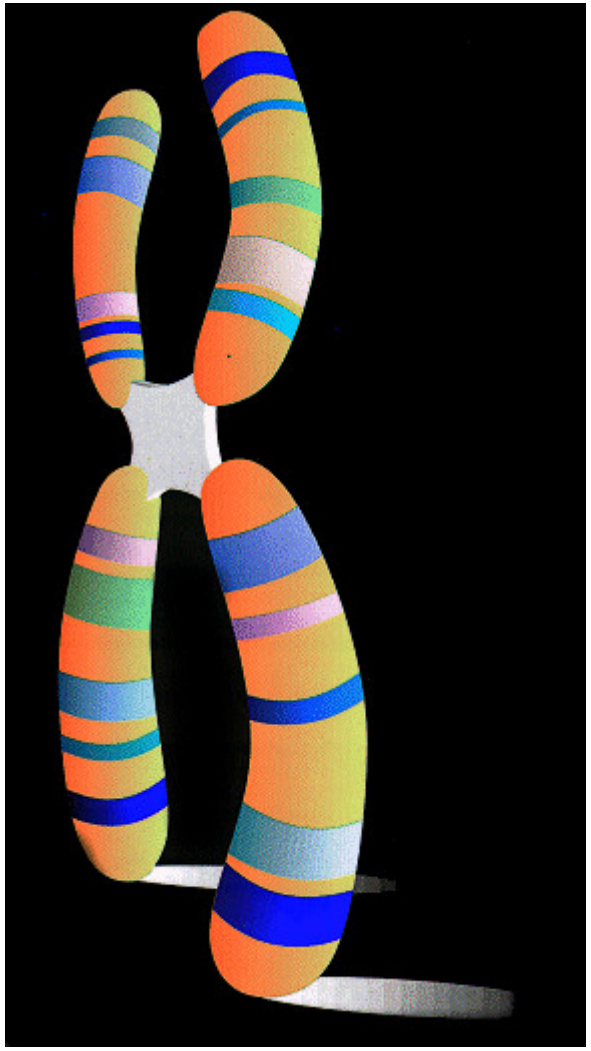
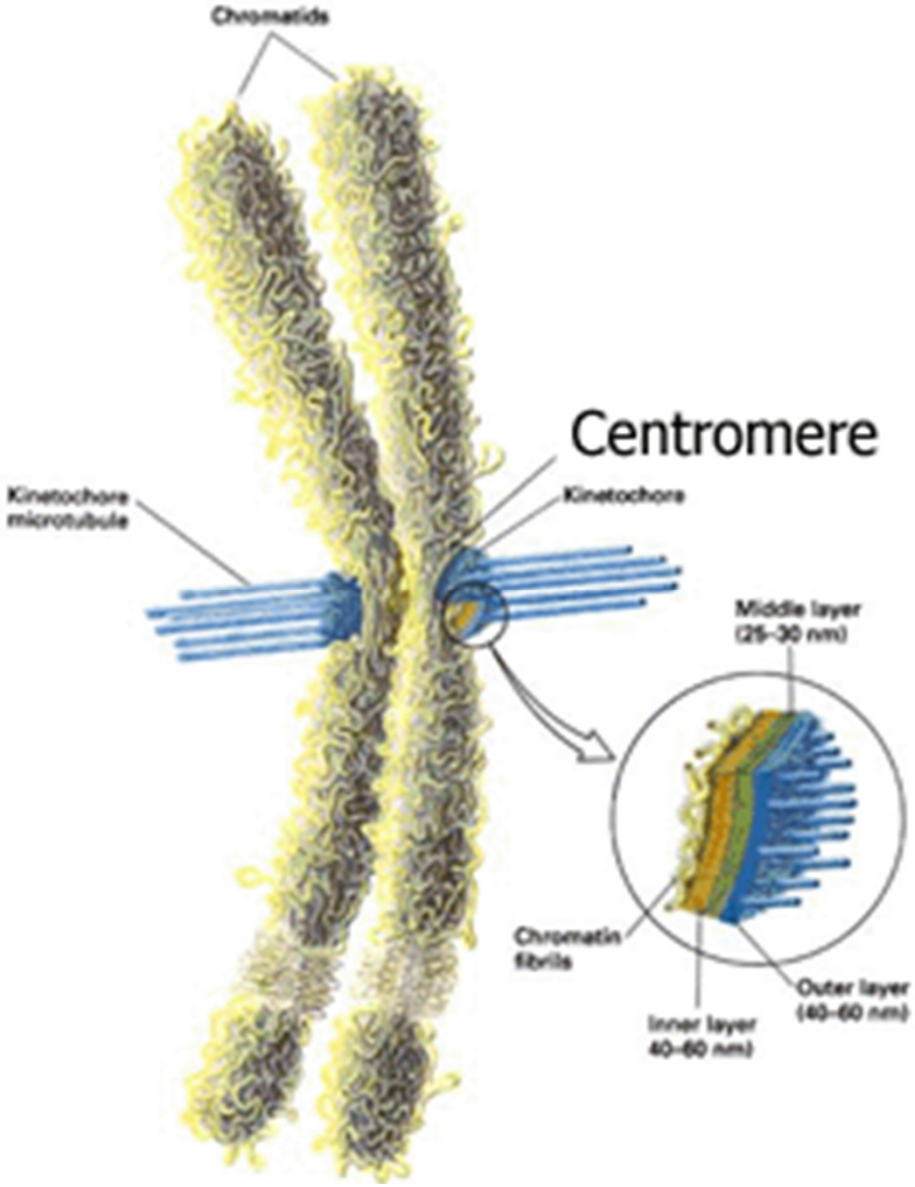
CENTROMERE




Chromatids
Centromere
Kinetochore microtubule
Kinetochore
Middle layer (25–30 nm)
Chromatin fibrils
Inner layer 40–60 nm)
Outer layer (40–60 nm)

CHROMOSOME MORPHOLOGY

- 1) Chromatid
- 2) Centromere
- 3) Telomere
- 4) Nucleolus organizer region
- 5) Chromomere

CENTROMERE

The **centromere** (centro- + -mere) is the part of a chromosome that links sister chromatids.

The word "centromere" is derived from the Greek words *centro* ("central") and *mere*("part")

During mitosis, spindle fibers attach to the **centromere** via the kinetochore.

Centromeres were first defined as genetic loci that direct the behavior of chromosomes.

