Biorheology, 1975, Vol. 12, pp. 149–152. Pergamon Press. Printed in Great Britain.

OPENING SESSION

Wix Auditorium, The Weizmann Institute of Science, Rehovot, Israel.
Chairman MARKUS REINER

Opening Remarks: MARKUS REINER Technion-Israel Institute of Technology, Haifa.

Welcome Addresses: G. GOLDRING* The Weizmann Institute of Science, for I. DOSTROVSKY, President, The Weizmann Institute of Science. M. SELA The Weizmann Institute of Science, for the Israel National Academy of Sciences and Humanities, Jerusalem.

Addresses: A. SILBERBERG President of the International Society of Biorheology and Congress President.
His Excellency EPHRAIM KATZIR* President of Israel.

Distinguished Guests, Ladies and Gentlemen

It is my privilege and great pleasure as Honorary Vice-President of the Second International Congress of Biorheology to address the opening session of the Congress. About biology we do not have to say much; biology is the science of life dealing with organized beings, animals and plants, both in deformation and flow. The term is in use since 1859.

But where does rheology come from?

Rheology is a branch of Mechanics. It exists as such since less than half a century. Mechanics as a science is not old. It started with Galilei in the 16th century, considering the behaviour of complete solid bodies. Later, Newton in the 17th century included liquids, but also as complete bodies. In the 19th century, Cauchy looked at these bodies as made up of particles and created *Mechanics of Continua* but distinguished separately solids and liquids. About a century passed away until Bingham came back to Heraclitos' *panta rei* or "everything flows" and founded Rheology, the science of deformation and flow. Bingham started with the investigation of plastic materials which under certain conditions could be considered as fluids and under other conditions as solids, depending upon the yield point.

The prophetess Deborah looked at rheological processes in a manner more general than *panta rei* by saying, "The mountains flowed before the Lord". When you look at a mountain during your lifetime, it does not change its shape; the forces which hold it together do not relax sufficiently during such time. But the geologist tells you from his scientific considerations that if you could sit before the mountain a million years, you could see it losing its form. But God's time of duration is so great, approaching infinity, that he can see the mountain flow, as predicted by Deborah. There is no qualitative difference between the rheology of a solid and one of a fluid. The difference is only quantitative, depending upon the ratio of the time of relaxation and the one of observation. This is the nondimensional number which may be called the Deborah number. God's time of observation approaches infinity and for him the Deborah number equals zero and *panta rei*. But for every actual experiment, the experimenting scientist should state how long his experiment was lasting or what his Deborah number was.

Going back to biorheology, we can say that it offers a framework to connect the sciences of biology with rheology.

When defining rheology, one should not make the mistake to consider this as a misprint for theology. Still, there is some relation between rheology and theology, through the Deborah number.

There is a story they tell about two students of theology. They were praising the Almighty God. Said one: "For God, one thousand years are like a minute. And as He is the Creator of all, a thousand dollars are for Him like a cent." Said the other: "Wonderful; next time I pray to God, I shall pray: 'God, give me a cent'." Said the first: "What will it help you? He will say: 'Wait a minute'."

*These two welcoming addresses cannot be published, as the speakers had no written texts and depended for their transcription on recordings which inadvertently were not taken.

This man did not take care of the difference between God's and his own time scale. And this is the connection between rheology and theology. In every problem of rheology make sure that you use the right Deborah number.

M. REINER

Mr. Chairman, President Katzir, President of the Weizmann Institute Professor Dostrovsky, Distinguished Participants of the Second International Congress of Biorheology

My duty is a short and pleasant one. I would like to extend to you the greetings of the Israel Academy of Sciences and Humanities and to wish you a most productive and successful congress.

As a member of the Council of IUPAB I would like also to take this opportunity to bring you the best wishes for a fruitful meeting on behalf of the International Union of Pure and Applied Biophysics, of which the International Society of Biorheology is an affiliated commission.

Israel hosts this year as many international congresses, symposia, seminars and courses as ever before. I think this symbolizes our deep desire to contribute our share, however modest, to the universal endeavour for the progress of mankind.

By best wishes for a most successful congress and for good advances and progress in biorheology.

