Molecular Biology

...for computer scientists

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MFF, Prague, 2010

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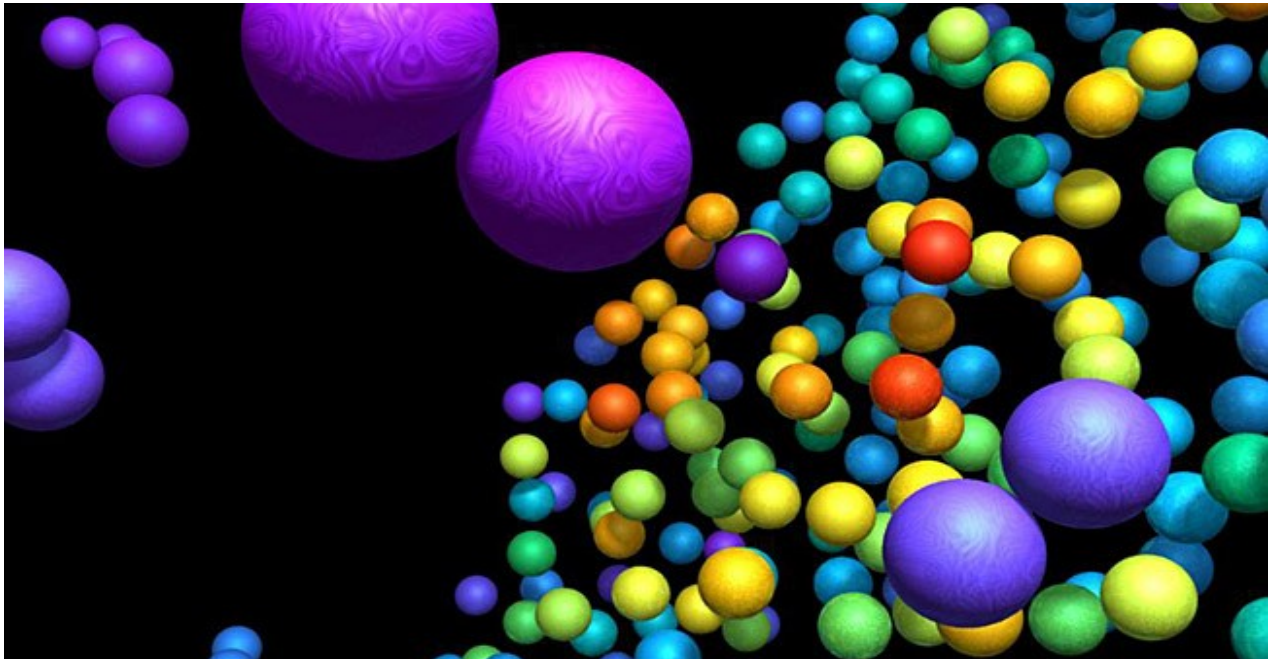


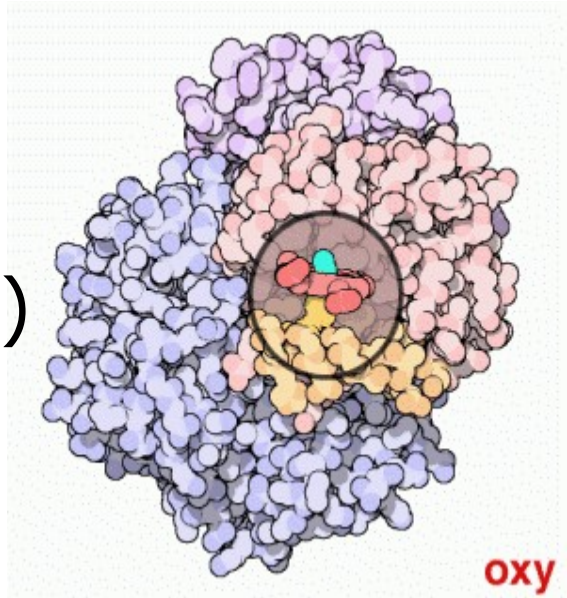
Hardware Environment

Hardware Environment

- **Cell** – a single hardware unit (autonomous or inter-networked or in-between)
  - Procaryotic or eucaryotic
- **Membranes** (I/O, access control)
- **Nucleus** (external memory – code storage)
- **Ribosomes** (the code execution units)
- **Mitochondria** (cell metabolism – power plant)