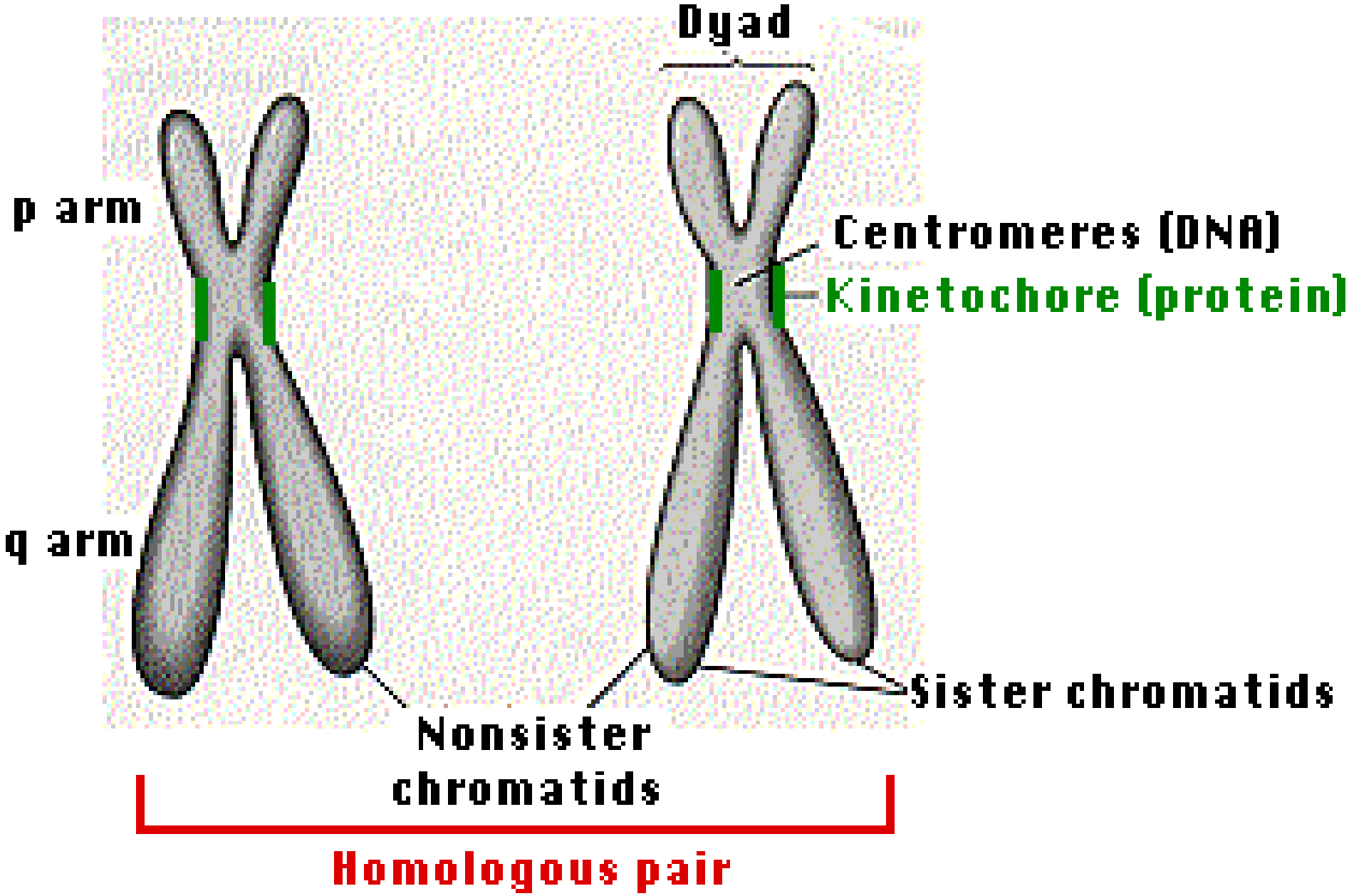
CENTROMERE

The centromere was first described by German biologist Walter Flemming in the 1880s as the "primary constriction" of the chromosome.

Scientists now appreciate that the centromere is a region of specialized chromatin found within each constricted chromosome that provides the foundation for kinetochore assembly and serves as a site for sister chromatid attachment

Errors in centromere or kinetochore function are catastrophic for cells.

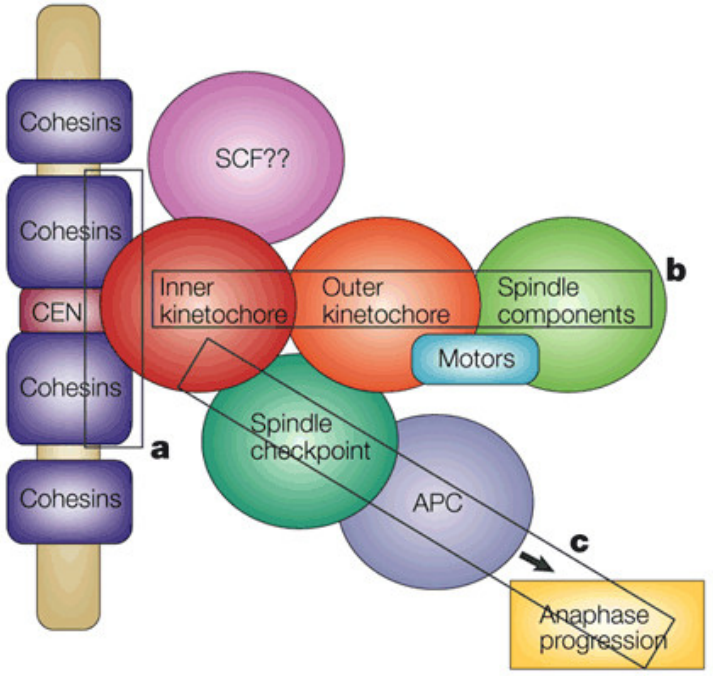
Such errors can lead to aberrant division and chromosomal instability, both of which are often observed in cancerous cells.


Dyad
p arm
Centromeres (DNA)
Kinetochore (protein)
q arm
Sister chromatids
Nonsister
chromatids
Homologous pair

CENTROMERE - STRUCTURE

The kinetochore can be thought of as three sets of subcomponents:

- (a) The chromosomal DNA-inner kinetochore protein interface
- (b) the inner kinetochore-mitotic spindle interface; and
- (c) the kinetochore protein-cell cycle machinery interface.
- (NB. APC = anaphase-promoting complex, CEN = centromeric DNA, and SCF = SCF ubiquitin-ligase complex.)



