STIMULATION OF CELL SURFACE CONTRACTION BY ISOLATED ASTERS OF THE MITOTIC APPARATUS IN ECHINARACHNIUS PARMA EGGS

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Cell division is accomplished by the contraction of an equatorial band of cell surface material which is organized in response to the presence of the underlying mitotic apparatus. Only the asters of the mitotic apparatus are essential for this activity and in spherical cells it was shown that at least two asters are necessary. Ability of single asters to elicit contractile activity in the cell surface has not previously been demonstrated. In order to better understand the mechanisms by which the mitotic apparatus establishes the cleavage furrow, the effect of isolated asters on the cell surface was studied in cylindrical cells.

Sand dollar (Echinarachnius parma) eggs were obtained by KCl injection and mechanically denuded after fertilization. During the time that the mitotic apparatus was developing, eggs were inserted by aspiration into 82 μm diameter capillary tubes cast in transparent silicone rubber which has better optical properties and less tendency to adhere to the cell surface than glass. In cylindrical cells with intact mitotic apparatus, the distance between the astral centers was 37 μm to 46 μm. These cells divided regardless of the distance between the asters and the poles. Asters can be broken off the mitotic apparatus by repeatedly moving the eggs in and out of the capillary and in these cells the distance between the astral centers is greater than normal. When the interastral distance is less than 68 μm, furrows usually form at the midpoint between the asters. But when the interastral distance is greater than 68 μm, no furrows form, but constrictions appear in the surface near the isolated asters. The single aster which remained after the other had been obliterated by stirring with a needle or aspirating with a pipet had the same effect upon the surface. The form of the constriction was related to the position of the aster in the cell. When the aster was located near the midpoint of the cell, the constrictions resembled cleavage furrows, although their form and relation to the aster was variable. They were less acute and slower than normal, and they rarely divided the cell completely and permanently. In some cases the constriction bisected the aster. When the aster was positioned 45 μm to 50 μm from one end of the cell, furrow-like constricitons did not occur. In this circumstance, the diameter of the adjacent cylindrical cell surface decreased, and it shrank away from the inside of the capillary; the radius of curvature of the end of the cell also decreased. Later, both dimensions slowly returned to their original values.

These results indicate that single asters can cause localized contractions in the adjacent cell surface if they are close enough to it. The contractions can cause furrow-like shape changes in cell shape which depend on the size and shape of the affected surface area. They suggest that in the establishment of the normal cleavage furrow by an intact mitotic apparatus the rapidity, shape and permanence of the furrow may be associated with geometrical circumstances which permit both asters to simultaneously interact with the same surface region in such a way that the intensity of the interaction and the size of the affected area are increased. This investigation was supported by NSF Grant PCM 7902624.