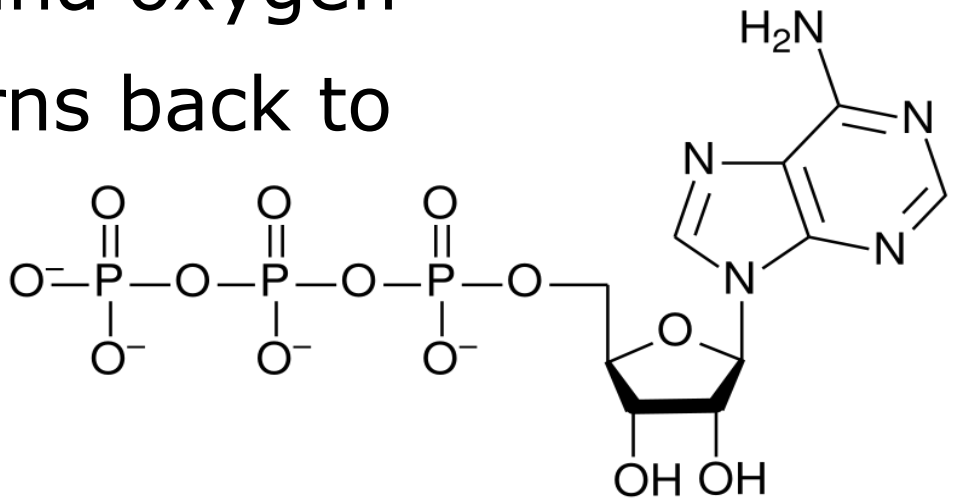
Proteins

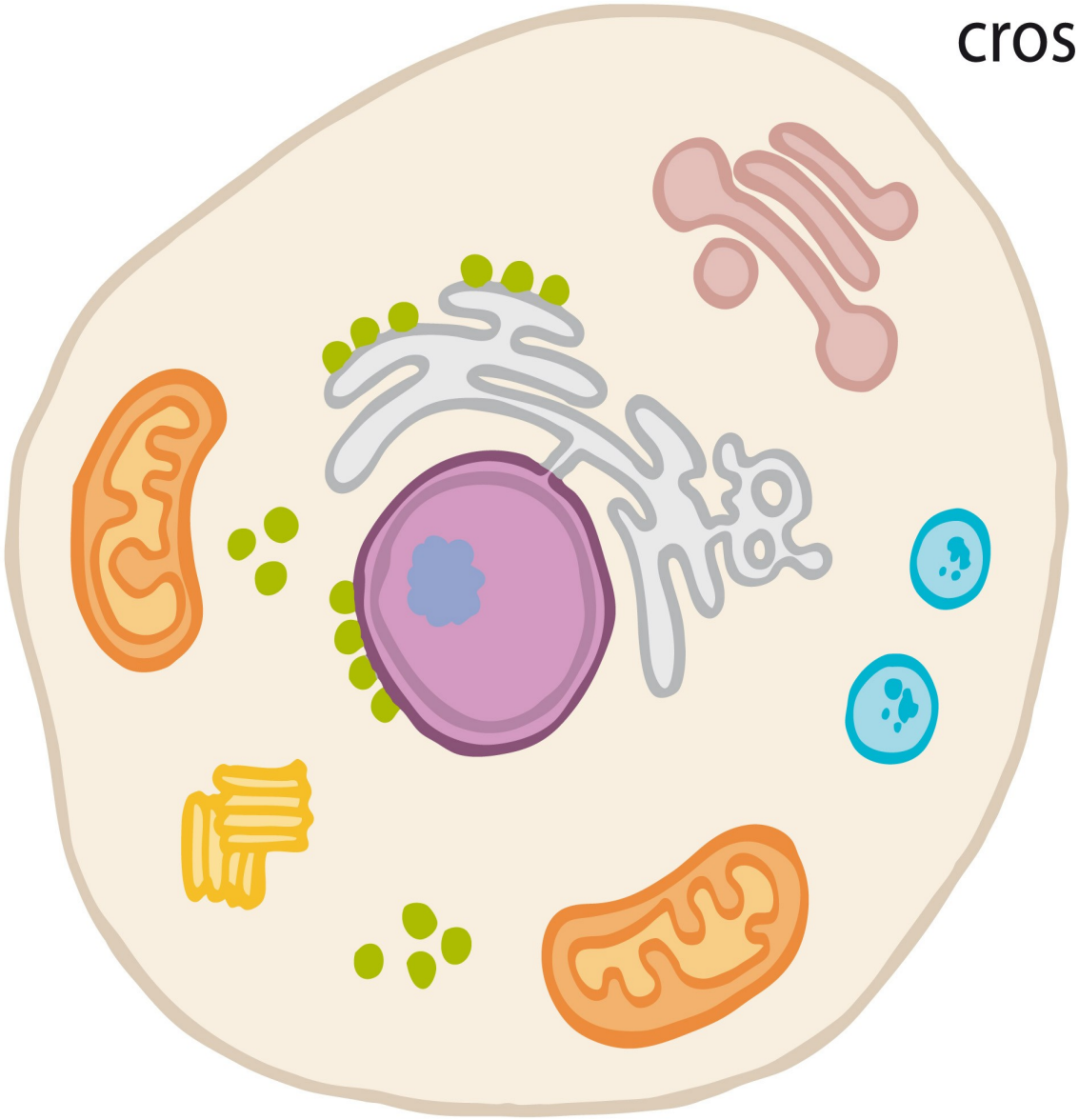
- Polymer molecules that perform everything; mammoth structure with a connection slot(s): **conformation**
- Proteins *bind* stuff or *catalyze* stuff
  - **Binding** to other molecules (transportation: hemoglobin)
  - **Binding** to each other (cell structure: membranes)
  - **Catalyzing** reactions (enzymes: metabolism, ion pumps)



Adenosin TriPhosphate

- Energy raw material in the cell; proteins "perform" chemical reactions, using ATP "fuel"
- ADP is converted to ATP by...
  - ...raw photon energy ("light")
  - ...glucose to ATP: light (photosynthesis) or enzymes and oxygen
- In reactions, ATP turns back to ADP, is recycled



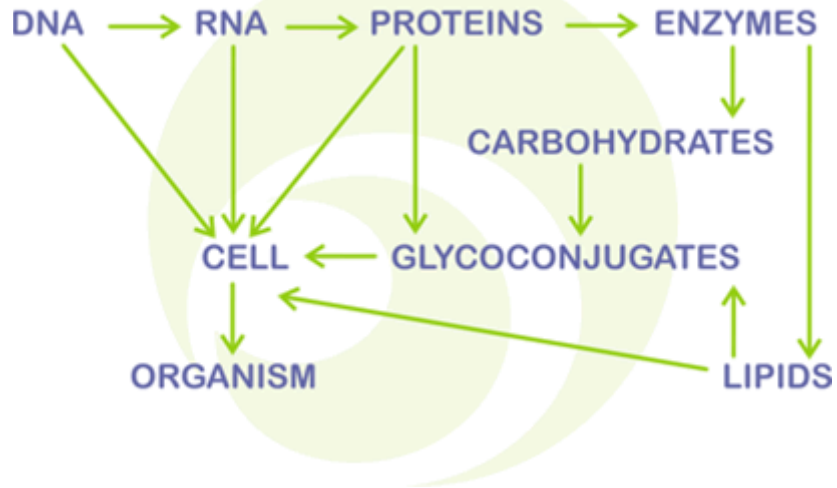


cross-section of an animal cell

- cell membrane
- cytoplasm
- nucleus
- nuclear membrane
- nucleolus
- endoplasmatic reticulum (ER)
- ribosomes
- golgi apparatus
- mitochondria
- lysosomes
- centrosome