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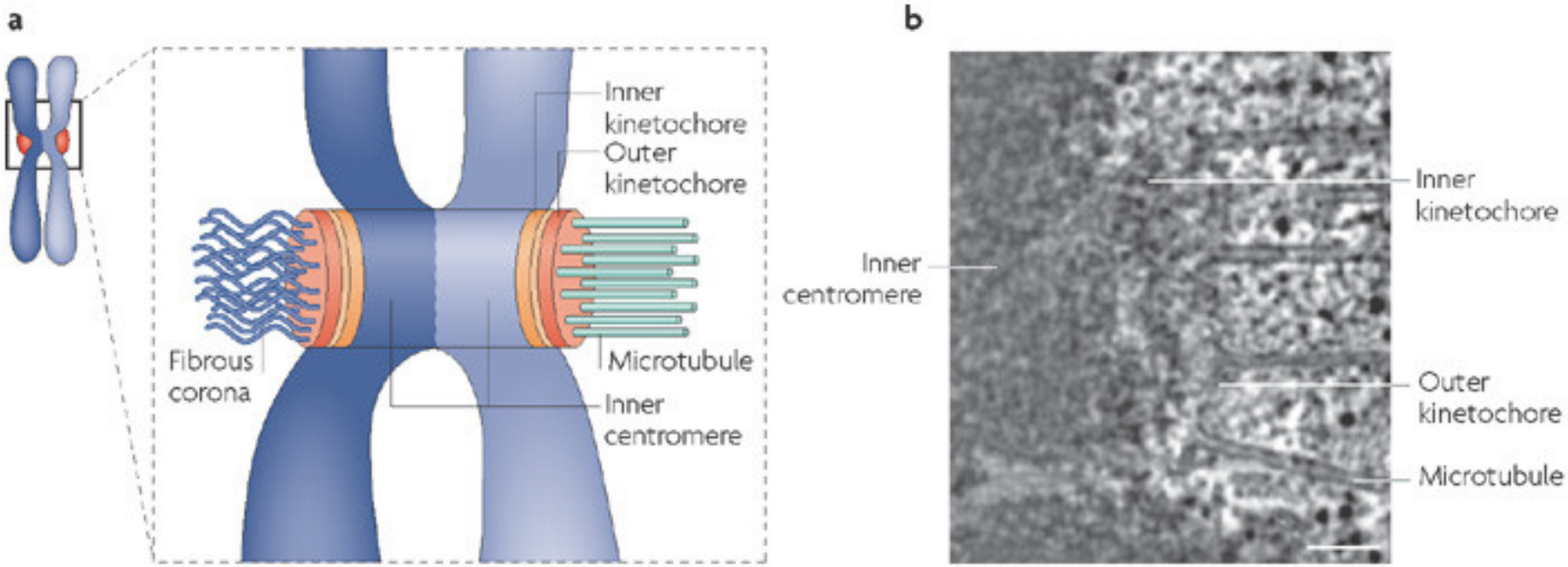
CENTROMERE



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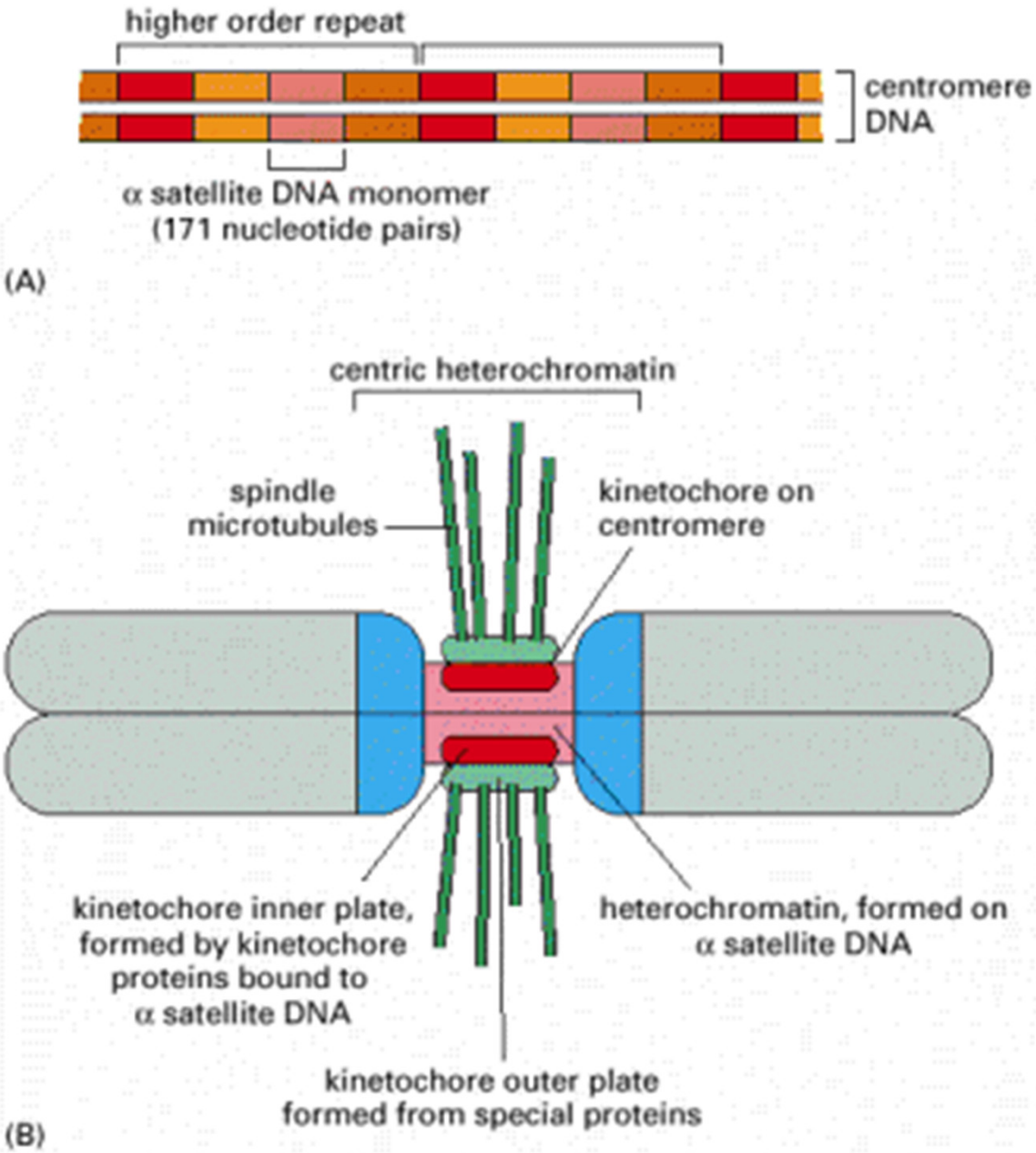

higher order repeat
centromere DNA
α satellite DNA monomer (171 nucleotide pairs)
(A)
centric heterochromatin
spindle microtubules
kinetochore on centromere
kinetochore inner plate, formed by kinetochore proteins bound to α satellite DNA
heterochromatin, formed on α satellite DNA
kinetochore outer plate formed from special proteins
(B)

