains



Nature Video takes you on a tour of the stunning 3D visualisations created by Karl Deisseroth and his team.

K. Chung *et al. Nature*

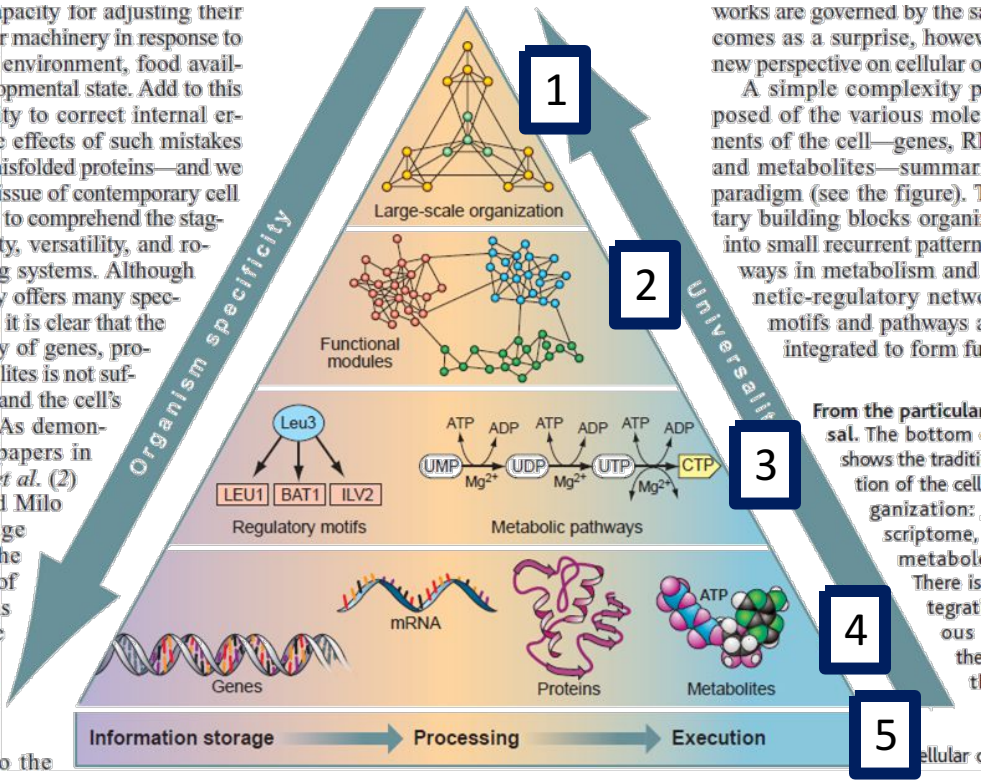
http://dx.doi.org/10.1038/nature12107; 2013).

http://www.theguardian.com/science/video/2013/apr/10/transparent-brains-reveal-secrets-video

Open problems:

1) *The origin of life*
2) *The genotype-phenotype relationship*
3) *Whether life is present elsewhere in the Universe*
4) *Whether evolution is the best model to undertand life origin*

Hierchical levels of cell complexity and our knoweldge



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