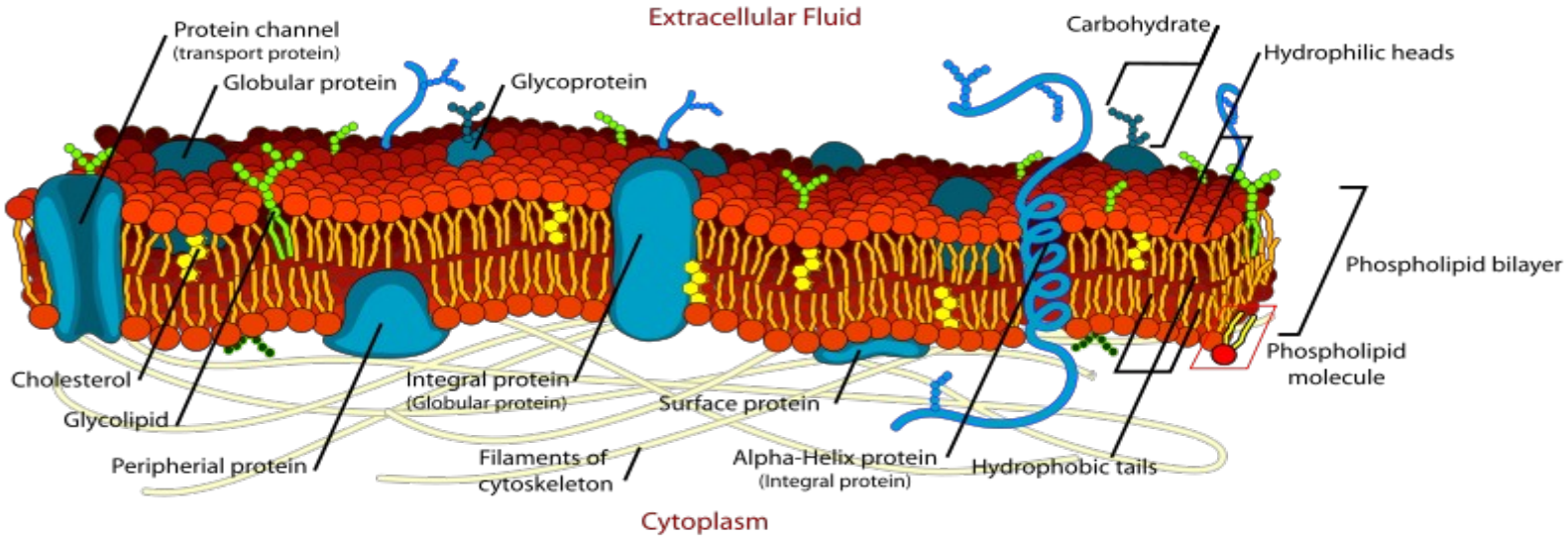
Cell Function

- Retrieve code (**nucleus**)
- Synthesize proteins by the code (**ribosomes**)
- Transport proteins(**endoplasmatic reticulum**)
- Combine proteins (**Golgi apparatus**)
- Do stuff using proteins and **ATP** (energy units)
- Generate ATP (**mitochondria**)



