Comment: “Microwave Irradiation Influences on the State of Human Cell Nuclei”

[Y.G. Schkorbatov et al., 19:414–419 (1998)]

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Schkorbatov et al. [1998] report that millimeter wave radiation changes the electrokinetic properties of nuclei in “intact” cells. Simple biophysical considerations would seem to rule out this interpretation.

The investigators measured the electrokinetic properties of buccal epithelium cells scraped from the cheeks of human subjects, using an applied electric field of 15 V/cm. They judged a nucleus as being negatively charged if it is “displaced to the anode” as observed by visual examination under a microscope.

But if the cell is really intact, its inside will be shielded from the external field by a factor of many thousands. This rules out the possibility of observing electrokinetic effects of the nuclei of intact cells. An external low-frequency field simply does not reach the nucleus, at least at levels that will cause visible electrophoretic responses.

For example, for a spherical cell of radius R in an initially unperturbed electrical field Eo, the field Ei inside the cell is approximately 1.5 EoRρiGm where ρi is the resistivity of the cytoplasm and Gm is the membrane conductance [Foster and Schwan, 1995]. For typical cell parameters (R = 10 μm, Gm = 1 S/m²) this corresponds to a reduction in field by a factor of 100,000, to levels far below those needed (tens of V/cm) to cause visible electrophoretic movements of the nuclei. It is hard to imagine any reasonable variation of this calculation, either in the shape of the cell or in its membrane conductance, that would result in induced fields at the nucleus that would be sufficient to cause visible dielectrophoretic movement of the nucleus. (In long cylindrical cells, such as muscle fibers or nerve axons, the situation might be different).

I conclude that either the cells were not electrically intact, or the investigators did not observe electrophoretic forces on the nuclei. Few experimental details are provided in this or in other papers from the group in English-language journals that I had access to, and it is difficult to judge the reliability of the qualitative observations on which the study is based. If the observations were correct, the simplest explanation is that the cells whose nuclei “displaced to the anode” had damaged plasma membranes, and the investigators were reporting differences in the fraction of membrane-damaged cells, a simple artifact.

Alternatively, the cells might have been intact, but the investigators (mis)interpreted electrophoretic forces exerted elsewhere on the cells as being due to the action of the fields directly on their nuclei. “Forces applied to a cell are distributed over many components, including the extracellular matrix, the bilayer, and the cytoskeleton” Akinlaja and Sachs [1998] recently observed, and “the latter distributes forces within the cell cortex and as deep as the nucleus”.

The proper interpretation of the study, if indeed the observations are correct, remains unclear.

REFERENCES


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