M. SELA

Mr. Chairman, Mr. President, Ladies and Gentlemen

This is the Second Congress on the science of biorheology which we are opening today. The First Congress was held in 1972 in Lyon, France, but the history of this group and of the Society goes back further than this. As part of the Fourth International Congress on Rheology in Providence in 1963, a Symposium on Biorheology was organized by Professor A. L. Copley and at a meeting at that Congress it was suggested that an international society of biorheology be founded. This led later to the foundation of the International Society of Hemorheology and the First Conference of this group was held in Reykjavik, Iceland, in 1966, under the Presidency of Professor Copley. At that meeting, the International Society of Hemorheology was formally founded. The Second Conference of that group was then held in Heidelberg in 1969 under the guidance of Professors Hartert and Quadbeck.

It may be of interest to many of you here that Aharon Katchalsky was deeply involved with the affairs of the Society and that in the intervening period between the First and Second Conference on Hemorheology, while he was President of the International Union for Pure and Applied Biophysics, he was instrumental in having the Society adopt a resolution to convert itself into the International Society of Biorheology and apply to the International Union to be recognized as an Affiliated Commission.

This recognition was given and our group here is charged by the International Union to foster, control and encourage all activities in the field of biorheology.

Our regular meeting in Lyon in 1972 was thus the first one as the International Society of Biorheology and Aharon Katchalsky had been asked and he had agreed to open the Congress with a lecture. Instead, following the tragic events of 30 May of that year, Aharon Katchalsky's lecture was converted into a Symposium in his memory and honor. It is thus particularly appropriate that Israel and this Institute were chosen as the site for the second Congress which we are opening today. Although this is not formally a meeting in his honor, I would like to look upon your presence here as a tribute to Aharon Katchalsky and his life-long interest in the subject matter of our science.

What is this science, what are our topics? If we accept that Rheology is the study of how materials respond to flow and deformation, Biorheology will be the study of how biological materials respond to flow and deformation; or, more formally, if Rheology is the study of constitutive equations of materials in general Biorheology is the study of the constitutive equations of biological systems. One is thus looking for relationships, generally of a tensorial character, giving the stresses as functions of the deformation gradients and the time rate of the deformation gradients. Simple examples, known to all of us, are the Newtonian fluid and the Hookean elastic body. Here the laws, the constitutive equations, are so simple that emphasis is almost entirely placed on what to do with these relations than with understanding, or studying them. Only the fact that a very large number of practical systems, in fact most of those encountered in early work, corresponded reasonably well to those models, made it worthwhile to devote so much effort to solving problems in these systems. It was really only with the advent of synthetic plastics and an increasing interest in biological materials, or materials of biological origin, that the need for a more sophisticated approach began to be felt. This gave impetus to the study of Rheology and of Biorheology at almost one and the same time.

Man is an engine and a machine and his environment is largely in mechanical interaction with him. Even his intake of food primarily involves mechanical handling. A man may observe and think, but when he listens, tastes and talks, he creates and is influenced by mechanical forces in his surroundings. When he wants to make a permanent imprint on his world, he must act and act mechanically. He can cause a very small action to produce enormous effects, but the principle remains that an effective intervention in our environment will have to be the result of some mechanical action which we initiated. The material properties of our tissues thus determine how our body can alter its environment and how in turn our body can understand what mechanical messages our environment is passing on to us. It is perhaps not often realized how important our awareness of mechanical contact really is. While man can survive blind, deaf and dumb and without a sense of taste, he is helpless and doomed to death if he cannot sense what touches, hurts or crushes him.

There are many interesting questions which are associated with mechanical functions and mechanical properties of tissue. How does our body deform, how does it create motion, how does it move, how does it interact mechanically with the material objects around us? And equally important, how does it move and deform internally in the performance of the physiological functions of our organs?

The flow of blood, the lubrication of our joints, the handling of food and waste products, the transport of lymph, the secretion of mucus, the growth of cells and the division of cells—in all these processes, mechanical tasks are performed for which the materials involved must possess appropriate properties.

Moreover, we know that things can go wrong. Tissue can be abused mechanically, biochemical processes can be upset altering the rheological response, disease and aging of tissue can affect its ability to perform the assigned mechanical role. We want to know what has gone wrong, how things can best be mended, how damage done can be undone or prevented.

