Cellular Organization

part of “Räumliche Organisation molekularbiologischer Prozesse”

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Leipzig, SS 2012

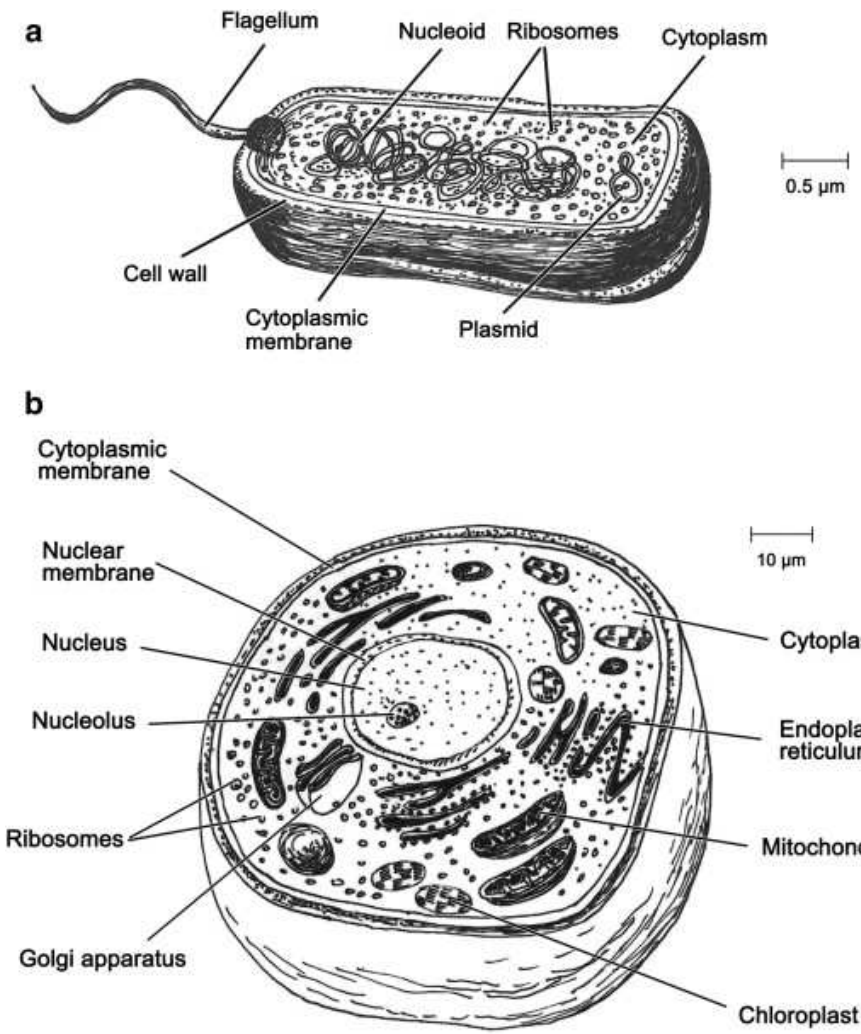
Class Schedule

10×60 minutes

- Cellular Organization and Cell Differentiation
- Sporulation of *Bacillus subtilis*
- Nuclear Organization of Eukaryotes
- Chromatin Capture Conformation
- Systems Biology
- Anterior-Posterior Patterning in *Drosophila* Embryos
- Cellular Automata - Conway's Game of Life
- Self-organization Giving Rise to Pattern Formation
- Gierer-Meinhardt Model
- Turing Pattern
- Gray-Scotts Model
- Cat Coat Pattern

Prokaryotes versus Eukaryotes

a . . . prokaryotic cell
b . . . eukaryotic cell



Prokaryotes versus Eukaryotes

prokaryotes	**eukaryotes**
"pro" . . . "before"	"eu" . . . "good"/"real"
"before" there was a "karyon"	with a "real" "karyon"
small cells $< 5\mu m$	large cells $> 10\mu m$
always unicellular	often multicellular
formation of a nucleoid	formation of a nucleus
i.e. DNA-dense region	i.e. DNA is separated from the cytoplasm by the nuclear membrane
circular chromosome(s)	linear chromosomes
no wrapping of DNA	DNA wrapped onto histone octamers, exception: Dinoflagellates
phases, binary fission or budding	cell cycle, mitosis and miosis
DNA replication and cell fission can be nested	DNA replication finishes before cell division
transcription in cytoplasm	transcription in the nucleus
70S ribosomes	80S ribosomes
conjugation possible	true sexual reproduction possible
no membrane-bounded organelles	mitochondria, chloropasts, vacuoles, endoplasmatic reticulum
immortality?	mortality?

Symmetric Cell Division

Symmetric cell division yields morphologically and functionally identical cells.

non-genetic inheritance

- cell grows to double its normal volume
- than devides in the middle into two equally sized cells
- concentration of protein products is equivalent in both cells
- if the process of protein distribution is stochastic
  - large number of identical gene products: both cells obtain about the same amount
  - small number of identical gene products: problematic (cannot be distributed equally)

genetic inheritance

- both daugthers get an old DNA strand of comparable quality
- semi-conservative replication of the DNA introduces independent errors with the same frequency

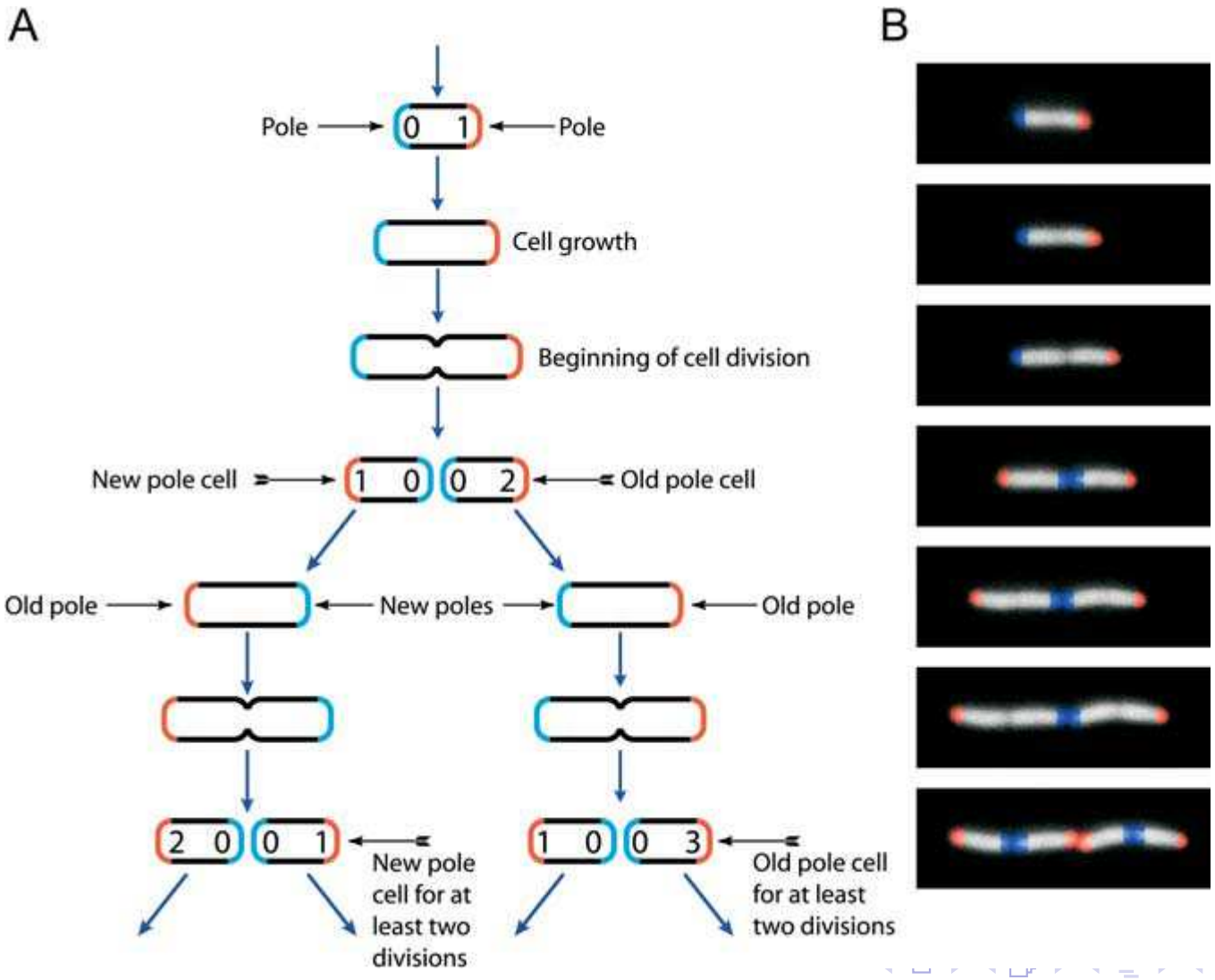
Bacterial Aging – Asymmetric Cell Division

A cell ages when it accumulates damaged/non-functional gene products.

