Study of life

Premedical course I

Biology

Evolution: **biologic and genetic changes**

in time

evolutionary mechanisms, processes (duplication of genes, mutations, genetic drift, adaptation)

Biology includes among other two different approaches

- **understanding life via study at the lowest level**

Continuity of life is based on the genetic information. Orderliness, structure and functional coupling is encoded in the DNA

- **understanding diversity and unity via study of evolutionary processes**

If we study life at the lowest level, we find out that everything fundamental is common for all types of living organisms and that all is functionally and structurally related.

The most common experimental organisms

Models *in vivo*:

- Drosophila *(Drosophila melanogaster)*
- Mouse *(Mus musculus)*
- Rat *(Rattus norvegicus)*
- African clawed frog *(Xenopus laevis)*
- *Caenorhabditis elegans*

Models *in vitro:*

- Cell/Tissue cultures
  - a) permanent cell lines (He-La cells)
  - b) primary cultures

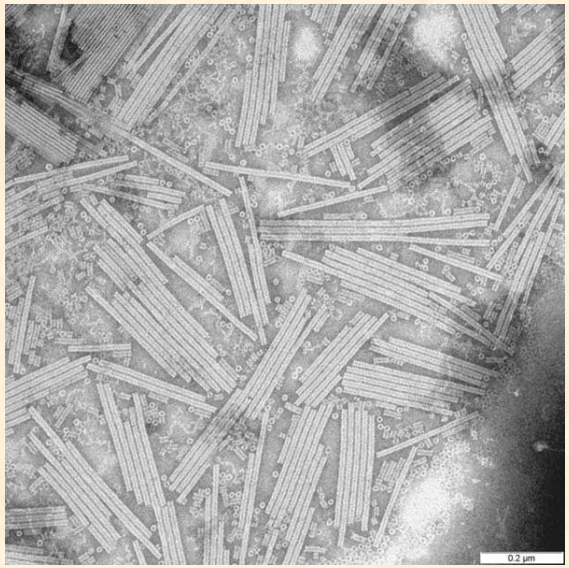
viruses – lambda phage, tobacco mosaic virus;

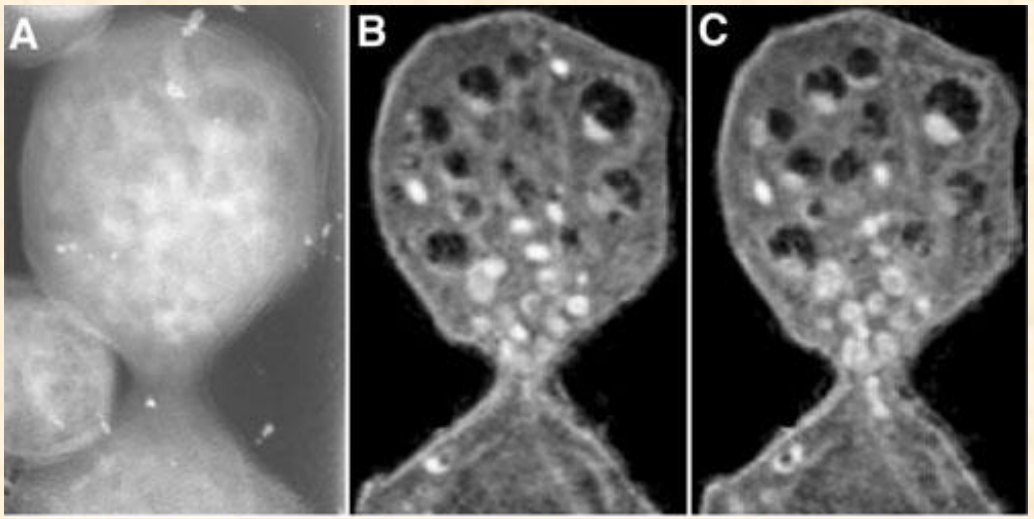
bacteria – *Escherichia coli, Bacillus subtilis*

