Biorheology, 1968, Vol. 5, pp. 241–244. Pergamon Press. Printed in Great Britain.

NOTES AND NEWS

Report on U.S.–Japan Cooperative Seminar on Biophysics and Bioengineering of the Peripheral Circulation

THIS seminar was held at the International Hotel of Nagoya, Japan, from 8 to 12 May, 1967, which was followed by an informal meeting at the Laboratories of Angiology, Kure, on 14 May 1967. This seminar originated from a proposal by Professor H. Wayland (California Institute of Technology). The organizers of the seminar were Professor H. Wayland and Professor K. Takagi, (Nagoya University, Japan.)

The seminar covered various aspects of "Biophysics and Bioengineering of the Peripheral Circulation". It included sessions on morphology, diffusion, lymph flow, autoregulation, rheology, mechanical properties and methods. Six American scientists and more than twenty Japanese scientists participated in the seminar and contributed original papers.

The program was as follows:

American Team

1. Harold Wayland (California Institute of Technology): Blood Rheology and Its Relation to Microcirculatory Flow.
2. Curt A. Wiederhielm (Department of Physiology and Biophysics, University of Washington School of Medicine, Washington): Transcapillary and Interstitial Transport Phenomena in the Mesentery.
3. Wallace G. Frasher, Jr. (University of Southern California, Calif.): Mechanical Properties of Blood Vessels.
4. Paul C. Johnson (Department of Physiology, Indiana University School of Medicine, Indiana): Gross and Microscopic Studies of the Autoregulatory Mechanism of the Intestine.
5. Gido Majno (Department of Pathology, Harvard Medical School, Mass.): Ultrastructure of Blood Vessels.
6. Sam A. Threefoot (Tulane University School of Medicine, Louisiana): Lymph Flow.

Japanese Team

1. K. Hama (Department of Anatomy, Medical School, Osaka University, Osaka): Studies on the Fine Structure of Some Invertebrate and Vertebrate Blood Vessels.
2. F. Kato (Department of Anatomy, Nagoya City University Medical School, Nagoya); The Fine Structure of the Lymphatics.
3. T. