THE CELL CYCLE

Cell cycle: cycle of duplication and division.

M PHASE IS TRADITIONALLY DIVIDED INTO 6 STAGES

MITOSIS
nuclear division

- Prophase: mitotic spindle assembly
- Methaphase: arranging sister chromatids into the methaphase / equatorial plane
- Anaphase: separation of sister chromatids pulling apart the chromosomes

CYTOKINESIS
cyttoplasmic division

- Cytokinesis: cutting the cell into two cells

WHERE FORCE IS NEEDED

SPINDLE APPARATUS
MITOTIC SPINDLE
microtubule-based
segregates chromosomes

CONTRACTILE RING
CLEAVAGE FURROW
actin-based
cuts the cell into two

CYTOSKELETAL MACHINES IN CELL DIVISION

Two distinct cytoskeletal machines are assembled to perform the mechanical processes of mitosis and cytokinesis.

THE CYTOSKELETAL SYSTEM – MECHANICS OF CELL DIVISION

Beáta Bugyi - University of Pécs Medical School Department of Biophysics
HOW TO GENERATE FORCE IN CELL DIVISION

MICROTUBULE DYNAMICS and ASSOCIATED MOTOR PROTEINS

ACTIN DYNAMICS and ASSOCIATED MOTOR PROTEINS

SPINDLE APPARATUS - MITOTIC SPINDLE

3 classes of spindle microtubules

HeLa cell
spindle MTs
kinetochores
chromosomes

Phase-contrast image of a mitotic spindle at metaphase.

PROPHASE: MITOTIC SPINDLE ASSEMBLY

INTERACTIONS BETWEEN OPPOSING MOTOR PROTEINS AND MTs OF OPPOSITE POLARITY DRIVE SPINDLE ASSEMBLY

POLARITY OF THE SPINDLE

GROWTH OF THE SPINDLE

minus end-directed motor proteins rearrange MTs to form a focus of minus ends

plus end-directed motor proteins slide antiparallel MTs

ANAPHASE: CHROMOSOME SEPARATION AND SPINDLE ELONGATION

MICROTUBULE SHORTENING DURING ANAPHASE A

ANAPHASE A
initial poleward movement of chromosomes
kinetochore MTs

Force:
- kinetochore MTs depolymerisation at the kinetochore (+ end)
- motor proteins at the kinetochore

ANAPHASE B
separation of the poles
overlap and astral MTs

Force:
- elongation of overlap MTs
  - motor proteins at the 1. poles: plus-end-directed motor proteins
  - spindle: minus-end-directed motor proteins

ANAPHESE, CHROMOSOME SEPARATION AND SPINDLE ELONGATION

POLEWARD FORCE ON THE CHROMOSOME DURING ANAPHASE A

ANAPHESE, CHROMOSOME SEPARATION AND SPINDLE ELONGATION

SPINDLE ELONGATION DURING ANAPHASE B

ANAPHESE, CHROMOSOME SEPARATION AND SPINDLE ELONGATION
The cytoskeletal system - Mechanics of cell division

BOTH PUSHING AND PULLING FORCES CONTRIBUTE TO ANAPHASE B

CLEAVAGE FURROW

CONTRACTILE RING

CONTRACTILE RING – MYOSIN II

CONTRACTILE RING – ACTIN FILAMENTS