yeasts - *Saccharomyces cerevisiae, Schizosaccharomyces pombe*

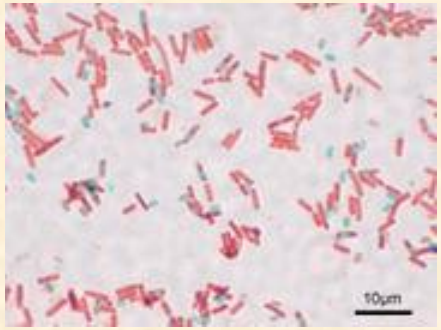
Model organisms

Tobacco mosaic virus



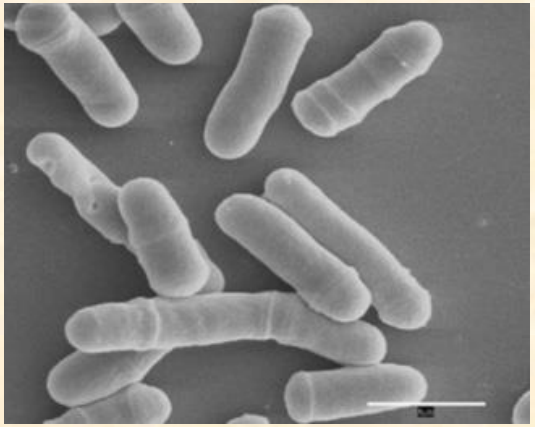


Saccharomyces cerevisiae



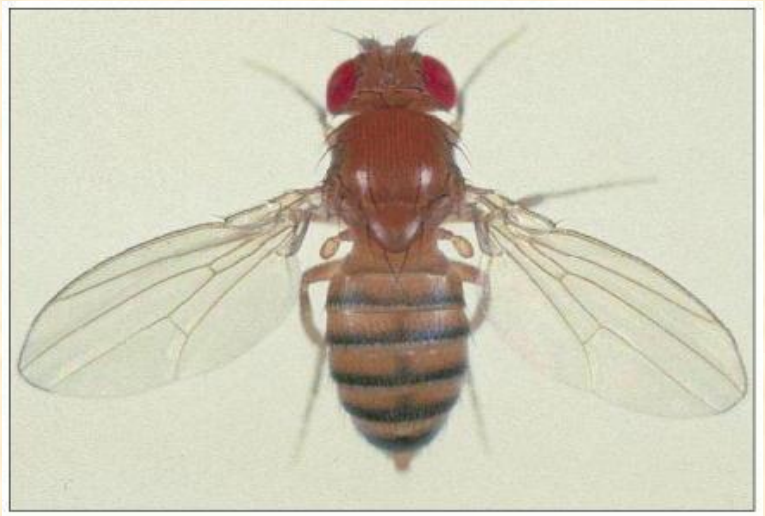
Bacillus subtilis

Schizosaccharomyces pombe



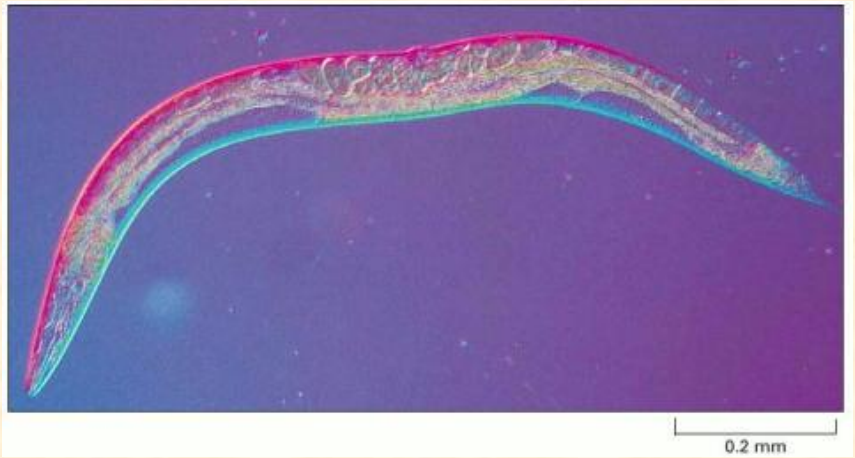
Model organisms

Drosophila melanogaster



Xenopus laevis

Caenorhabditis elegans



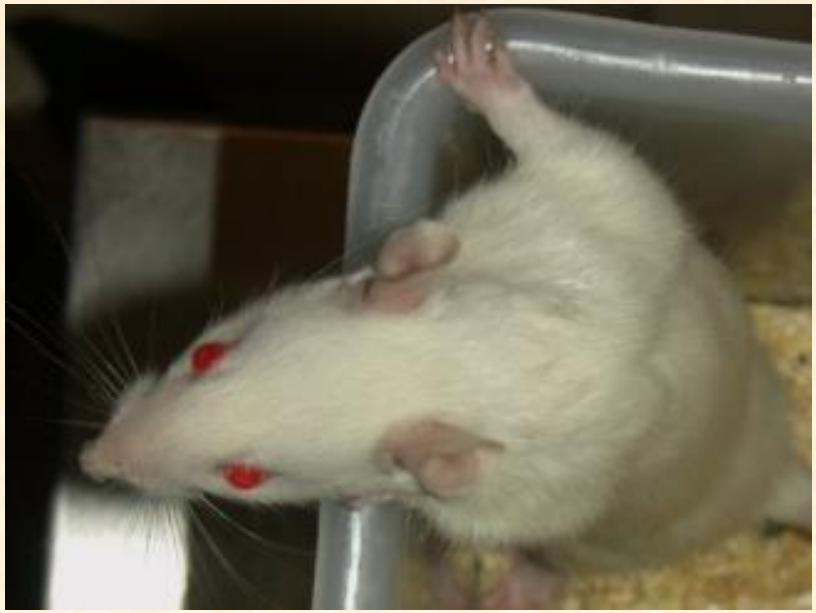
Arabidopsis thaliana

Zea mays

Model organisms

Mus musculus, Rattus norvegicus

70% homology of human and mice genome



Mutation of same gene

Levels of Biological Organization

- Molecules
- Organelles
- Cells
- Tissues
- Organs
- Organ Systems
- Organisms
- Populations
- Communities
- Ecosystems
- Biosphere

1. Organization

Cell is the basic structural and functional unit of the organism.

