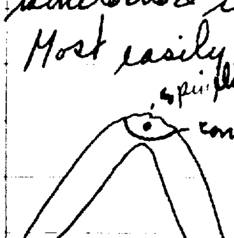
KINETOCHORE

Many synonyms: centromere, spol pt., kinomere and kinosome; primary constriction.

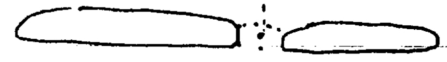
Schrader Biol Bull (1936) 1. If there is a well defined half spindle fiber it goes to a particular spot on the chromosome.
2. At anaphase, this spot leads the chromosome poleward
3. In acentrics, the chromosomes cannot indefinitely persist mitotically. The loss of the chromosome need not occur immediately.

Not really — Most of our knowledge is recent. One "constriction" is always associated with the fiber. These are by definition primary. Others, called secondary, may be associated with nucleoli.
In some cases, the region is more chromatic.

See Chromosoma 1 (1939) Amphiuma, other Amphibia — Analysis rather complete. Chondriosomal techniques, with overfixation, demonstrate the kinetochore; with finest differentiation a granule can be seen within. The kinetochore is different from the rest of the chromosome.
Most easily demonstrated in arachnids, mammals.



At metaphase: (?)



Plant homologies obscure. In Tradescantia, and others, there is a projecting knob (sometimes double), which

Kopach X Chromosoma 1 '40 is Feulgen positive

Iwata Jap J Bot '40 — In Zea there is a large kinetochore at pachytene, a clear knob. At anaphase, there is a knob (Darlington) Consider that maize has no centriole.

Descr in pl	The spindle spherule divides first.
Tzenkowsky Z. Zellf 10 1930)	In living grasshopper, there is a gap at the point. In Decanthus, there may be a centriole-like substance.
Rhoades Genet 21 25 1940	No case known to persist with a "terminal" kinetochore. Irreversibly lost. Cytological many organisms appear to have telomitic chromosomes. Ends of chromosomes are
Hinton & Atwood PNAS 1940	peculiar Telomeres.
McClintock Genetics 23 1938)	By X-Ray the kinetochore can be split functionally. The high frequency of such splits is disturbing.
Darlington J. Genet. 37 (1939) ?	Misdivision of the centromere (Fritillaria spp., certain forms) leading to isochromosomes, branched chromosomes, etc. (The centromere may be pulled out.) Probably the essential part is fibrous, in a fluid matrix. Acc. Nebel: oriented micellae, permitted crystalline breaks.
	Misdivision may be origin of attached X.
Conception of diffuse kinetochore	There is no (little) experimental basis for a kinosome-
Test for terminal ~~...~~ kinomere	centriole relation, but a good, generalized idea. See
rods → isochromosome temporarily.	Pollister....
Hughes-Schrader & Ris JEZ 194?	Localized & diffuse kinetochore. A localized kinetochore diffuse into a region.

12/4 WHY DO CHROMOSOMES MOVE

(No consistent hypotheses)

1. Chromosomes pulled to pole by half-spindle fibres.

Artifact — 2 ag fixes.

a. As chromosomes move the fibres do not thicken

b. Where there is a large centrosome the chromosomes may be brought past the point of chromosome attachment.

c. Crinkled interzonals (should be in tension.

d. Establishment of metaphase: how?

[Wetere proposes push: to equilibrium position: How anaphase?]

See Rashevsky, Bull Math Biophys '42

2. Diffusion currents [many botanists]

An apparatus is essential for demarcation of currents.

Schaede Beitr. Biol Pfl. 19 (1931) The currents start at center, end, and return.

Honeycomb spindle: But fibres are attached to chromosomes, particularly kinetochores

Bělař notes: If cytoplasmic currents are stopped, the chromosomes continue to move.

Stickiness of plant chromosomes.

V-shapes in anaphase chromosomes.

Is there then, normally, a spindle current????

Univalents X-chromosomes, move differently. If there are currents, should be no differential.

3. Lamb, Cannon... Hydrostatic waves, in resonance, induced by oscillation or pulsation of the centriole and possibly the kinomere. A change of density of the chromosomes after metaphase must be presumed. The kinomere must also vibrate if the forces are to be localized. Case of anastral, acentric spindles.