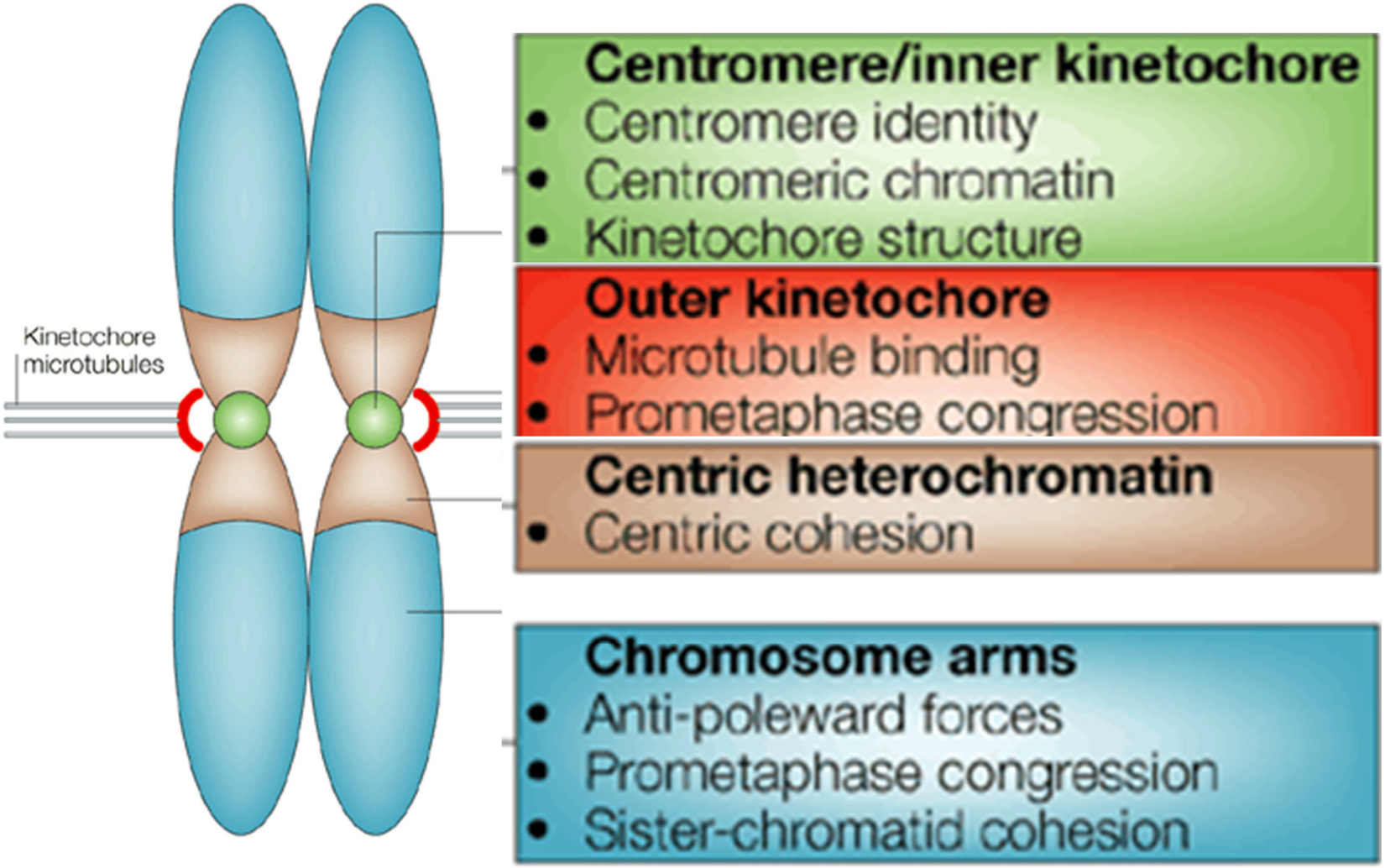
CELL DIVISION Animation

CENTROMERE

CELL DIVISION Live

- A **centromere** is a region of DNA typically found near the middle of a chromosome where two identical sister chromatids come in contact.
- It is involved in cell division as the point of mitotic spindle.