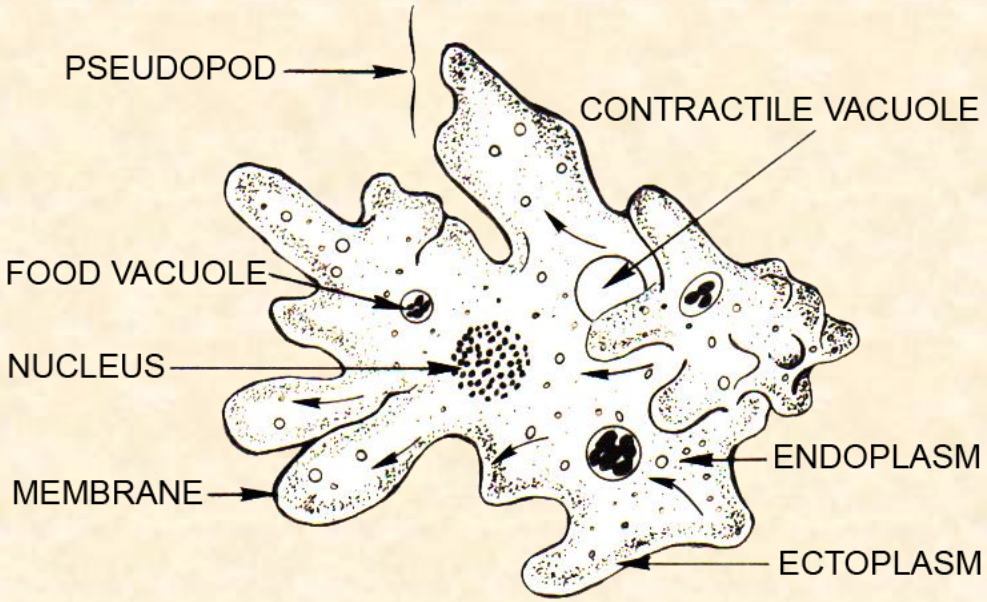
Cell is the lowest level of structure, which is able to carry out all processes of life.

Unicellular organism

Single cell –

Bacteria and Protista

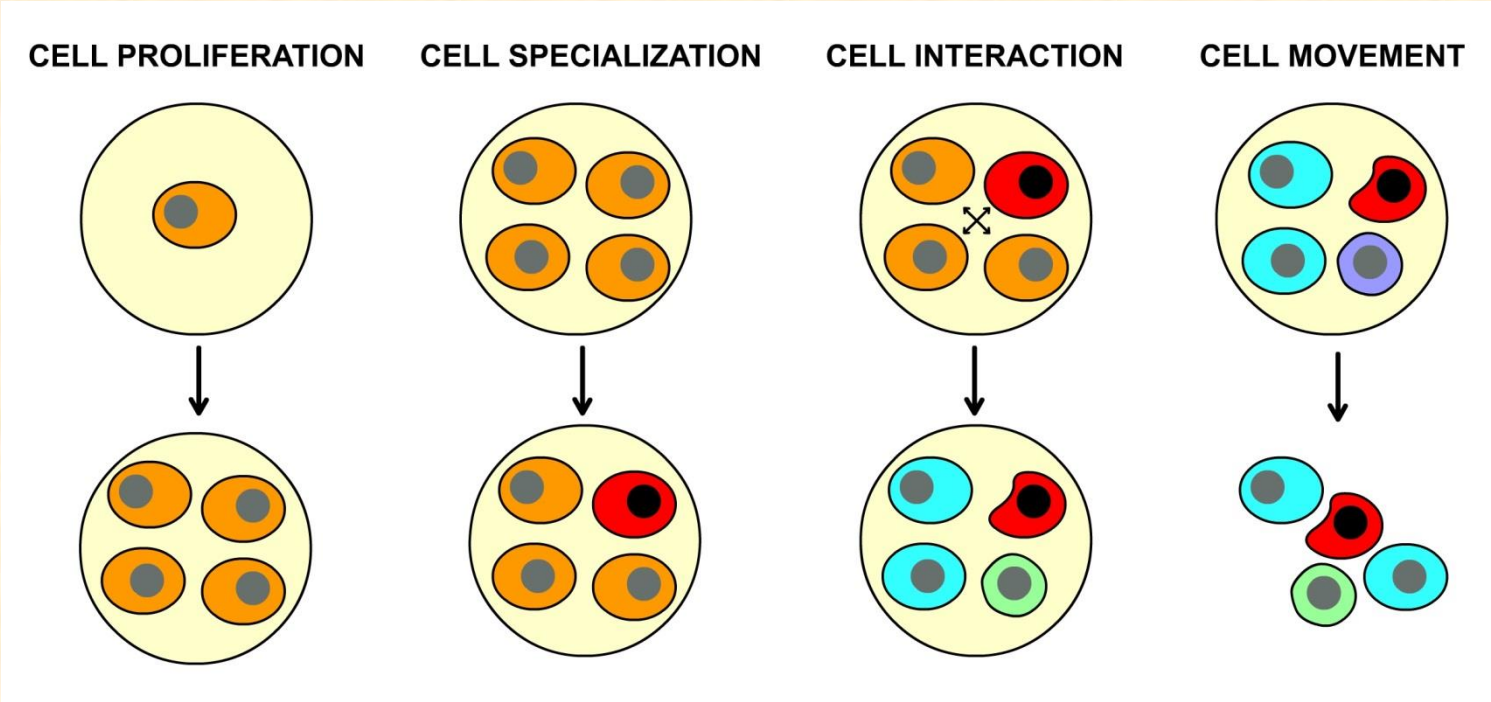
- Amoebas



Multicellular organisms

Each multicellular organism is a clone of one cell.

Four essential processes of the multicellular organism:



Structure and function are interrelated at all levels of organization. ***„Form fits function.“***

2. Metabolism

Organisms are **open systems - energy flows and converts.** Energy of chemicals (thermal) energy is converted into cellular components, reproduction and movements.

- **Catabolic reactions – degradation** of nutrients to small molecules; the cell use some of them as **building stones,**

useful form **of energy is released**

- **Anabolic reactions -** use energy **for biosynthesis**

• **Enzymes are** special proteins, which catalyze the reaction from substrate to product.

= any protein that acts as a catalyst, increasing the rate at which a chemical reaction occurs. **The human body probably contains about 10,000 different enzymes**. Each enzyme catalyzes a specific type of chemical reaction between a few closely related compounds, which are called substrates of the enzyme.