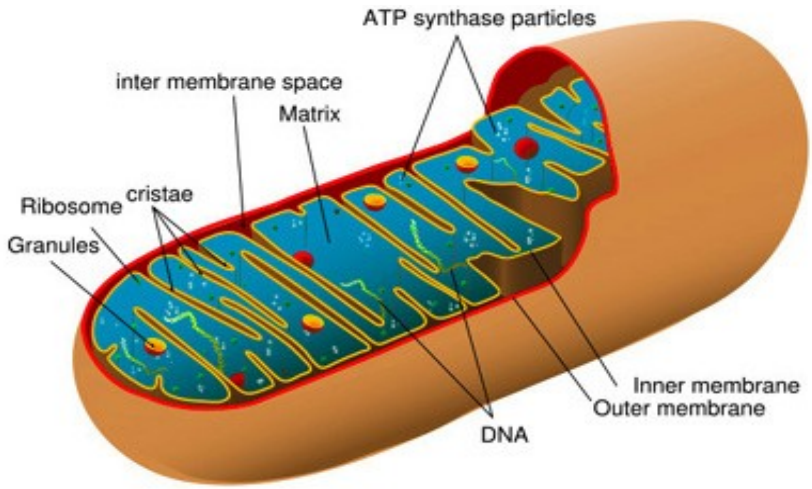
Organelles

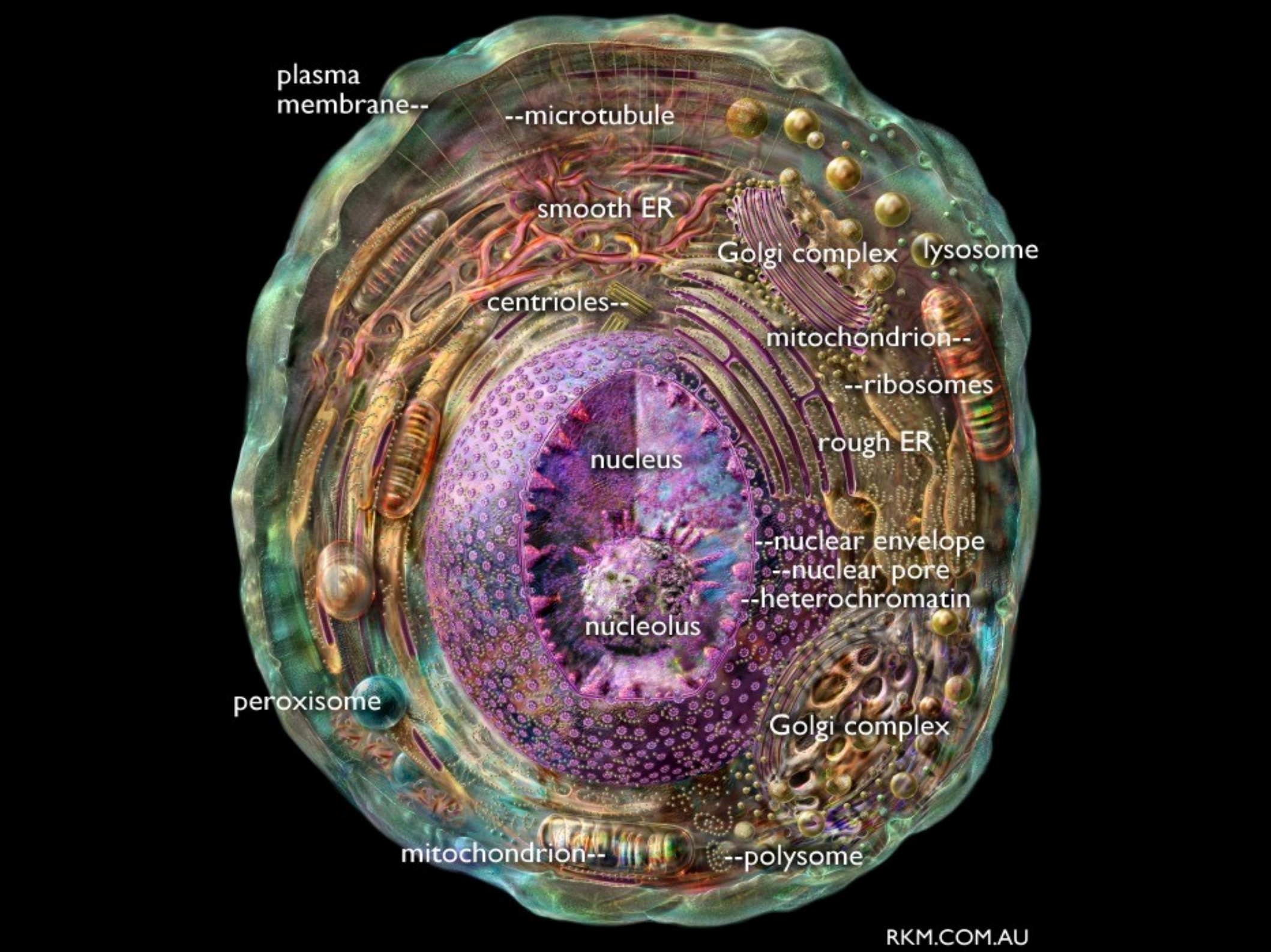
- Key structural component: **Membrane**
- Hydrophile/hydrophobic lipid chains
- Compartmentalization: Different chemical environment; proteins as molecular channels
- Membranes & ATP: chemical regulation



Mitochondria

- (...and **chloroplasts**)
- Semi-autonomous subsystem with dedicated ribosomes and internal firmware DNA, former symbiosis w/ absorbed protobacteria cells
- Bulk of ATP generation in eucaryotic cells
- Other cell maintenance functions (calcium ions management, hormone production, regulation)




plasma
membrane--
--microtubule
smooth ER
Golgi complex
lysosome
centrioles--
mitochondrion--
--ribosomes
rough ER
nucleus
--nuclear envelope
--nuclear pore
--heterochromatin
nucleolus
peroxisome
Golgi complex
mitochondrion--
--polysome
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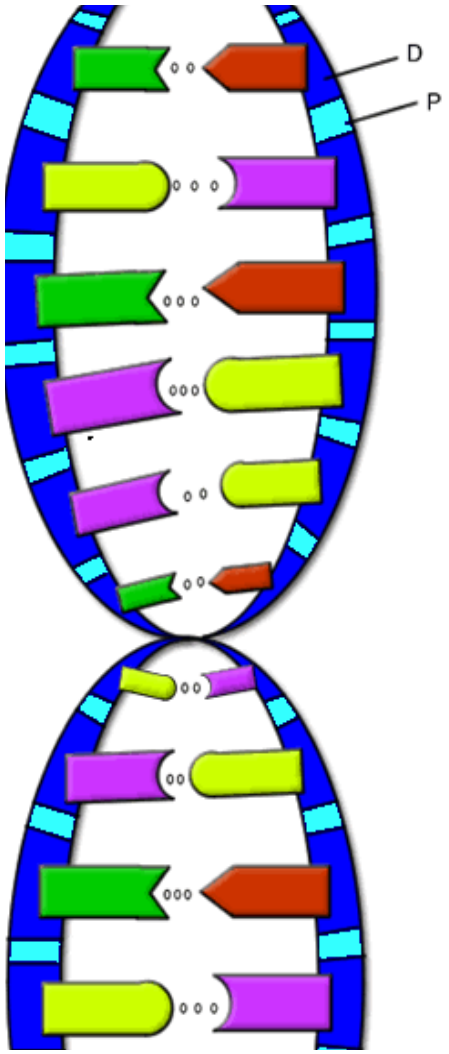
Execution Environment

Code Syntax



Thymine
Adenine
Guanine
Cytosine

D = Deoxyribose (sugar)