CENTROMERE



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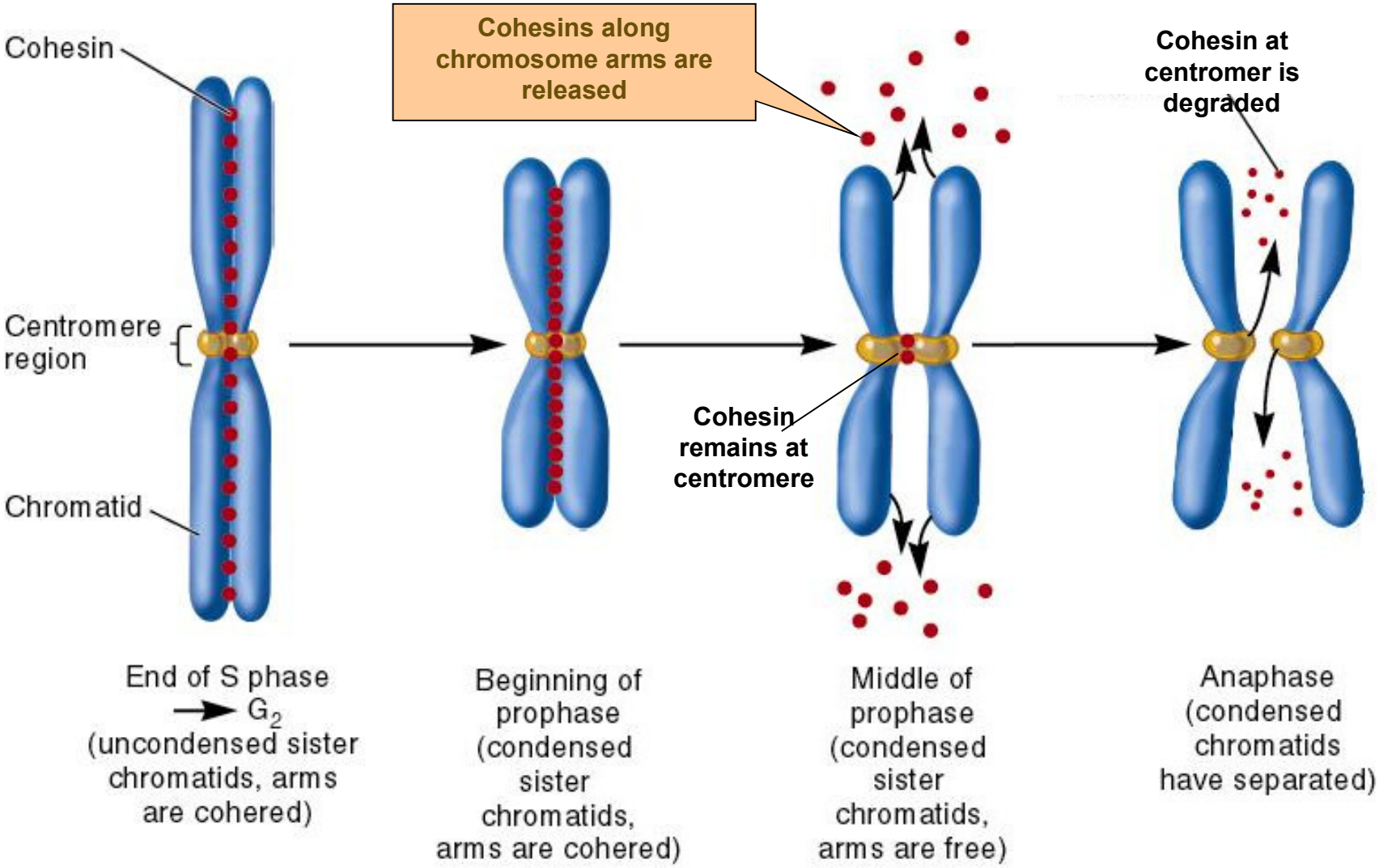
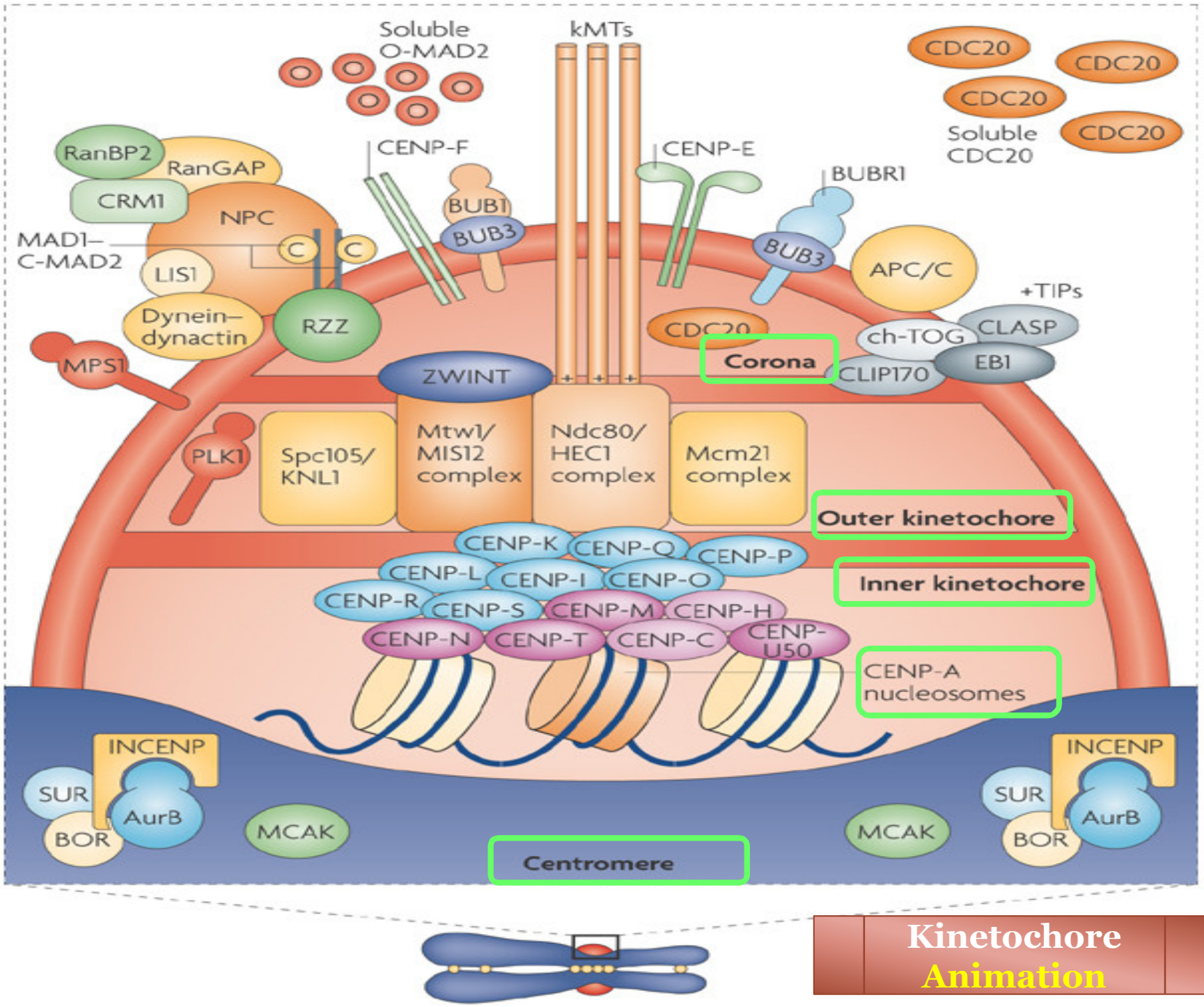
CHROMOSOMES DURING MITOSIS



The alignment of sister chromatids via cohesin



Kinetochore Animation

CENTROMERE

- The **centromeres** are, together with **telomeres** and **origins of replication**, one of the essential parts of any eukaryotic chromosome.
- The centromere usually contains specific types of DNA sequences which are in higher eukaryotes typically tandem repetitive sequences, often called "**satellite DNA**".
- These sequences bind specific proteins called "cen"-Proteins.

- During mitosis the centromeres can be identified in particular during the metaphase stage as a constriction at the chromosome.
- At this centromeric constriction the two mostly identical halves of the chromosome, the sister chromatids, are held together until late metaphase.
- During mitotic division, a transient structure called **kinetochore** is formed on top of the centromeres.
- The kinetochores are the sites where the spindle fibers attach.
- Kinetochores and the spindle apparatus are responsible for the movement of the two sister chromatids to opposite poles of dividing cell nucleus during anaphase.

