This Week's Citation Classic®

Robbins E & Gonatas N K. The ultrastructure of a mammalian cell during the mitotic cycle. *J. Cell Biol.* 21:429-63, 1964.
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This paper describes in a systematic fashion the morphological changes of centrioles, mitotic spindles, kinetochores, chromatin, the nuclear envelope and the endoplasmic reticulum, multivesicular bodies, and the Golgi complex in cultured HeLa cells during mitosis. [The *SCI*® indicates that this paper has been cited in over 440 publications.]

Centrioles, Microtubules, and the Golgi in Mitosis

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In 1961-1963, as a postdoctoral fellow at the Albert Einstein College of Medicine in the Bronx, I was engaged in the electron microscopic study of human neurodegenerative disorders. At the same time in an adjacent laboratory, Dr. Elliott Robbins was studying mitosis. During one of our discussions, he mentioned an old paper by Albert Dalton, regarding the disappearance of the Golgi apparatus during the process of cell division. This was the era of several innovations in the electron microscopic armamentarium, including glutaraldehyde as a fixative for preserving microtubules.[1] Elliott had evolved a method for the controlled fixation and selection of single mitotic cells at various stages of division, and together we embarked on an evaluation of the vanishing Golgi apparatus, in an attempt to assess its morphological changes at this crucial time of the cell cycle.[2] While we started with a rather modest goal, the technology allowed assessment of multiple organelles during the mitotic process, and visualization of each of these in previously unseen detail was a most exciting experience. Included in our documentation were changes of centrioles, microtubules and the mitotic spindles, chromosomes, kinetochores, the endoplasmic reticulum, the nuclear envelope, lysosomes, and the Golgi apparatus. These descriptions became a reference for subsequent studies on mitosis.[3]

The original stimulus for the study, namely, the Golgi apparatus, was in fact noted to disperse such that it was not readily visualized either electron microscopically or enzymatically. Recently, after 23 years, J.M. Lucocq and colleagues, using new methods of immunoelectron microscopy, have found a mitotic form of the Golgi apparatus in some cells.[4] In any case, it always seems to disperse at mitosis. The association of the Golgi apparatus with the cytoskeleton is now well established, but the molecular basis for this linkage is still unknown.[5] Twenty-five years after our original study, I continue to be preoccupied with the Golgi apparatus, even as a neuropathologist. Elliott has gone from molecular biology into the practice of radiology. But this is another story.

1. **Sabatini D D, Bensch K & Barrnett R J.** Cytochemistry and electron microscopy. The preservation of cellular ultrastructure and enzymatic activity by aldehyde fixation. *J. Cell Biol.* 17:19-58, 1963. (Cited 5,915 times.)
2. **Robbins E & Gonatas N K.** *In vitro* selection of the mitotic cell for subsequent electron microscopy. *J. Cell Biol.* 20:356-9, 1964. (Cited 90 times.)
3. **Gerace L.** Functional organization of the nuclear envelope. *Annu. Rev. Cell Biol.* 4:335-74, 1988.
4. **Lucocq J M, Pryde J G, Berger E G & Warren G.** A mitotic form of the Golgi apparatus in HeLa cells. *J. Cell Biol.* 104:865-74, 1987.
5. **Robbins E & Gonatas N K.** Histochemical and ultrastructural studies on HeLa cell cultures exposed to spindle inhibitors with special reference to the interphase cell. *J. Histochem. Cytochem.* 12:704-11, 1964. (Cited 230 times.)

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