Drosophila centers are seen to move, but irregularly and slowly within the centrosome.

See Wassermann

24.

Handb. d. mikr. anat. d. Menschen. Vol II

Wassermann

Movement is due to "directed viscosity changes". Physically untenable.

Metz Biol Bull 1933 Science

Jour. Gen. Physiol. 77 1937
PNAS 21 1935

Teorell Diffusion potentials can arise by known chemical situations; may modify direction of chemical reactions.

12/9/42.

Arch. Centrum 118: 446-456

Bělař

1. Internal chromosome division is autonomous.
2. Spindle contains only continuous fibers
3. Chromosomes are pushed into the equator by the growing out of fibers from both poles.
4. Kinetochore secretes some adherent substance and attaches to spindle. When attached, the chromosomes are pushed to the equatorial plane.
5. The secretion uses up the continuous fibers toward the poles. This secretion is called the Zugfaser.
6. First split and movement autonomous.
7. The Zugfaser slides with the chromosomes.
8. 3 mechanisms for further movement.
    a. Sliding along the Zugfaser.
    b. contraction of Zugfaser
    c. Expansion of continuous fiber = Stemm

In Artemia, there is no expansion of the Stemmkörper, or in distance between centrioles.

Lagging of univalents, in grasshoppers with large Stemmkörper.

Spindles are not all continuous fibers (kinetics)

PS B121 (1936)

Darlington: Electrostatic, after Lillie

Fittberg

1. Unsplit genes attract; split repel split. After splitting they repel; in meiosis chiasmata hold chromosomes together.

At late ~~metaphase~~ prophase the chromosomes are

or paired.

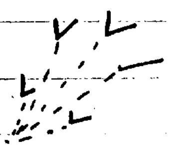
already split, repel any other chromosome. This accounts for the universal diakinetic repulsions.

The centers go polewise, mutually repelling. Spindle is established through a "redistribution of water. The chromosomes have kinetochores, but these do not split for a time. The first anaphase movement is the autonomous specific repulsion. The chromosomes reached the metaphase by centriole repulsion. Their charge now wanes, and the chromosomes go poleward.

Does not take expansion of Stemmkörper into account

Schrader

Anisolabis; 1 Chromosomes attracted to centers of diakinesis 2. When nuclear membrane breaks down, the chromosomes congress. The nuclear membrane must play some role. The metaphase is then set up quite orthodoxly. The ends of chromosomes must be rather peculiar for they are specifically attracted in the pachytene bouquet. (This is true also for chromosomes with subterminal kinetochore.)



The cases of Sciara and Micromalthus must be considered. Before division the chromosomes aggregate about the centriole. Then a monocentric mitosis; the V's are all pointed centrally; some chromosomes move away. If anything, the spindle fiber impedes the movement. Autonomous chromosome movement proposed.

Mety Cytologia 7 1936
Scott J Morph 59 1936
Korny Biol Bull 71:375 (1936)

FURTHER ON MITOTIC MECHANISM

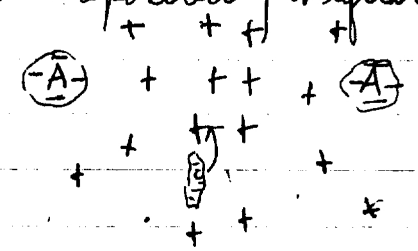
The Electrostatic hypothesis proposed by RS Lillie

Lillie Am J Physiol 15:46-84 (1905) The first to emphasize (if hastily + erroneously) the colloid character of protoplasmic substrates. His work must be considered in the light of modern knowledge of double layer phenomena, and of diffusion potentials. The Donnan equilibrium expressions had not yet been formulated.