CENTROMERE

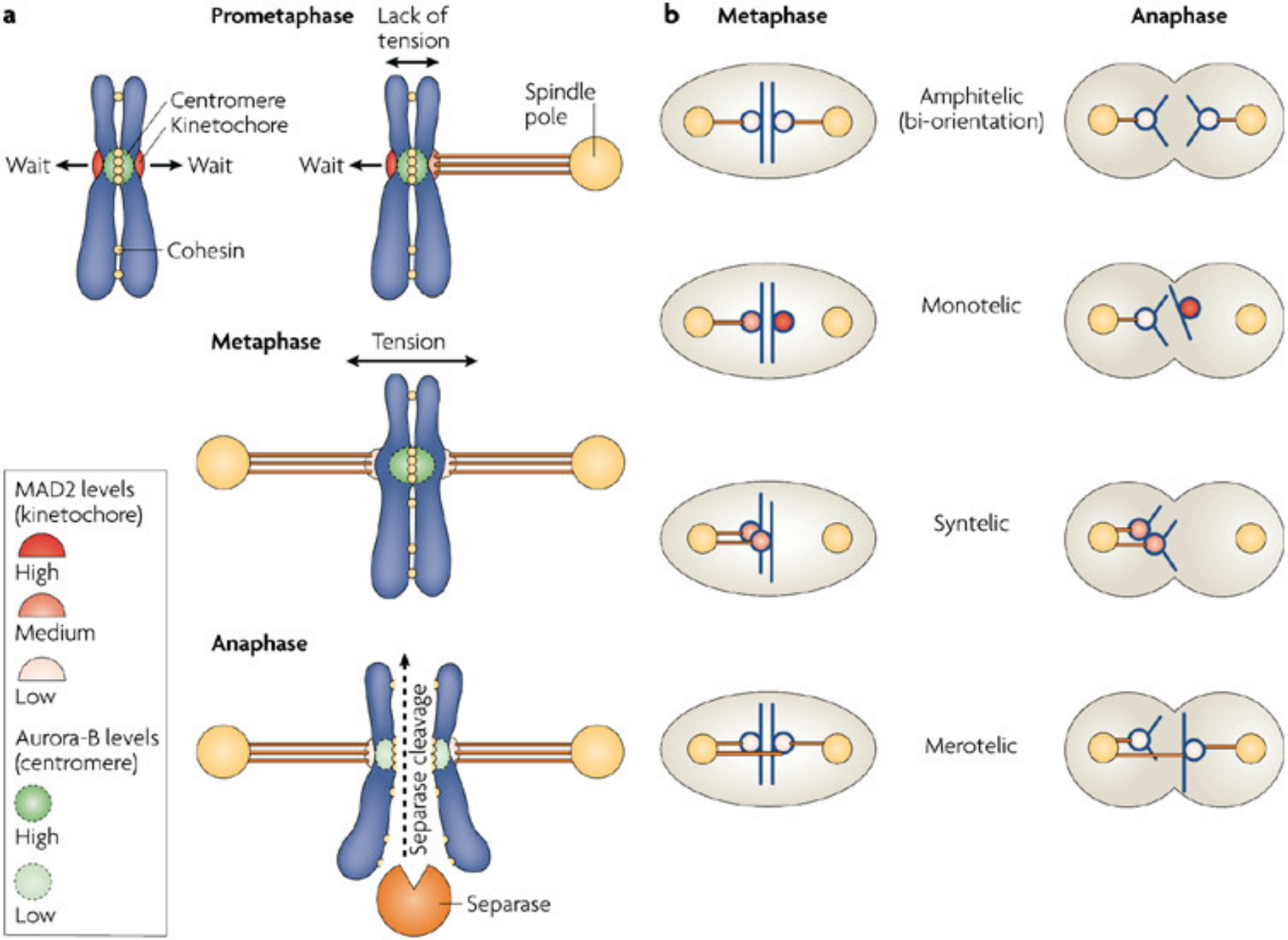
- Usually the mitosis is immediately followed by a cell division cytokinesis. However, mitosis and cytokinesis are separate processes and can be uncoupled.

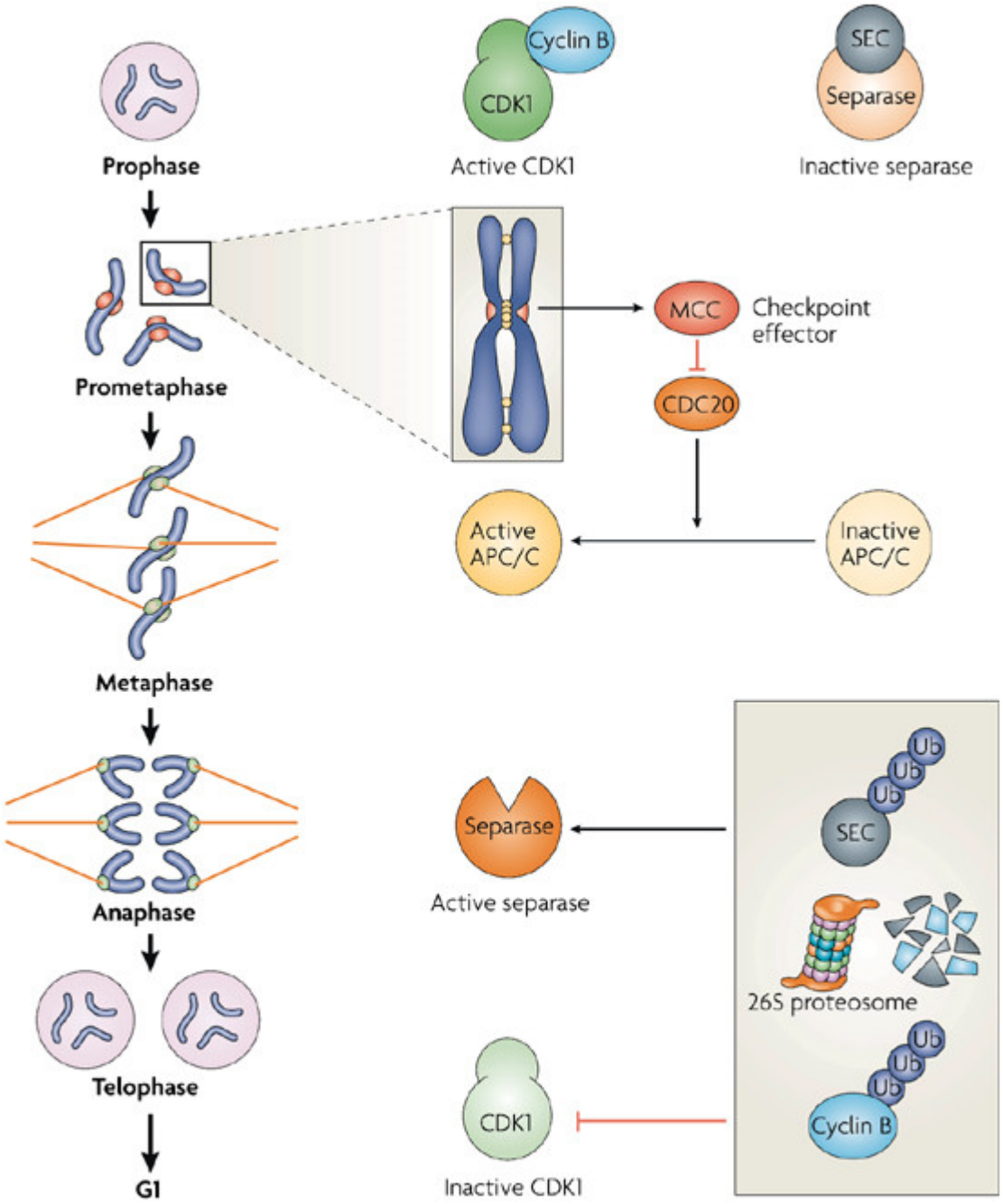
- A centromere functions in sister chromatid adhesion, kinetochore formation, and pairing of homologous chromosomes during meiosis, prophase and metaphase.

- The centromere is also where kinetochore formation takes place: proteins bind on the centromeres forming an anchor point for the spindle formation required for the pull of chromatids toward the spindle poles during anaphase and telophase of mitosis.