The cell composes**,** decomposes and alters **nutritive substances as aminoacids, lipids, sugars, nucleotides, proteins** and other.

Figure 25.7 A Summary of the Energy Yield of Aerobic Metabolism

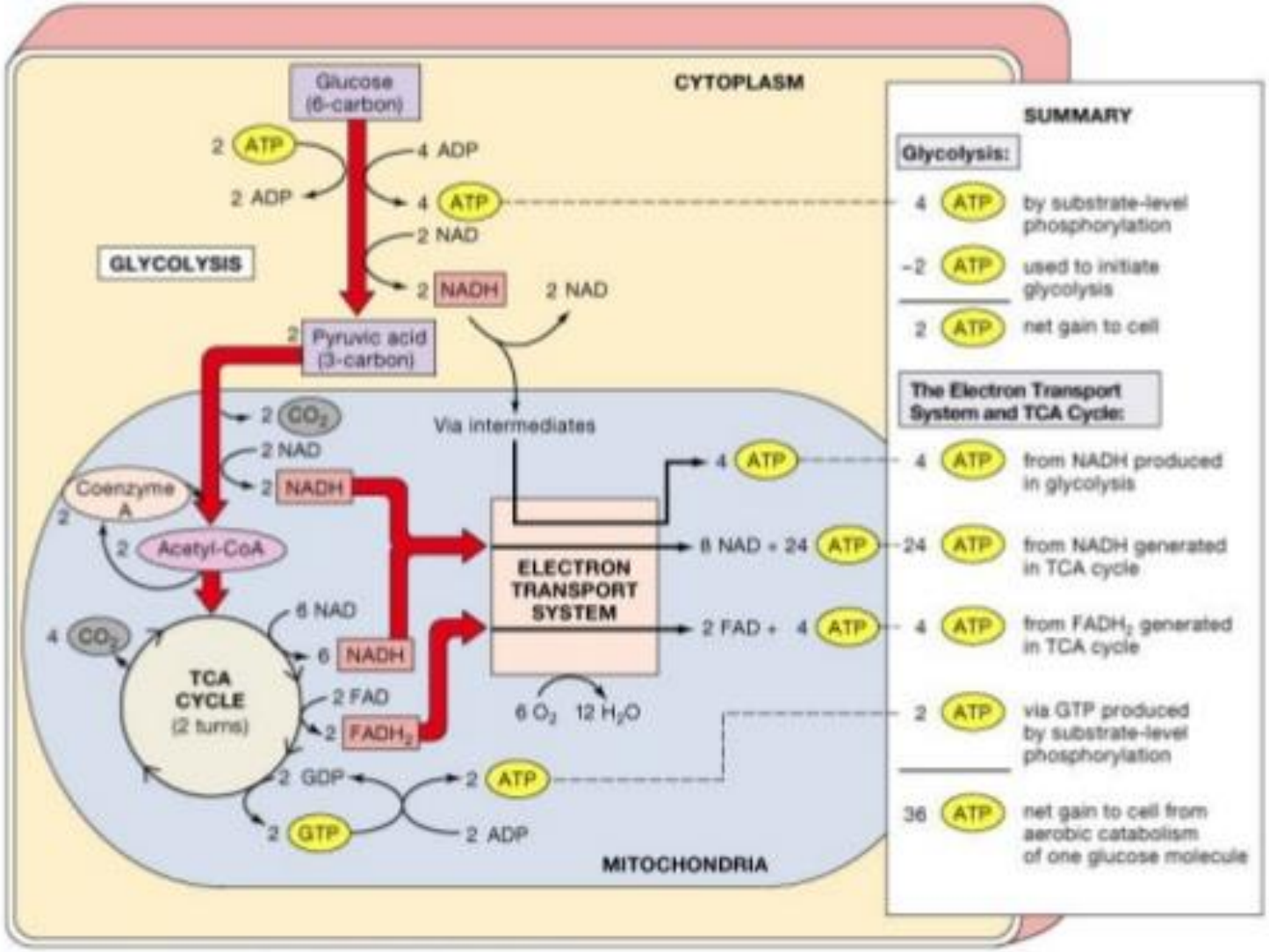


Figure 25.7

3. Homeostasis:

= the maintenance of metabolic equilibrium within an organism by a tendency to compensate for disrupting changes of temperature, liquids, pH, electrolytes ...

Regulators try to maintain the parameter at a constant level in the large-scale environmental variations.