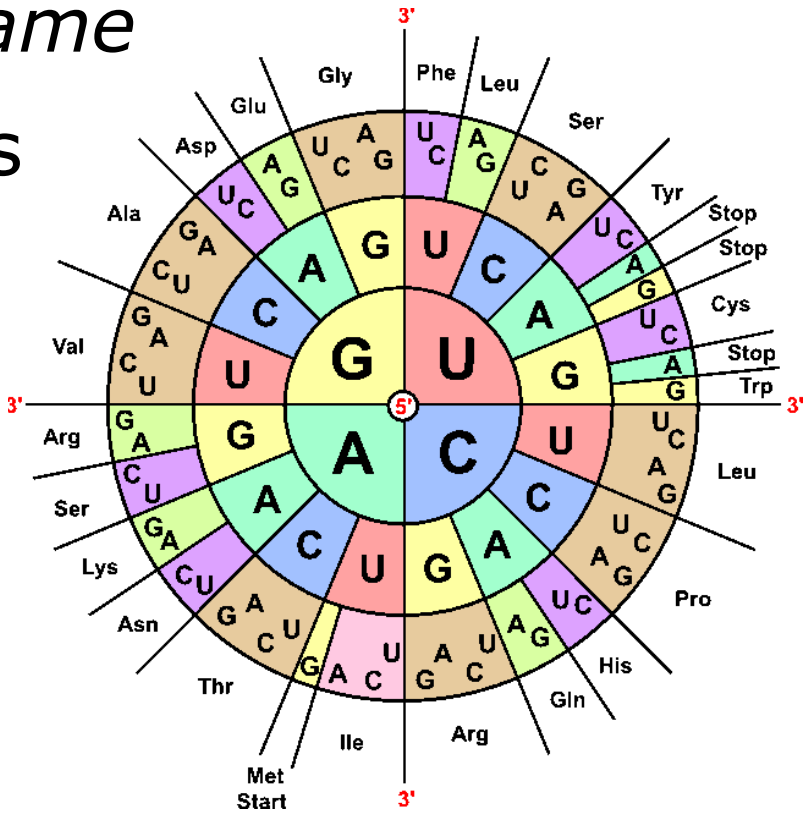
P = Phosphate

Hydrogen Bond

- Code bit: **Base** (A-T,C-G)
- Code word: **Base triplet** (**codon**: GGT)
- Code pairing – transcription, duplication
- Code linkage: **DesoxyriboNucleic Acid**; double-twisted sequence of base pairs
- Code units:
  - Procaryotic: DNA cycle
  - Eucaryotic: Chromosomes, nucleus

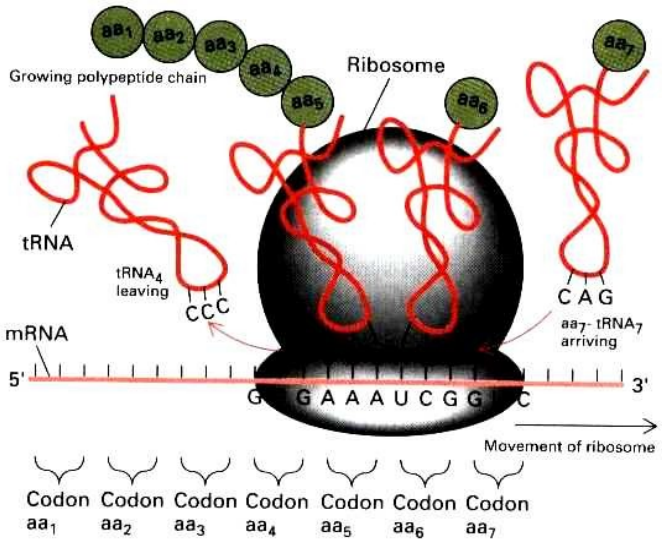
Code Semantics

- Codon matching: *Reading frame*
- Codon meaning: Amino-acids
- Each triplet matches certain amino-acid
- Amino-acids are chained up and *fold* to build proteins
- Special codons: Start/stop



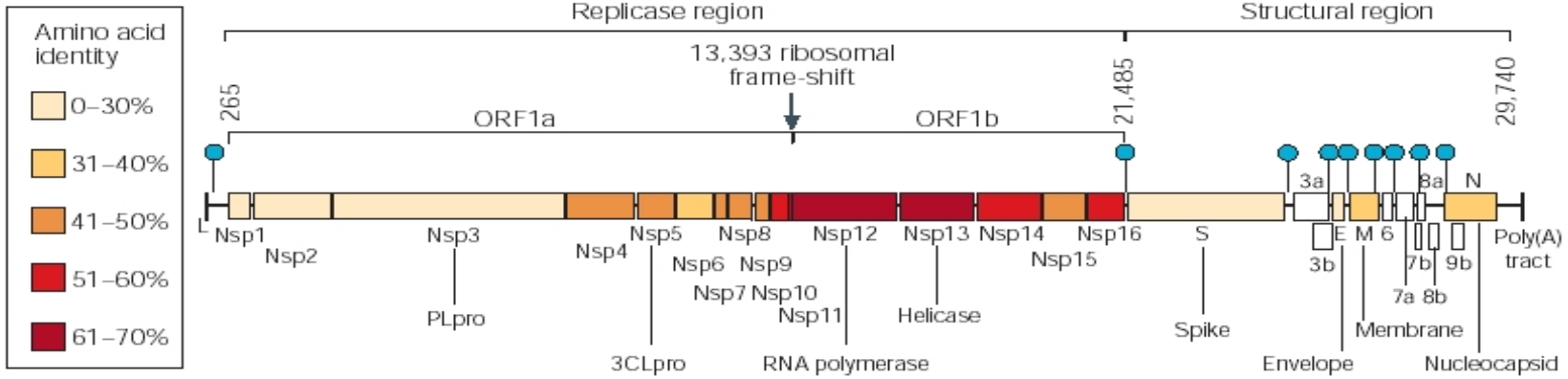
Code Execution

- **Transcription**: Matching up and sequencing complementary bases (T->A,A->U,C->G,G->C)
  - Mutations: *Imperfect* transcription
- Within the nucleus: Chromosome unwound to DNA, one strand transcribed to RNA



