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SYMPOSIUM ON BIORHEOLOGY
IV. INTERNATIONAL BIOPHYSICS CONGRESS

Moscow, U.S.S.R., 7–14 August 1972

THE CONGRESS was held under the auspices of the International Union of Pure and Applied Biophysics and the Academy of Sciences of the U.S.S.R. There were 12 major symposia devoted to the main topics of modern biophysics, including molecular biophysics, membrane structure and functions, biophysics of motility, communication and control processes in biophysical systems, etc. Symposium XI on Biorheology was organized by Professor A. L. COPLEY (U.S.A.) and Dr. V. I. VOROB'EV (U.S.S.R.), who acted as co-chairmen. There were approximately 175 sessions of contributed papers in 25 sections classified according to major topic headings such as Excited States in Biology, Radiation Biophysics, Biophysics of Photosynthesis, Nucleic Acid and Protein Structure and Function, Transport through Biomembranes, Biophysics of Reception, etc. There were about 1600 papers given by the 2500 participants.

The Symposium on Biorheology was held in the Central Lecture Hall of the Physics Building on 8 August 1972. The first opening address, entitled "Biorheology as an Organized Science: A Brief Survey", was given by A. L. COPLEY. He emphasized the role of the late Professor AHARON KATCHALSKY, who, in arranging the affiliation of the International Society of Biorheology to the International Union of Pure and Applied Biophysics, made this Symposium on Biorheology possible. He asked the audience to pay tribute in one minute of silence to Aharon Katchalsky who was murdered at Lydda Airport, Israel, upon his return from scientific Conferences in Boston and Göttingen. The subsequent Opening Address, entitled "Problems and Perspectives of Biorheology", was given by V. I. VOROB'EV.

Drs. A. S. POPEL, S. A. REGIRER, I. M. SKOBELEVA and P. I. USIK of the Institute of Mechanics, Moscow State University, U.S.S.R., presented a paper on the formulation of the macroscopic blood flow equations. They considered blood to be a concentrated suspension of deformable particles which can rotate and form aggregates. The concentration of red blood cells, their angular velocity and deformation rate, as well as an aggregation parameter, are treated as unknown variables. The model was shown to predict and describe the Fåhraeus Lindquist and Segrè Silberberg effects. A simple rheological model of muscle tissue was described which is necessary in particular for the proper formulation of the boundary conditions for flow in vessels with walls having smooth muscle or skeletal muscle tissue.

Professors A. L. COPLEY, C. R. HUANG and Mr. R. G. KING from the New York Medical College and Newark College of Engineering, U.S.A., reported measurements on the viscosity of whole blood at shear rates down to 0·0009 sec^{-1}. The authors contended that their data confirmed the existence of a yield stress for blood. The data were divided into three regions: (1) 1000–50 sec^{-1}, exhibiting nearly Newtonian behavior; (2) 50–0·01 sec^{-1}, which may be considered thixotropic; and (3) 0·01–0·001 sec^{-1}. In region (3), the shear stress value is considered to be below the yield stress of blood. A solid structure of red cell rouleaux exists which flows as a plug and slip may occur at the blood wall interface on a plasma layer. At 0·01 sec^{-1} a discontinuity in the viscosity vs shear rate plot occurs which is considered as a manifestation of the actual yield point and the associated yield stress is a measurement of the yield value. Findings, secured with different gap sizes on samples of the same blood withdrawal, using two Weissenberg Rheogoniometers, show conformity in regions (1) and (2), while in (3) the larger gap size gave higher values which provide additional evidence that blood exhibits yield characteristics.

Drs. J. F. GROSS and J. AROESTY, Rand Corporation, U.S.A., discussed the use of power law models in unsteady hemodynamics. Experiments have shown that blood flow in the microcirculation is pulsatile, periodic, and synchronous with the arterial pulse. The implications of this time-dependence on a non-Newtonian rheology were previously shown by the authors for a Casson fluid. A power-law fluid, which is a simpler and perhaps more appropriate rheological approximation to blood in small arterioles, was analyzed in the case of a time-dependent flow. It was shown that the resulting flow behavior was relatively insensitive to the value of the exponent. A series of calculations employing Newtonian approximations for the viscosity was compared to the exact non-Newtonian result for a Casson fluid, and it was shown that a viscosity obtained from a time-averaged wall shear model provided a good estimate of the average flow. The use of such models in a microcirculatory bed analysis was discussed.

The phase transitions in the deformation of biopolymers was discussed by Drs. L. V. KUKHAREVA, V. I. VOROB'EV, B. M. GINZBURG and S. YA. FRANKEL' from the Institute of Cytology, Academy of Sciences, Leningrad, U.S.S.R. They investigated the hydrothermal and chemical contraction of native collagen fibers. Two experimental methods – isometric and isotonic – were used and the phase transitions obtained were confirmed by X-ray data. The coincidence of isometric and isotonic data permits the consideration of a certain portion of the isometric

curve as a phase equilibrium curve similar to the pressure temperature curves of phase equilibrium for low molecular weight substances. This permitted the first experimental corroboration of a theoretical prediction that certain critical points existed above which the existence of the polymer in the given ordered state was impossible. Estimates of the enthalpy of melting in the case of hydrothermal contraction and the corresponding value of the "enrichment of salt" in the case of KCNS-contraction were obtained. The nature of the transitions occurring was discussed in terms of the theory of order–disorder transitions in unidimensionally ordered systems.

A paper of piezoelectric phenomena in biological systems by Professor E. FUKADA, Institute of Physical and Chemical Research, Saitama, Japan, was presented in his absence by Professor N. KAMIYA. It is known that mechanical strain and electrical polarization are closely linked in a number of biological substances by the piezoelectric effect. Stress induced polarizations and field induced strain were observed in the oriented solid states in a number of biological macromolecules such as cellulose, collagen, myosin, actin, fibrin and DNA. The effect was shown to depend on the orientation of molecules, the temperature, and the frequency of measurements. Complex piezoelectric stress- and strain-constants were determined as a function of temperature and frequency. Piezoelectric relaxations are associated with viscoelastic and dielectric relaxations in both crystalline and non-crystalline regions of the polymer. The physiological meaning of piezoelectricity in tissues was discussed.

Professor A. SILBERBERG, Weizmann Institute of Science, Israel, discussed the biorheology of epithelial mucus. The epithelia of the semi-exposed air passages in the lung, throat, nose and ear are composed of cells having finger-like protrusions, cilia, which are covered by a layer of mucus. These cilia are in a continuous beating movement which induces transport of the mucus layer over the epithelium. The mucus is secreted from cells in the epithelium and acts to protect the surface. It was shown that the biorheological properties of the mucus enable it to act as a mechanical coupler in the process of epithelial wall protection. Furthermore, this function is related to the structure of the glycoproteins composing the mucus. The viscoelastic properties of mucus were discussed.

Appraisals of the achievements of the Symposium were then given by Professor S. S. GRIGORJAN from the Institute of Mechanics, Moscow State University (U.S.S.R.) on the presentations in hemorheology and by Professor SILBERBERG on the other biorheological contributions.

There was a prolonged discussion for most of the presentations which extended the period of time scheduled for the Symposium by nearly 2 hr. This enthusiasm was also reflected by the continued presence of two excellent interpreters for simultaneous translation from English into Russian and from Russian into English, respectively. In his closing remarks A. L. COPLEY thanked the speakers, discussants and other participants and expressed the hope to greet many of them at our Congress at Lyon one month later. He also thanked the interpreters and informed the participants that the texts of the presentations and the two appraisals will be published in Moscow as part of the Proceedings of the IV International Biophysics Congress.

J. F. GROSS