IMPROPER FUNCTIONING

- Centromeres result in the chromosomes that do not align and separate properly, resulting in aneuploidy or daughter cells receiving the wrong number of chromosomes. Aneuploidy can cause conditions such as Down syndrome if the cells survive at all.


a
Prometaphase
Lack of tension
Centromere
Kinetochore
Wait
Wait
Wait
Spindle pole
Cohesin
Metaphase
Tension
Anaphase
Separase cleavage
Separase
MAD2 levels (kinetochore)
High
Medium
Low
Aurora-B levels (centromere)
High
Low
b
Metaphase
Anaphase
Amphitelic (bi-orientation)
Monotelic
Syntelic
Merotelic



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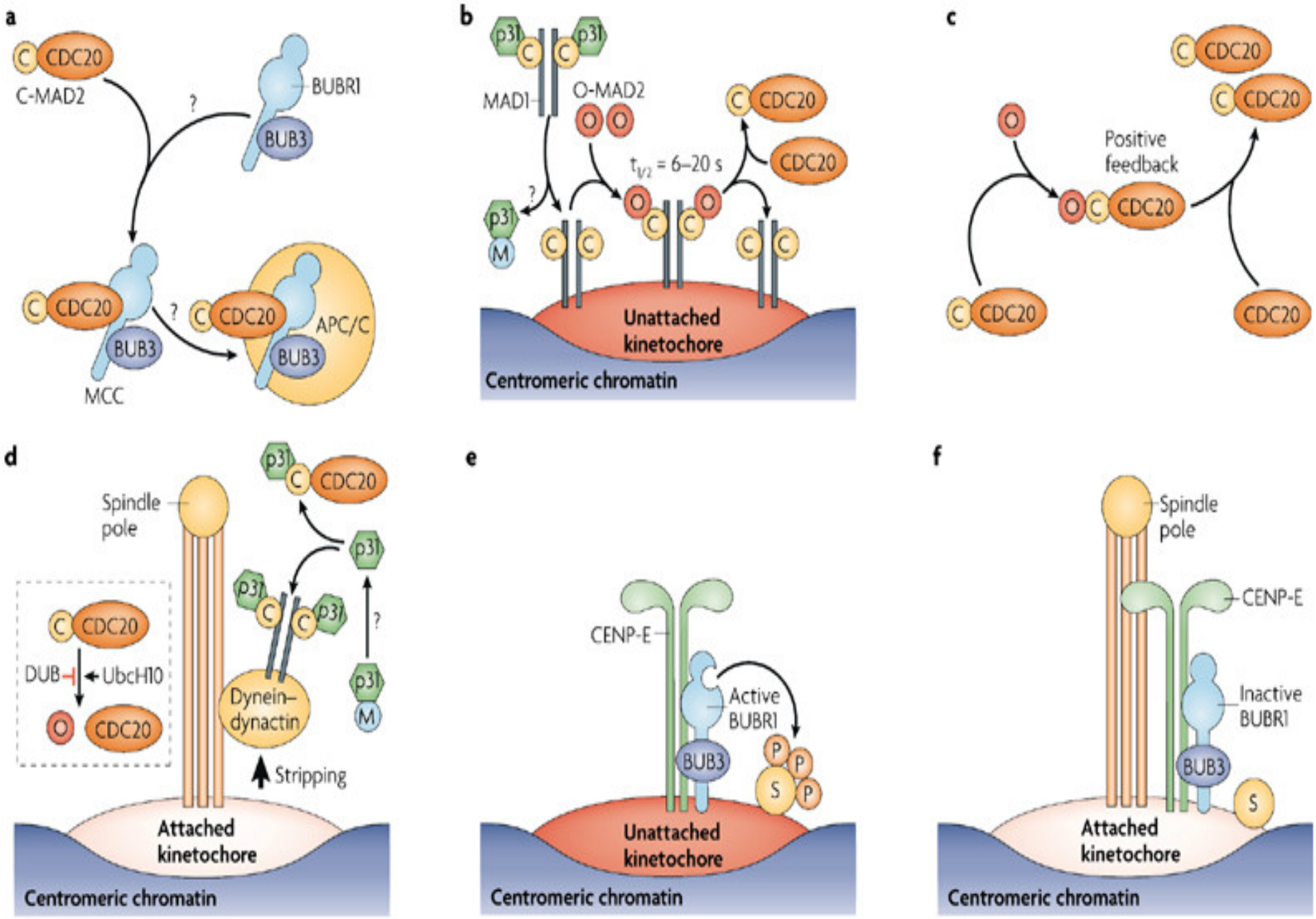
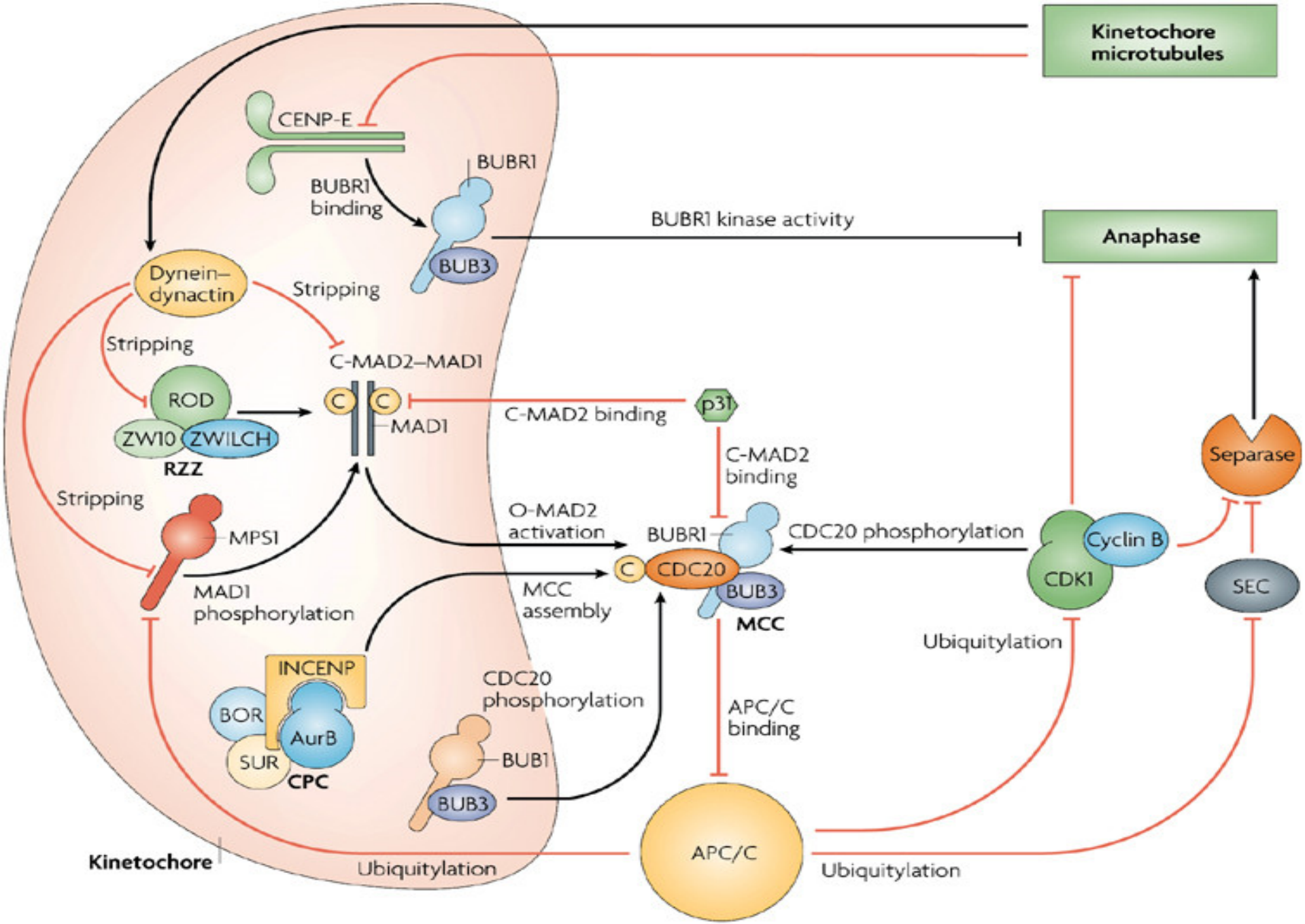