$Ncl^{\circ} \rightleftarrows Ncl^{-} + \oplus$

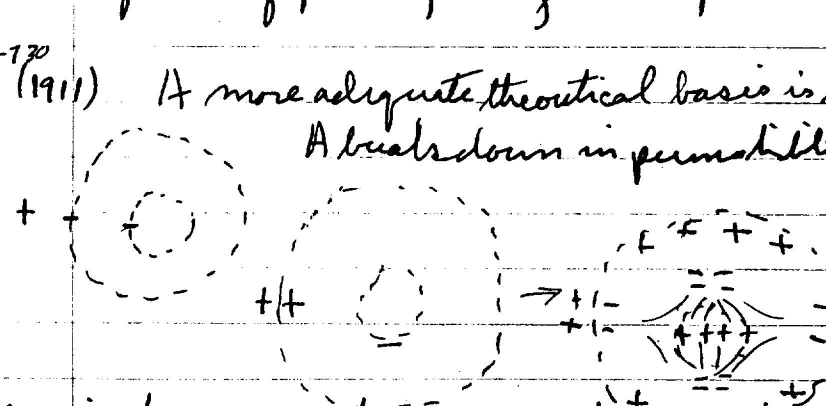
One cannot assume a concentrated + ionic charge. Must assume a uniform distribution of mutually repelling $\oplus$ charges, even if they arise from chromatin dissociation. In this event, consider: reciprocal repulsion would not centralize a chromosome; reciprocal attraction is a system of high instability because of the $1/R^2$ law.

Chromatin, particularly chromosomes, are strongly electro negative, or acid. The appearance of chromosomes in the ~~central~~ equatorial region is due to the center's being also negative and the highest concentration of electropositivity at equator.



The basic assumptions, therefore, at metaphase are polar repellent and interastral attractive field, with mutual chromosome repulsion. Models are reported of floating magnets, spheres, etc.

Lillie J Morph 22:695-730 (1911) A more adequate theoretical basis is established. A breakdown in permeability equatorially.



Then a change in charge must be assumed.

Mitotic
mechanism

What are the general conditions that must be satisfied by a theory of mitosis:

Diffuse kinetochore" can be regarded as a limiting case of multiple kinetochores.

1. <u>Localized application of force</u> to the kinetochore region.
2. <u>Stable</u> equilibrium at metaphase
3. The existence of spindle fibers
4. A marked "Stemmung" in the interzonal in some cases; its absence in others.
5. Anastral, acentric mitosis
6. Specificity of action: precocious or lagging X.
7. The anomalous cases of <u>Sciara, Micromalthus and, in meiosis</u>
8. Body repulsion at diakinesis
9. Synaptic attraction; saturation
10. In Amoebae, the centriole-chromosome attraction
11. The division of the centromere.

ALSO

12. Autonomous split in c-mitosis, etc.
13. Pressure inhibition of chromosome movement
14. Anisotropy of the spindle
15. Coorientation and congression
16. Specificity of metaphase pattern, even in polyploids.
17. Ion rich cytoplasm. High Dielectric Constant.
18. Existence and orientation of multipolar spindles, and the chromosome movements resulting.

12/11/42

NUCLEOLI

Plasmosomes and karyosomes.
↓ heteropycnosis of chromosome or part of it

Mottier '99
Gray

heavier than rest of nucleus. Generally visible in vivo. May be heterogeneous. Old rules of basophily are inadequate, particularly in oögenesis.

The Feulgen-(Light Green) reaction is now employed. But almost certainly some Feulgen negative components exist in the chromosomes. In most animals there is no plasmosome at anaphase; reappearance in telophase. May sometimes be lost in the spindle, and drawn out considerably. But there is no direct continuity of the plasmosome from generation to generation.

In the lower vertebrate eggs, the plasmosome fragments into particles which may look like chromosomes, but are only thinner threads than the latter. The plasmosomes here are Feulgen-negative.

Amphinucleoli In Anilus (Hemiptera) the karyosome increases and accretes the plasmosome; the chromosomes (compound X) breaking apart. Finally they leave the plasmosome for the spindle.

Agar QJMS 67 1923

In Marsupalia, a "mixed-up" amphinucleolus. Toward metaphase, the components segregate. Acc. to Agar, this is a fixation artifact, the fixation contracting the chromosome and forcing out a more liquid medulla of the chromosome.

Function:

1. Paragenoplastin — Too many cases of persistent nucleoli

2. Relation to chromosomes: In some animals the nucleolus is large relative to the chromosomes which ensue.

3. Secretion, yolk formation —

Schreiner Arch. mikr. Anat. 89; 92 (1916) Myxine slime cells, very active in the young. (1 fish in an inevitable bucket, after McGilgar). Development traced. Young cells show budding of nucleolus; squeeze through nuclear membrane.