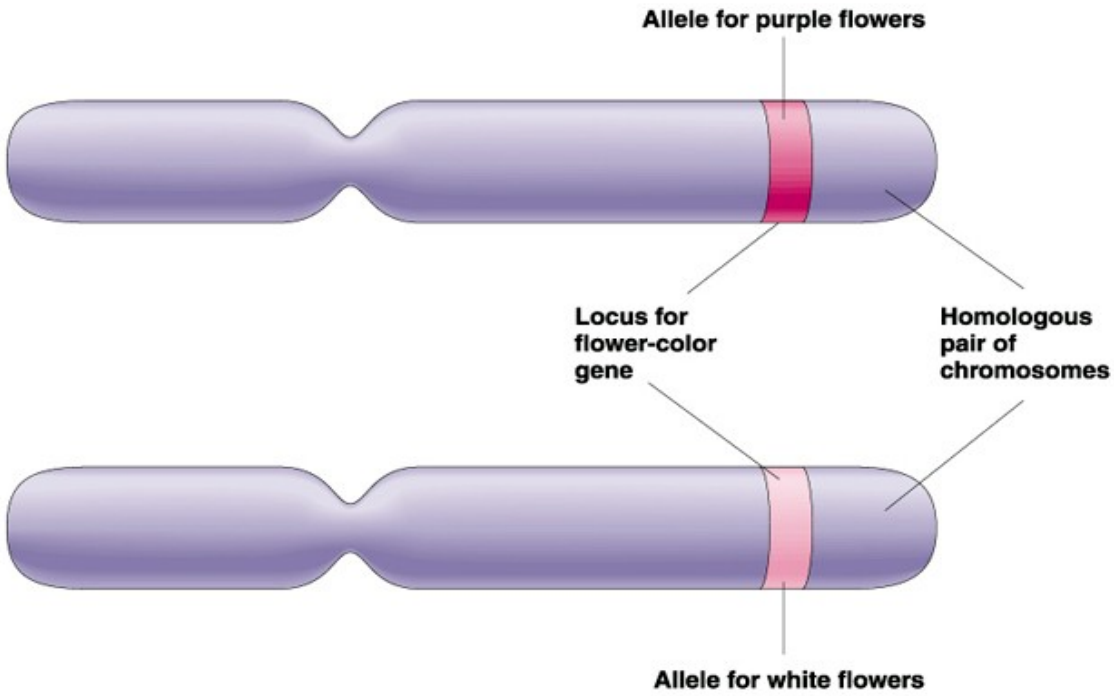
  - RNA released from nucleus to ribosomes
  - **Translation**: Match up and chain up amino-acids based on triplets (t-RNA)

Genome Structure



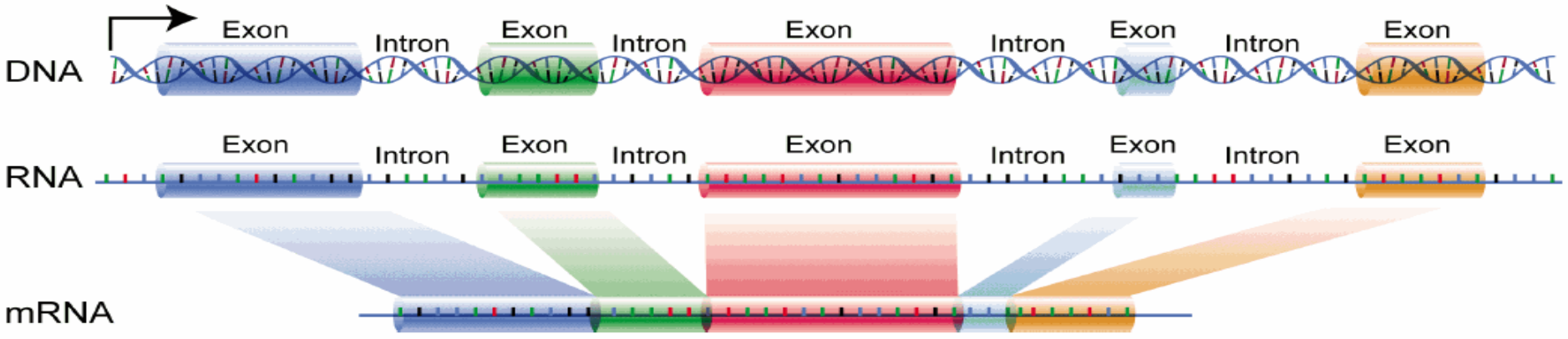
Terminology

- Feature manifestation in individual: **phenotype**
- Feature specification of individual: **genotype**
- Genetic code of individual: **genome**
- Particular feature subroutine: **gene** at **locus**
- Gene instance (implementation): **allele**