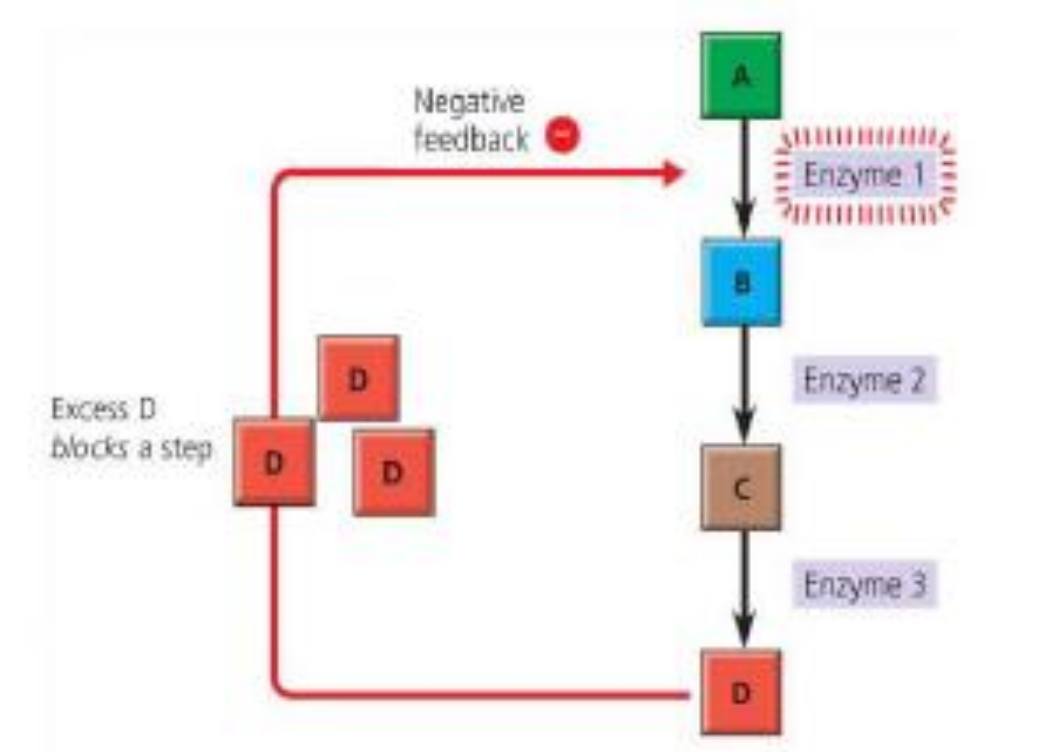
endothermic animals - mammals and birds

Conformers allow the environment to determine the parameter.

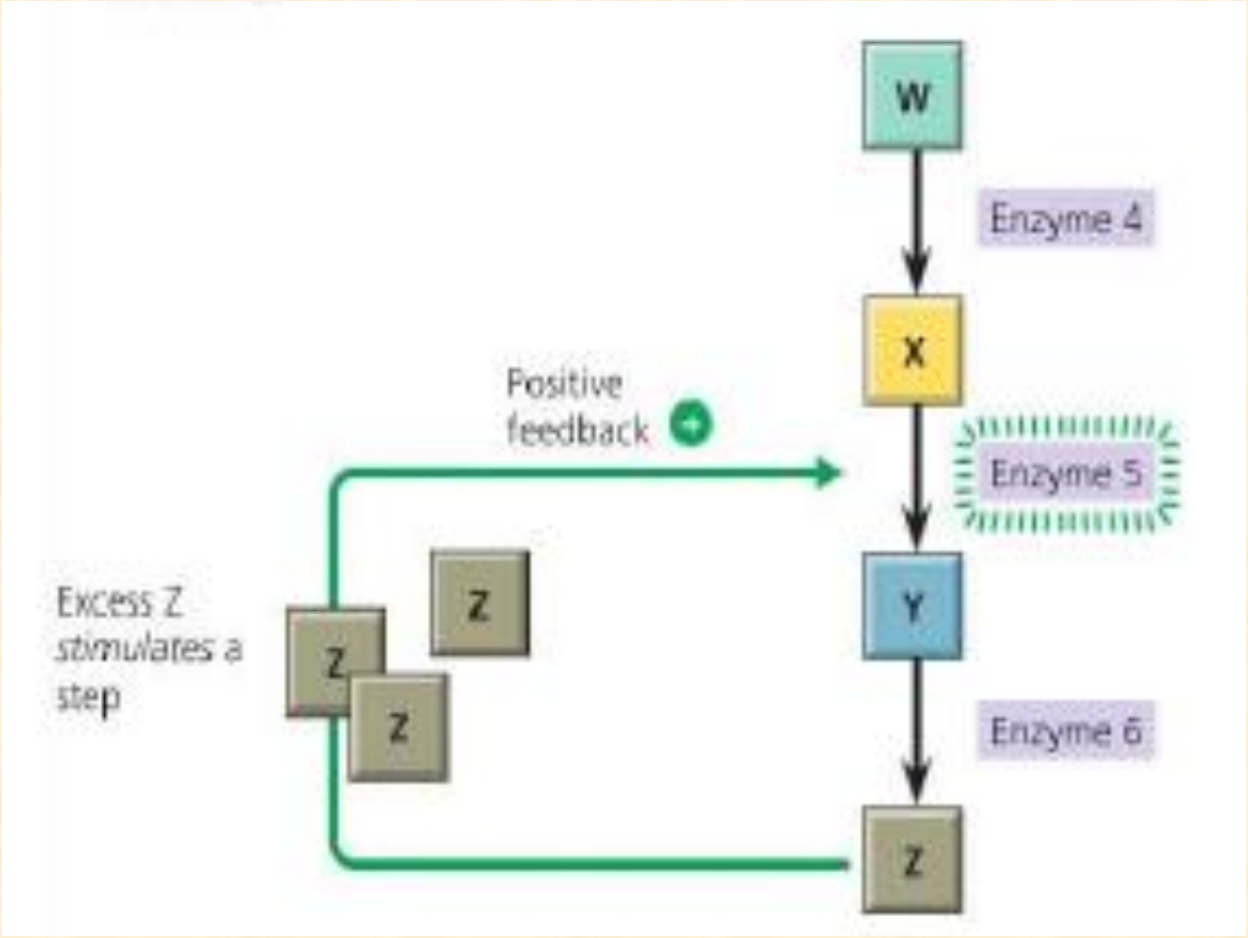
exothermic (both ectotherm and poikilotherm) – reptiles and some sea animals

Many biological processes are **self-regulated**, they operate by a mechanism called **feedback -** an output or a product regulates that process.