Beams & Wu J Morph 47 (1929)
Gardiner J Morph 44 (1927)

Similar phenomena in trichopterous insect — Caddis Fly larva; detailed account in deutogenesis, Limulus eggs —

After the ultimate gonium, no plasmosome. As egg grows, small irregular lumps in the cytoplasm; later, similar lumps in the nucleus; increase proportional to increase. Lumps fuse. Chondriosomes then appear in the cytoplasm. Simultaneously plasmosome has budded, extruded. In cytoplasm, chondriosomes & Golgi aggregate. Yolk spheres appear at the aggregates. "Test for plasmosomes!" During emission, high P content as shown by (NH_4Mo) test.

Apparently not all plasmosomes are related specifically to chromosomes.

12/17/42

Relation to chromosomes. — Zea Mays

Zirkle, C. Bot Gaz 86 (1928)

Plasmosome persist at telophase; In early prophase the plasmosome connects with a chromosome. The plasmosome decreases in size; His interpretation as filling the inside of a hollow tubular chromosome. (See Fikry). But the chromosome is not a hollow tube, the spireme is not continuous.

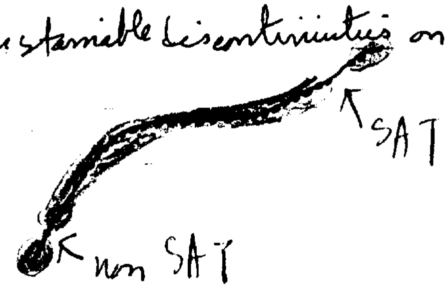
Heitz Z/AV 70:405 (1935)
Planta 12: (1931)
Lorbeer Jahrb. w. Bot 80 (1934)

"Secondary constrictions" Appearance varies. Usually nothing more than a gap. Satellites (SAT). In some cases association with the plasmosomes. In early telophase, the nucleolar globule increases. In a few cases, the plasmasome is formed as a collar at the SAT.

Balbiani - Chironomus
McClintock Z. Zellf 21 (1934)

By X-Ray split of the organizer at (VI), a heteropycnotic region, the relationship between nucleolus, organizer and matrix was established....
[Geitler opposes this interpretation].

Chromosome structure — Gene string, with other stainable discontinuities on it (chromomeres)



There is more than one kind of plasmosome; do not generalize.

THE GERM CELL

Darwin — Gemmulae (submicroscopic, hypothetic units) at some time the gemmules are circulated and gather in particular, which accumulated themself.

Weismann — "determinants" In differentiation, a germ cell is set aside, an undifferentiated cell.

Now recognized that all cells essentially have identical genotypes. Germ cells generally "immortal" Some somatics also (veget. propagation). Consider the parasitic role of the germ cell.

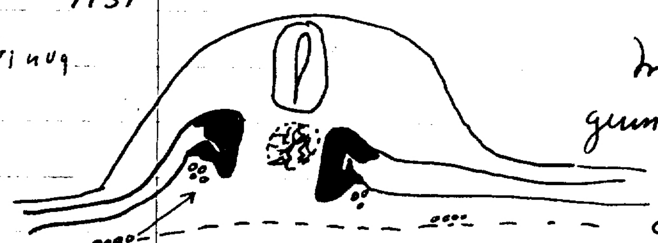
? point of optical differentiation of the germ in vertebrates Ceaseless, (futile) controversy!! Usually primordial germ cells have a large hypochromatic nucleus.

Waldeyer: - rather late differentiation, from epithelial cells.

Then ideas of migration; now accepted

Allen, on Dodd's goosefish, turtle

Heys QRB 6 1931
most recent review; ...



In bull frog, the primary germ cells, do not form the testes; the primordials disintegrate after starting to mature - Then a new batch sets in.

Swingle JEZ 32 1921
Kingery Biol Bull 27 1914 (mouse)

In coelenterates any undifferentiated cell can give rise to the germ.

~~Boveri Entstehung of Hoffer 1879~~
Hargitt J Morph 40 1925