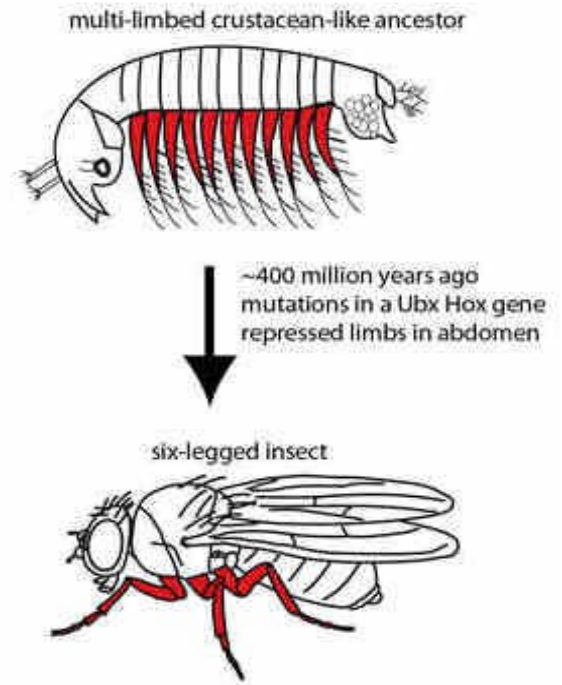
Genome Structure

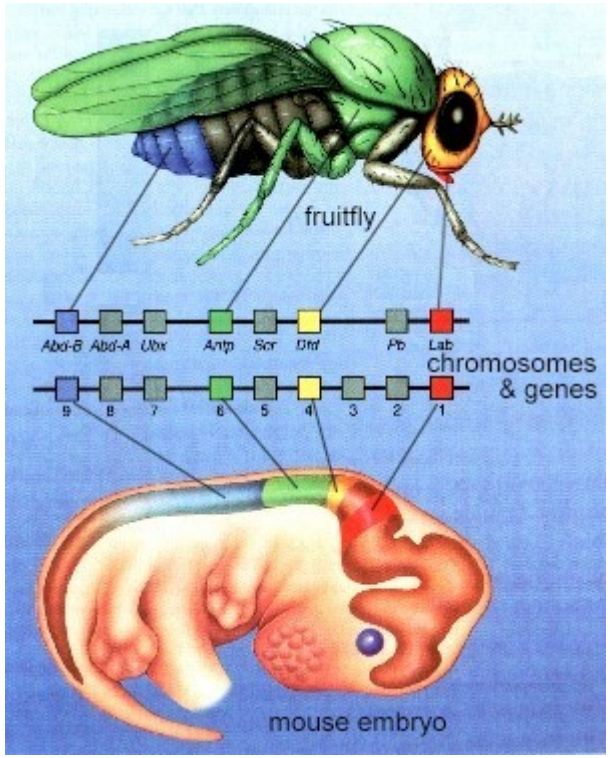
- Set of chromosomes encoding genes at arbitrary locuses; genes encode proteins
- Execution – **transcription factors**
  - Proteins from other genes or external
  - Chemical cell balance, mechanics
- **Introns** – no proteins X special functions (70%)



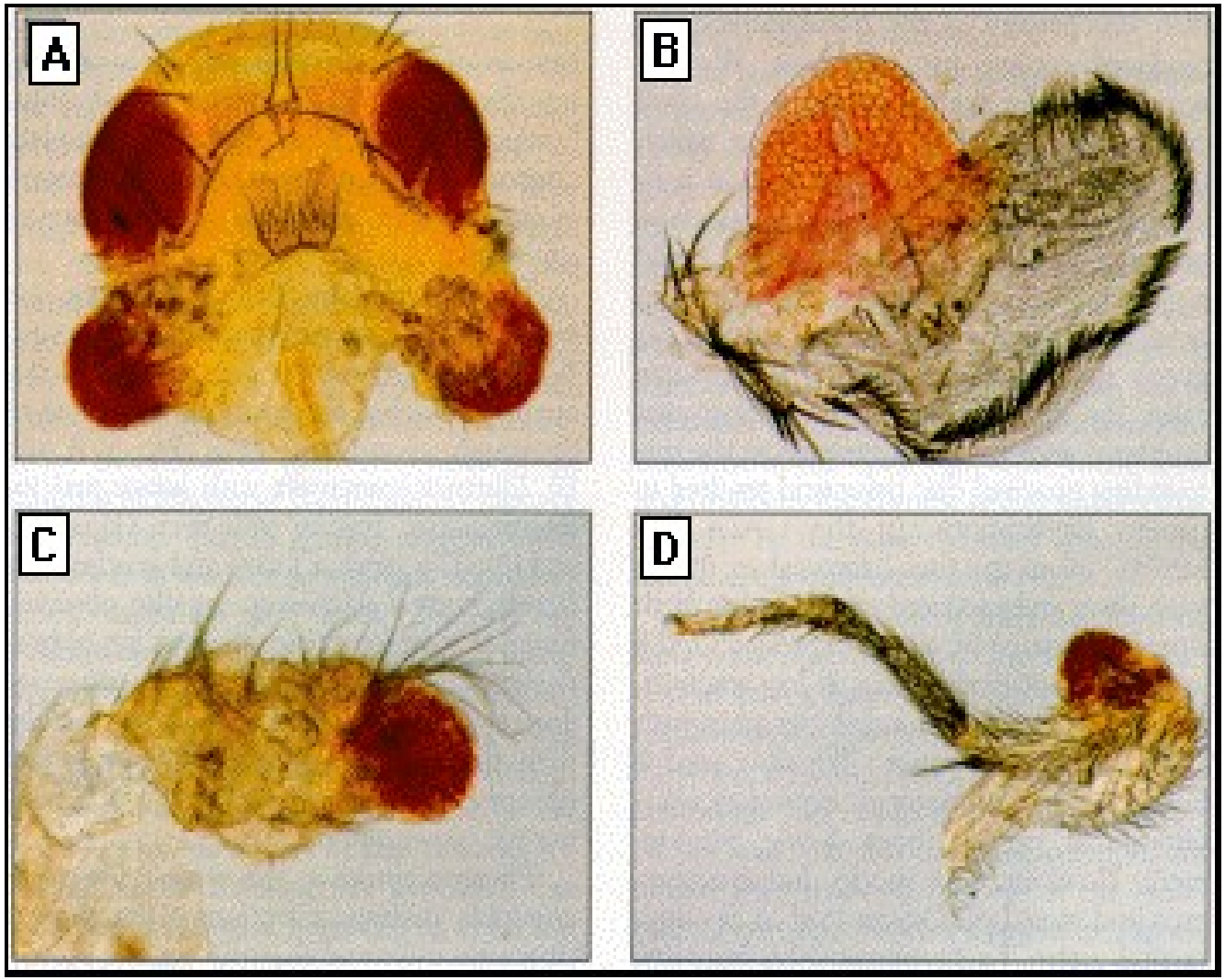
Structured Genome Programming

- **Homeobox** genes – high-level organism structure
- *Segments* (homeodomains) => *hox genes* (eyes, antennae, wings) – protein exprimation
- **Evo-devo** approach to evolutionary biology