Negative feedback – inhibition by the product or the output: level of glucose and insulin, temperature in birds and mammals



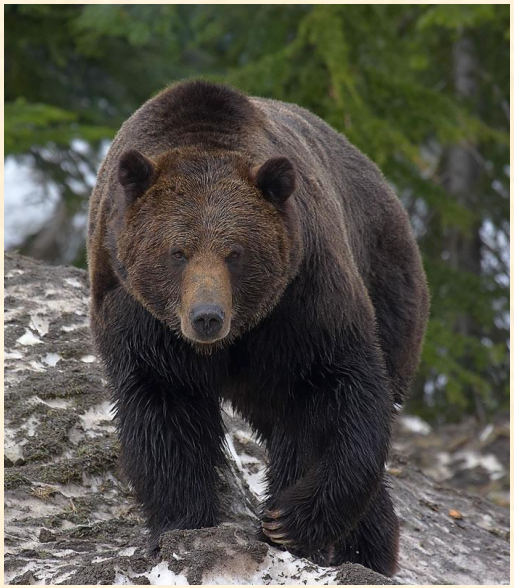
Positive feedback – activation by products or outputs: blood precipitation and function of blood platelets



5. Evolutionary adaptation

Only organisms, which are able to adapt, will survive in changing conditions on Earth.

The ability to change over a period of time in response to changes of the environment.



Ursus arctos horribilis

Ursus maritimus

Grolar bear, Nanulak

Crossbreeding between species

A **mule** is the offspring of a male donkey (jack) and a female horse.

Hinny, which is the offspring of a female donkey (jenny) and a male horse (stallion).

Zebroids: Zonkey – donkey + zebra, Zorse – zebra + horse

Crossbreeding between species

Liger Hercules

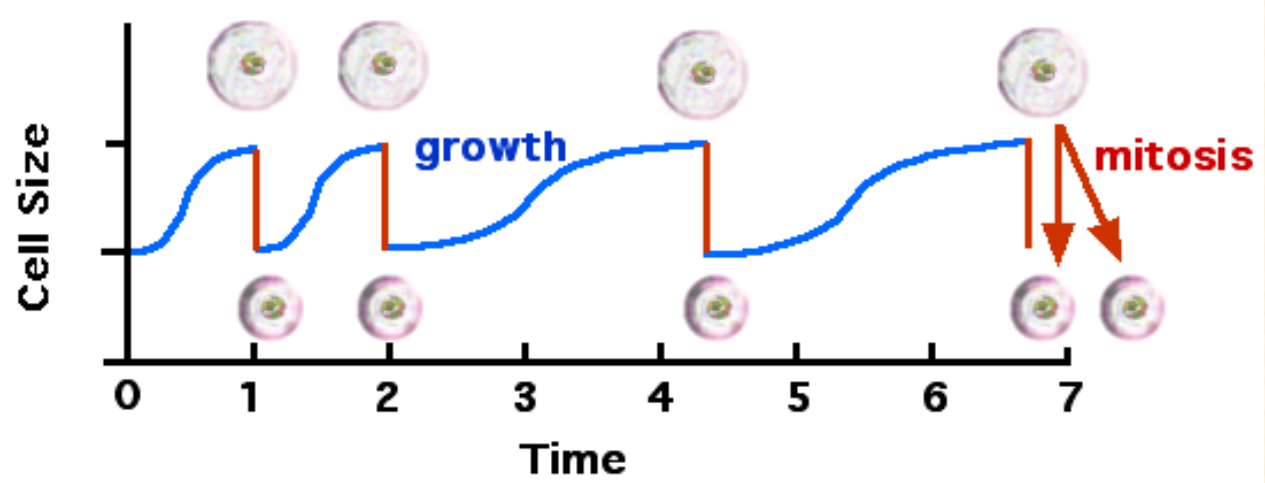
The **liger** is a hybrid cross between a male lion (*Panthera leo*) and a tigress (*Panthera tigris*). It is distinct from the similar hybrid **tigon**.

4. Growth and development

Maintenance of a higher rate of anabolism than catabolism.

A growing organism increases in size in all of its parts, rather than simply accumulating matter.