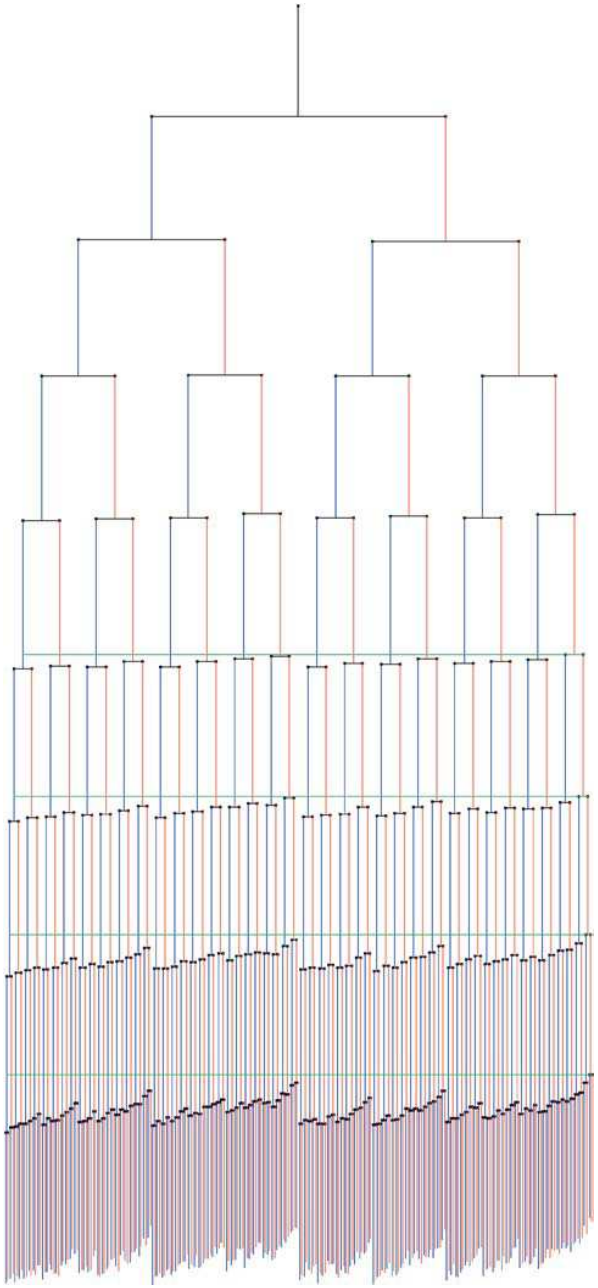
- genotypic damage
- phenotypic damage
  - membrane- or cell wall-bound damage
  - cytoplasmatic damage
  - (epigentic damage)

The Role of the Pole in (*E. coli*)

The pole structures inhibit non-conservative dispersion of damaged gene product.



Bacterial Aging – Experimental Measurement



The lengths of the lines connecting cells to their progeny are proportional to the average growth rate of that cell. Cells inheriting the old pole (red) show a decrease in growth rate.

Interpretations

- **Symmetric Division does not exist.**
  - Asymmetric division and aging is a consequence of physical or metabolic constraints, a side effect of living, a problem evolution did not yet overcome. A mandatory phenomenon.
- **Morphological Symmetry and Functional Asymmetry.**
  - Asymmetric division and aging is advantageous, e.g. seggregating damage is more cost efficient than repairing damage, and has, therefore, been selected by evolution.
  - If asymmetric division is advantageous under only most but not all conditions, it would be further advantageous for the cell to regulate the degree of asymmetry for each cell division.

Importance of Asymmetric Cell Division

Symmetric Division

- generates identical cells
- is the cause of immortality

Asymmetric Division

- generates different cells
- gives rise to division of labor, cell differentiation and development, and lays the basis of multicellularity and germline-soma seperation

Literature

Nyström Thomas (2007). *A Bacterial Kind of Aging.* PLoS Genetics 3(12):e224.

Eric J. Stewart, Richard Madden, Gregory Paul and Francois Taddei (2005). *Aging and Death in an Organism That Reproduces by Morphologically Symmetric Division.* PLoS Biology 3(2):e45