*Europ. J. Cancer*, Vol. 16, pp. 1–16

0014-2964/80/0101-0001 $02.00/0

*Perspectives in Cancer Research*

# Motility, Shape and Fibrillar Organelles of Normal and Neoplastic Cells

## Proceedings of a Workshop of the EORTC Tumor Invasion Project Group's Working Party on Cell Motility, held in Zürich on 9 and 10 November 1978

Participants: M. BESSIS, *Kremlin-Bicêtre;* G. A. DUNN, *Cambridge;* H. FELIX, *Zürich;* G. HAEMMERLI, *Zürich;* G. ISENBERG, *München;* E. F. LÜSCHER, *Bern;* M. MAREEL, *Gent;* E. RUNGGER-BRÄNDLE, *Genève;* U. GRÖSCHEL-STEWART, *Darmstadt;* P. STRÄULI, *Zürich;* K. E. WOHLFARTH-BOTTERMANN; *Bonn*

**Abstract**—*Cell motility, mainly in the form of locomotion, is considered to be one of the mechanisms contributing to tumor invasion. To be able to migrate within a tissue, a cell must do two things: generate a propulsive force and adapt its shape to the texture of the environment. These two activities are closely interconnected. Their display requires a motor and a skeleton, and there is good evidence that both together are represented by the cell's fibrillar organelles: microtubuli, microfilaments and intermediate filaments. Just which organelles serve which part of the machinery is not altogether clear yet, and a considerable functional overlap among the differentiations of the cytoplasm responsible for motility and shape must certainly be taken into account. In mechanical terms, this apparatus can be expected to operate along the same lines in normal and neoplastic cells, although differences must be anticipated in the regulatory mechanisms. Contractility in non-muscle cells is a relatively new research area in cell biology, at least with regard to vertebrate cells. Therefore, the emphasis of the workshop was put on the mechanophysiology—and possibly mechanopathophysiology—of cell motility, whereas a thorough discussion of control mechanisms was postponed. Within this limited approach, joint consideration of normal and neoplastic cells was regarded to be indispensable. Thus, the aim of the workshop was:* (1) *to collect the available basic data on motility, shape and fibrillar organelles of cells in general, and of a few representative types of normal and neoplastic cells;* (2) *to integrate these data into a heuristic concept of cell motility, particularly locomotion;* (3) *to evaluate cell motility as an element of tumor invasion.*

The first two contributions are minireviews presenting the fundamental information on motility, shape and fibrillar organelles of cells in general.

## Cell Motility and Cell Shape

G. HAEMMERLI

*Abteilung für Krebsforschung, Institut für Pathologie, Universität Zürich*

OUR PRESENT knowledge of cellular motility and cellular shape stems mostly from investigations carried out *in vitro* by allowing the cells to settle on a flat surface, frequently glass, in a culture chamber. Under these conditions, many cell types, like fibroblasts and epithelial cells, normal as well as malignant, spread and become flat. White blood cells, on the other hand, keep their spherical configuration, provided they are not compressed. After having established contact with the substrate, the cells can display two types of motility: a stationary and a translocative form. For the study of the interrelation of motility and configuration, the concurrent use of microcinematography (MCM) and of scanning electron microscopy (SEM) is of particular value. While the phase contrast optics employed for MCM allow the recognition of the overall

Accepted 10 May 1979.

shape of the moving cells, SEM reveals details of surface configuration that are important for motility, but cannot be recognized at the light microscopy level. This approach, 'dynamic morphology', has revealed that the two types of motility distinctly influence cell shape and surface architecture [1].

Stationary or surface motility is characterized by the appearance and disappearance of cytoplasmic extensions of varying sizes and shapes. During this activity the cell neither changes its position nor becomes polarized. In our experience the only exception regarding polarization are some types of white blood cells: leukemic blasts, stimulated lymphocytes and granulocytes. They can display stationary motility in a polarized configuration by producing a single major extension. This is used for fastening the cells on the substrate or on other cells and for making bending movements into all directions; we call it 'on spot motility'. [2].

During translocative motility, locomotion, the cells are always polarized. Although manner and degree of polarization can be different from one cell type to the other, most cells achieve it by the continuous development of cytoplasmic extensions at the front part. While the rear end of blood cells frequently shows a tail-like single extension, flattened cells tend to assume a trapezoid shape.

What has been said so far is based on studies performed under *in vitro* conditions, and we have, therefore, to ask whether these observations have any relevance to cellular behavior in the living organism. Microcinematography *in vivo* is technically difficult. For this reason we have chosen a model that stands halfway between *in vitro* and *in vivo* conditions: the rat mesentery after intraperitoneal injection of leukemia cells [3]. Once the leukemia cells have penetrated into the mesentery in the host, the organ is removed and placed into a culture chamber. We could show that leukemia cells within the mesentery move in the same overall manner as on glass. The cells exhibit surface motility and locomotion in their known polarized configuration [4]. However, the histologic structure of the mesentery imposes a locomotive activity that is characterized by short tracks and frequent changes in direction. In addition, the model reveals that besides propulsion, locomotion within a tissue forces a cell to pronounced adaptations of its shape to its momentary environment.

In summary it can be said that cells under identical *in vitro* conditions can exhibit two types of motility, stationary and translocative, and stay spherical or flattened according to their origin. These features combine in a way that both spherical and flat cells are able to develop stationary and/or locomotive activity. In the living tissue, a further ability is indispensable: changes of shape that allow movement despite the presence of a restrictive structured environment.

## REFERENCES


1. H. Felix, G. Haemmerli and P. Sträuli, *Dynamic Morphology of Leukemia Cells: A Comparative Study by Scanning Electron Microscopy and Microcinematography*. Springer-Verlag, Berlin (1978).
2. G. Haemmerli and P. Sträuli, Patterns of motility in human leukemias: a study by time-lapse cinematography. *Leukemia Res.* **1,** 71 1978).
3. G. Haemmerli and P. Sträuli, Motility of L5222 leukemia cells within the mesentery: a study by time lapse cinematography. *Virchows Arch. B. Cell path.* **29,** 167 (1978).
4. G. Haemmerli, H. Felix and P. Sträuli, Motility of L5222 rat leukemia cells. *Virchows Arch. B. Cell Path.* **20,** 143 (1976).


# Biochemistry and Immunochemistry of Cytoplasmic Filamentous Structures


UTE GRÖSCHEL-STEWART

*Institut für Zoologie, Technische Hochschule, Darmstadt*


The cytoplasmic matrix contains at least 3 different filamentous structures (microtubules, intermediate filaments and microfilaments) which, in their entity, participate in cell motility, the maintenance of cell shape, attachment to substratum, nuclear anchorage, transport of organelles, cell division and secretory processes. Electron microscopy and, later on the use of specific antibodies in the immunofluorescent technique have revealed these cytoplasmic structures in almost all eukaryotic cells.