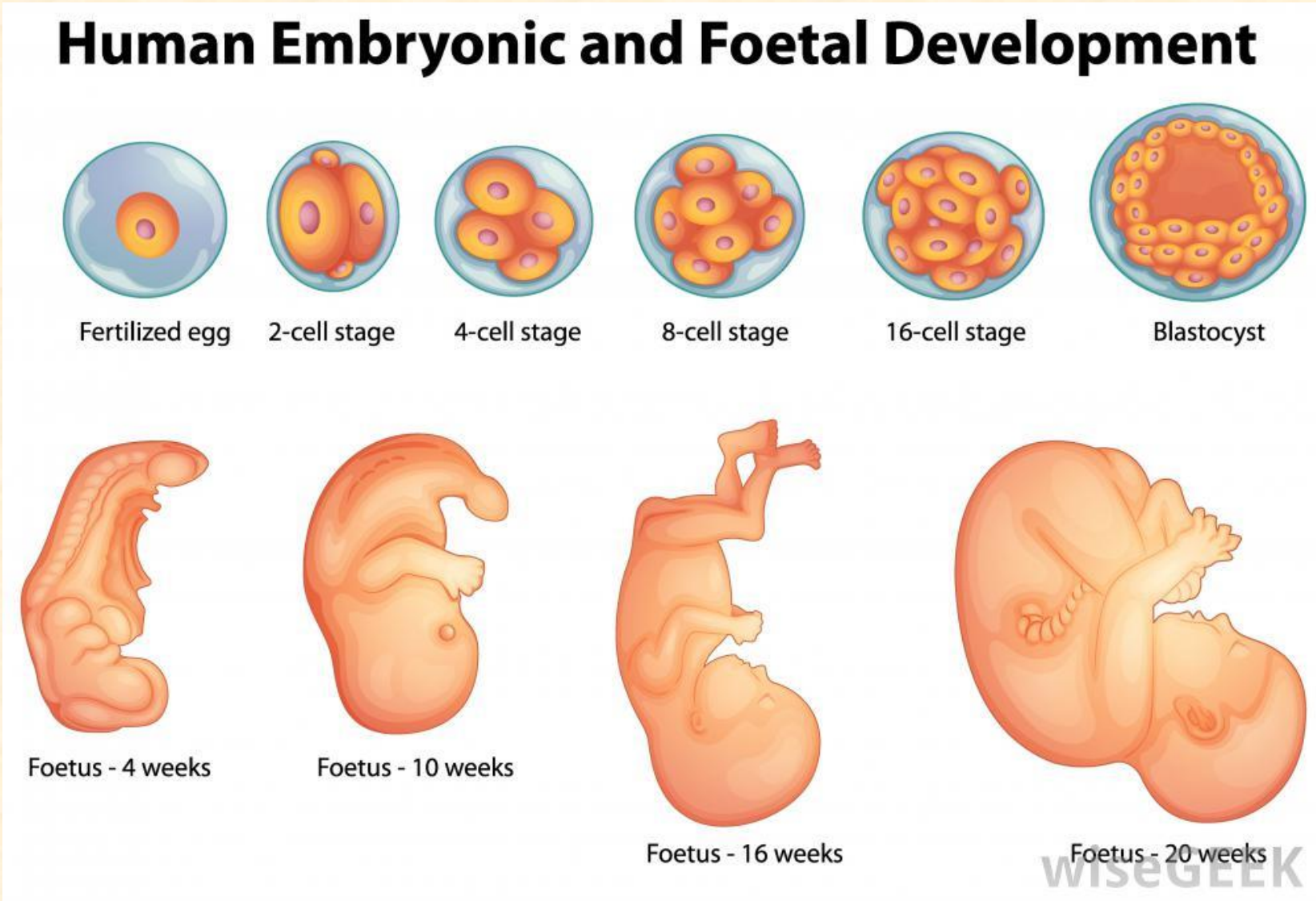
• Cell growth – proliferation: cell development and division