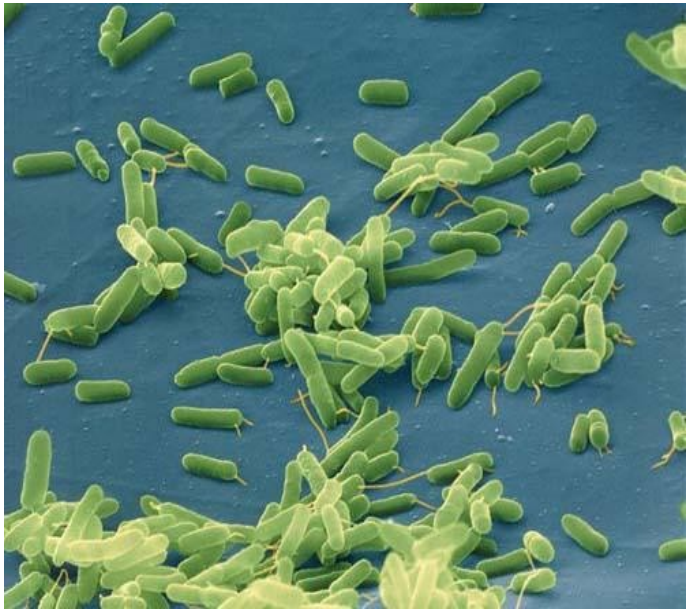


Eyeless Hox Gene in Drosophilia

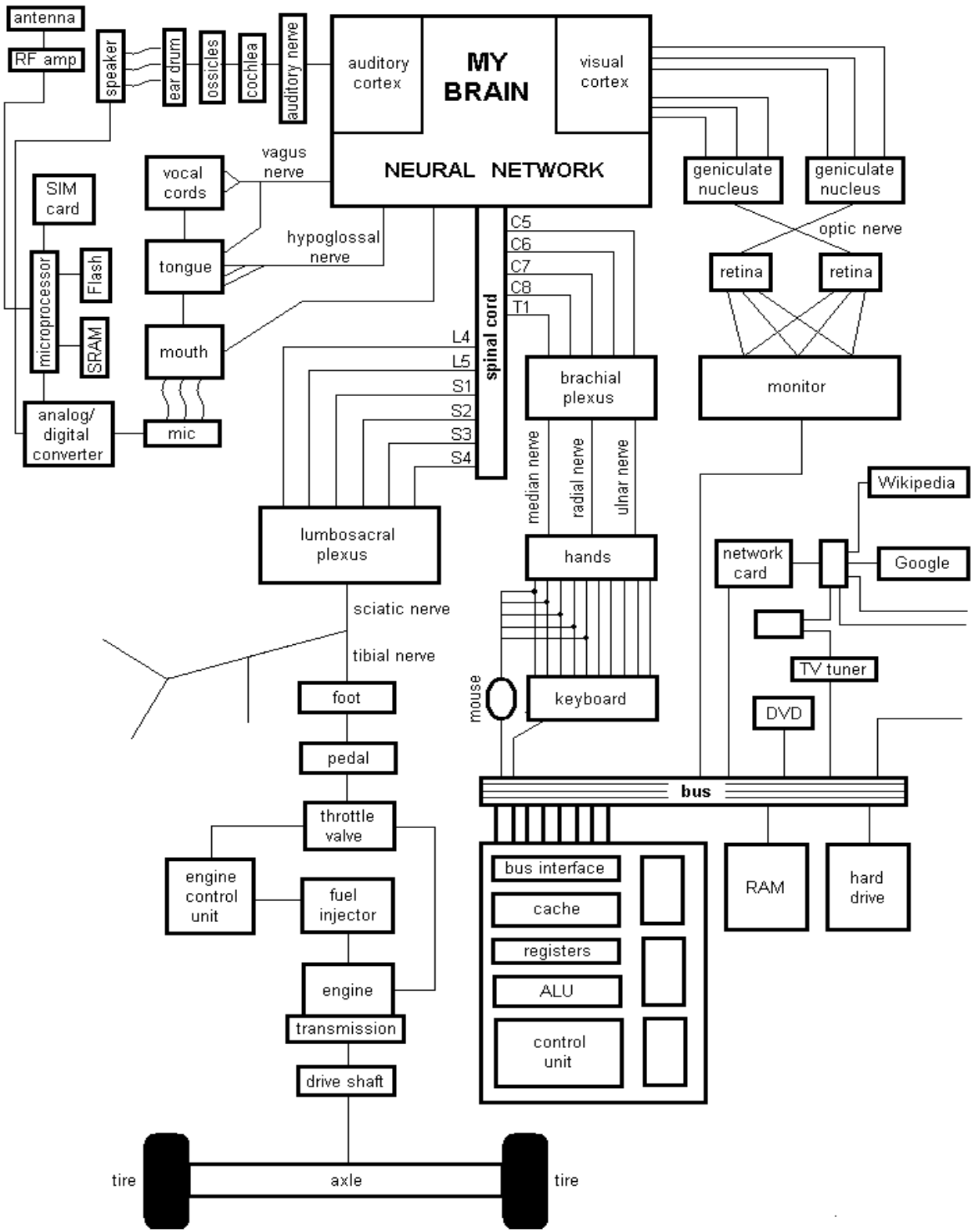


Complexity of Nature

- Organism boundaries
- Protists "inheritance"



- Epigenetics
- Re-invention of wheel
- Junk DNA, allele comb.
- Experiment designs
- Genesis theories


antenna
RF amp
speaker
ear drum
ossicles
cochlea
auditory nerve
auditory cortex
MY BRAIN
visual cortex
NEURAL NETWORK
vagus nerve
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tongue
hypoglossal nerve
microprocessor
Flash
SRAM
mouth
analog/ digital converter
mic
C5
C6
C7
C8
T1
spinal cord
L4
L5
S1
S2
S3
S4
brachial plexus
lumbosacral plexus
median nerve
radial nerve
ulnar nerve
hands
sciatic nerve
tibial nerve
foot
pedal
throttle valve
engine control unit
fuel injector
engine
transmission
drive shaft
tire
axle
tire
mouse
keyboard
geniculate nucleus
geniculate nucleus
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retina
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Thank you!

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