Biorheology is thus not only concerned with a description of properties but very directly with a study of why a set of particular properties are required, how these are linked to the tasks to be performed, what structural principles are involved and how all these effects can be linked to the molecular build-up and arrangement of the tissue or system. In cases of pathological deviation, moreover, how are the biorheological and the biochemical and structural changes which cause them interrelated?

We must learn to think and function at a variety of levels so that our contributions to the field can best find their mark. We must understand the mechanical requirements, the molecular and structural requirements, the physiological requirements and the results of pathological deviation. Moreover, we must equip ourselves with methods to measure and to control the parameters which we deem to be important. Here we move close to the physician and the bioengineer who have to measure a body function or want to adapt an instrument or machine for interaction with the living system. Moreover, we must be active in the development of theoretical understanding, methodology and techniques, since without these we would be lagging in our ability to interpret results and develop working hypotheses.

In selecting the topics for this Congress we were concerned with allowing all these questions to be brought out for discussion. Moreover, we felt it to be important to let different groups learn about each others problems. So we avoided parallel sessions and hope for your presence at all sessions. As you will learn from the variety of contributions to be heard, Biorheology has been taken far beyond its almost exclusive involvement with the flow properties of blood in the past.

There is one aspect of particular historical interest connected with our Symposium on

Cytoplasmic Streaming. Professor Kamiya of Osaka University, who should have been here with us but was unfortunately prevented from attending by ill health in his family, has pointed out that this year represents the 200th anniversary of the discovery of this phenomenon. He has sent me the following remarks which I would like to read out to you in this connection:

"It was in 1774 that an Italian botanist, Bonaventura Corti (1729–1813) for the first time described cytoplasmic streaming in cells of *Characeae.* The symposium on cytoplasmic streaming, which forms part of this Congress, is thus being held in the very year of the bi-centennial anniversary of its discovery.

'Corti was rector of the College of San Carlo, Modena, Italy and later Professor of Botany and Agriculture at the University of Bologna (1805–1809). His discovery of cytoplasmic streaming was achieved more than half a century ahead of the time of the establishment of cell theory by Schleiden and Schwann. It is thus all the more remarkable that Corti described the structure of this alga and the phenomenon of streaming fairly exactly.

'Despite the importance of Corti's discovery, it was not recognized as such by his contemporaries. It was only after his death in the early 19th century that this phenomenon again began to attract biologists and that further observations and experiments were done using various plant materials.

'Interestingly enough, however, recent work on cytoplasmic streaming still uses the classical giant *characean* cell in which Corti discovered the phenomenon.

In *characean* cells, it is now generally accepted that streaming is the result of a force generated at the boundary between the stationary ectoplasmic layer and the flowing endoplasm. The magnitude of this force has also been measured. It is at this very interface that many fine fibrils running in the direction of streaming have been found. Each of these fine fibrils is a bundle of *F*-actin filaments with a diameter of 5 nm. While this is established, we know little about the localization of the myosin and the mode of its interaction with the *F*-actin bundles. It is presumed that the interaction is the origin of the sliding force produced.

'Another material, on which many recent investigations have been made, is the acellular slime mold *Physarum polychephalum.* This material not only exhibits streaming, but can also be cultivated in large quantities. It is thus a favorable system for biochemical studies of the contractile proteins.

'As in the case of muscle contraction, the actomyosin–ATP system constitutes the mechano–chemical basis for cytoplasmic streaming in *Physarum* and possibly also in *Nitella.* Morphologically, formation of microfilament bundles seems to be essential for producing the mechanical force. As to the microtubule system, our knowledge is still uncertain with respect to its exact relation to cytoplasmic streaming.

'In contrast to the striated muscles of vertebrates, the structural organization of cytoplasm in streaming is quite different and often ephemeral. And yet the contractile proteins are similar.

'To gain further insight into the mechanism of streaming, various lines of approach are open. One of the most important and fruitful ones is to generate the motile system in a cell-free suspension, i.e. *in vitro* using the substances known to be essential for streaming. Work along this line was already started, and we are looking forward to its development in the near future."

The Society which I represent here wishes all of you a most successful meeting, fruitful discussions and a great spurt forward in advancing our field.

A. Silberberg

Presentation of the Poiseuille Gold Medal Award to Professor SYOTEN OKA by Professor ALFRED L. COPLEY.