- Fungal growth as hyphae on or in solid substrates

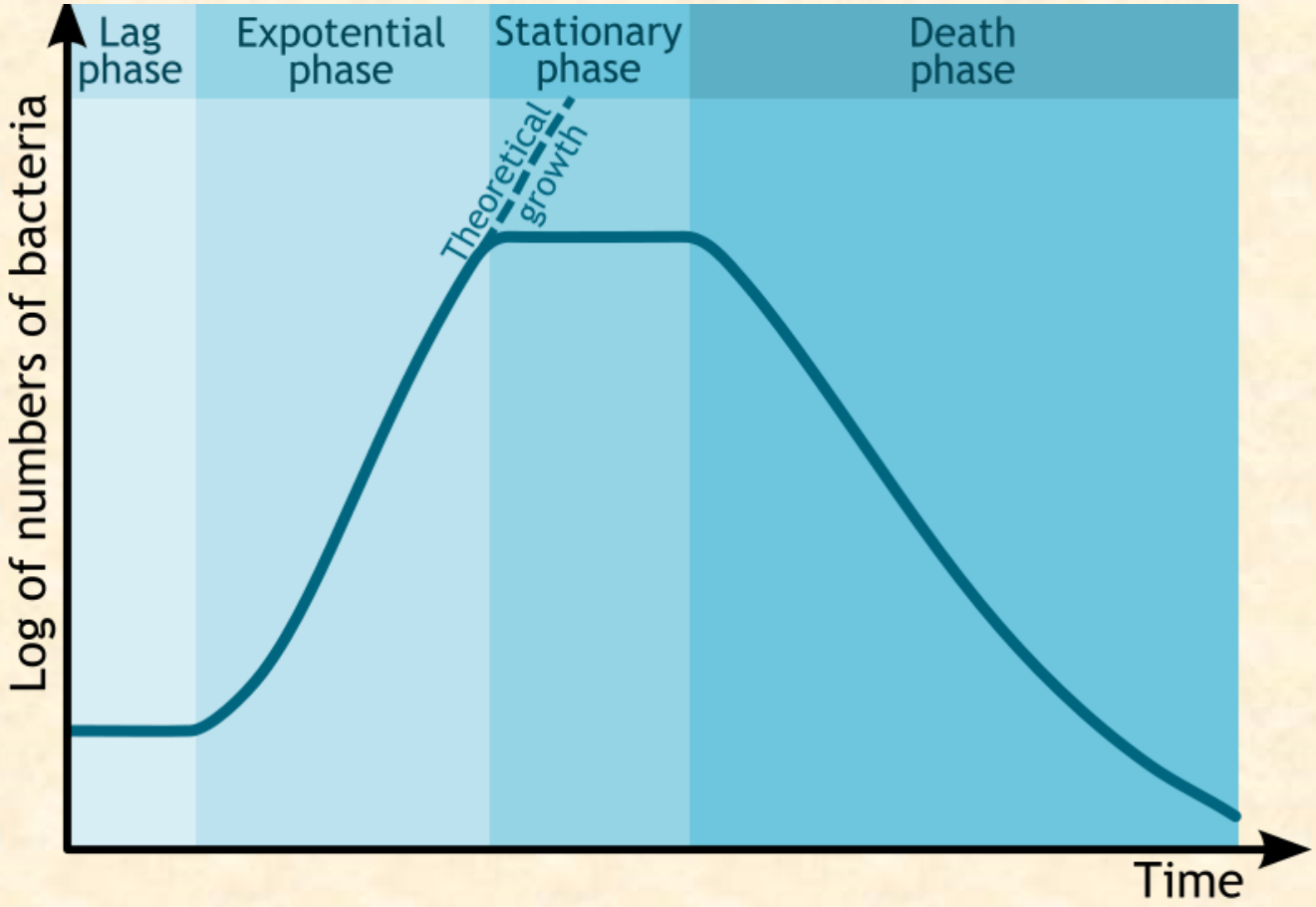
- **Human, Animal development**

The zygote undergoes series of rapid cell division with no significant growth (the cleavage) and cellular differentiation, leading to development of an embryo.



From 1 one cell to 10^{13} cells

• Bacterial growth in batch culture managed by **binary fission**, bacterial growth can be modeled with four different phases



6. Response to stimuli

can take many forms:

• the contraction of a unicellular organism to external chemicals

• complex reactions involving all the senses of multicellular organisms

e.g.:

phototropism - the leaves of a plant turning toward the sun

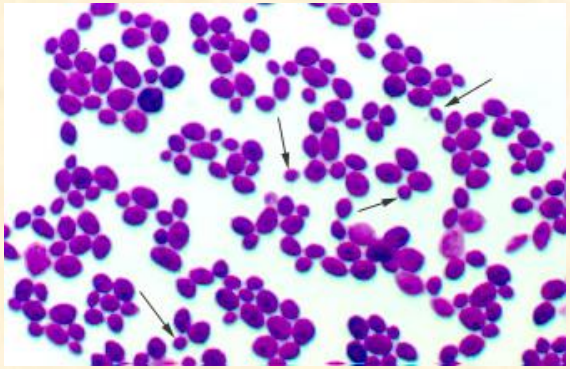
chemotaxis: a movement toward or away from a stimulus, a change o movement pattern in response to chemicals

7. Reproduction

The ability to produce new individual organisms,

either **asexually** from a single parent organism,

or sexually from two parent organisms.



budding yeast (arrows)

Asexual reproduction

is not limited to **unicellular organi**sms.

Most plants have the ability to reproduce asexually:

- **binary fission -** Bacteria
- **gemmation, budding** - yeasts and Hydras

  (invertebrates of the order *Hydroidea*)

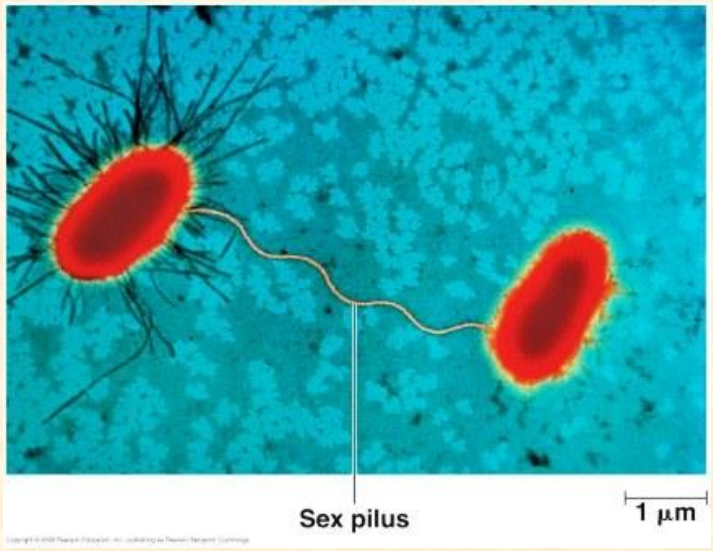
- **conjugation** - bacteria may exchange genetic information

Donor's plasmid (sexual plasmid) **F^+**

passes into acceptor's cell **F^-, <u>F-pili</u>**

on surface of one bacteria strain – **F^+,**

through conjugative bridge



- **parthenogenesis, fragmentation** and **spore formation** that involves only mitosis.

Parthenogenesis

occurs naturally in some species, including **lower plants** (where it is called **apomixis**), **invertebrates** (e.g. **water fleas, some bees and parasitic wasps**), and vertebrates (e.g. **some reptiles, fish, and very rarely, birds and sharks**).

Wingless female giving birth
Aphis
Aphid
Green-fly)

baby hammerhead

Sexual reproduction

by **combination of genetic material**
contributed from two different members
of the species

Each contributes **half of the offspring's genetic material**

In *anisogamous* species, the two sexes are referred to as **male (producing sperm or microspores)** and **female (producing ova or megaspores**).

Sexually reproducing organisms

have **two sets of genes for every trait (called alleles)**.

Offspring inherit one allele for each trait from each parent, thereby ensuring that offspring have a combination of the parents' genes.

Autogamy
= self-fertilization, occurs in hermaphroditic organisms

Allogamy
= fertilization of an ovum from one individual with the sperm of another.

Characteristics of alive systems:

- high organization, **orderliness**
- **dynamic system, maintains homeostasis**
- **metabolism -** ability of **energy consumption and transformation**
- **grow** in terms of a kind
- ability of **development and adaptation**

  in time – evolutional adaptation
- **answer to outer stimules -** open system

  exchange of molecules and energy
- ability of **reproduction**, life comes from life

Thank you for your attention

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**, Biology**, Benjamin-Cummings Publishing Company, 1996 –2010.