a
C
CDC20
C-MAD2
?
BUBR1
BUB3
C
CDC20
BUB3
MCC
?
C
CDC20
APC/C
BUB3
b
p31
C
C
p31
MAD1
O-MAD2
O
O
C
CDC20
CDC20
$t_{1/2}$ = 6–20 s
?
p31
M
O
O
C
C
C
C
C
C
Unattached
kinetochore
Centromeric chromatin
c
C
CDC20
C
CDC20
O
Positive
feedback
O
C
CDC20
C
CDC20
CDC20
d
Spindle
pole
p31
C
CDC20
p31
p31
C
C
p31
?
C
CDC20
DUB
UbcH10
O
CDC20
Dynein–
dynactin
p31
M
Stripping
Attached
kinetochore
Centromeric chromatin
e
CENP-E
Active
BUBR1
BUB3
P
P
S
P
Unattached
kinetochore
Centromeric chromatin
f
Spindle
pole
CENP-E
Inactive
BUBR1
BUB3
S
Attached
kinetochore
Centromeric chromatin



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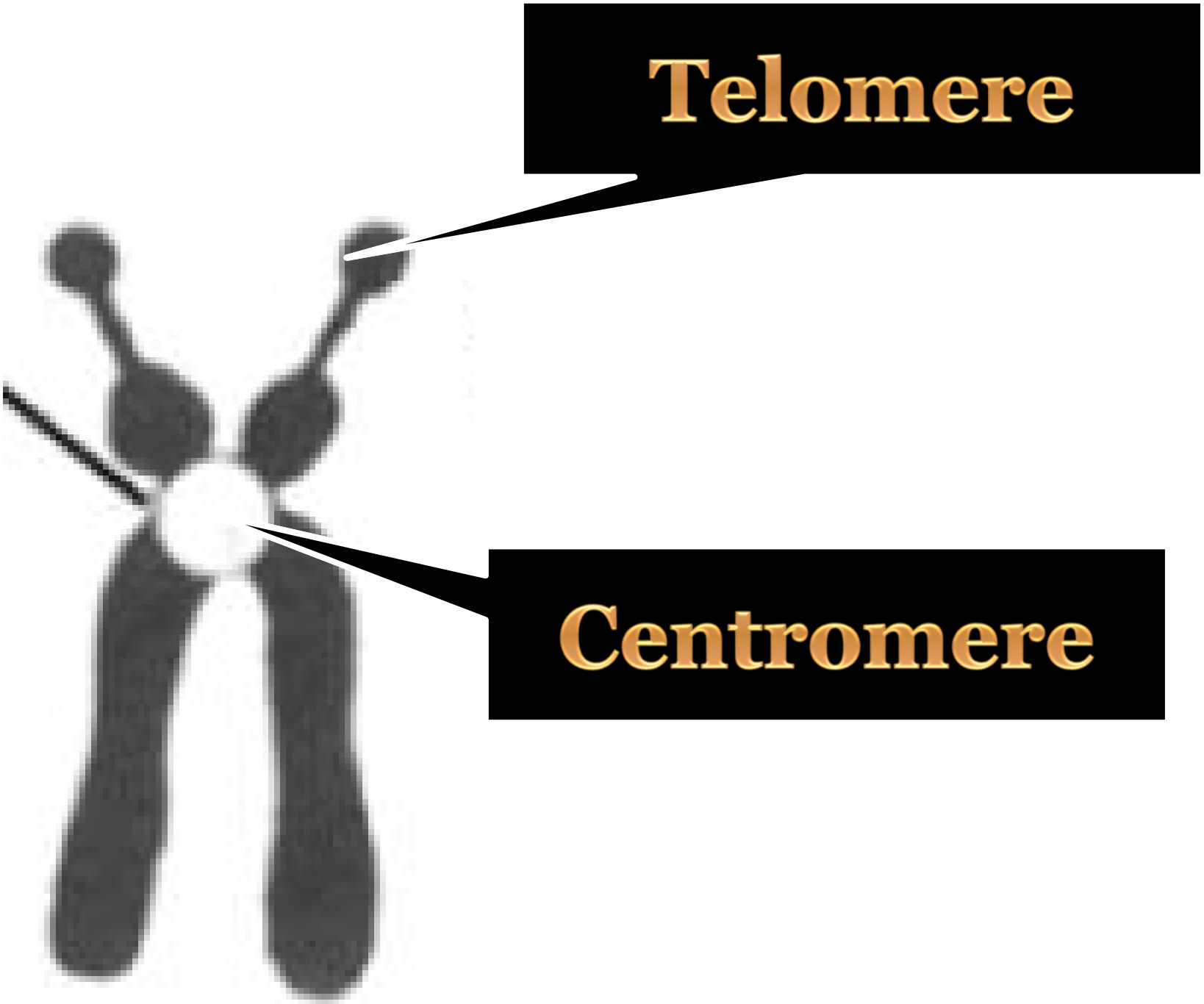
TELOMERE

- Two ends of chromosome.
- Highly stable
- Made up of loops (300 A0) chromatin fibers
- Maintenance of structural integrity.


Telomere
Centromere

NUCLEOLUS ORGANISER REGION

- It is also called as secondary chromosome
- Nucleolus formed during telophase.
- Chromosomal site of ribosomal RNA synthesis.

  Region between secondary constriction and nearest telomere called satellite.
- Satellites are attached to short arm of nucleolus organiz

KARYOTYPE AND IDIOGRAM

For cytogenetical studies, when the chromosomes of a species are arranged according to their shape, size and structure, than that is called karyotype of that species. Further, when the karyotype of a species are represented by the diagram then such diagrams, are called idiograms.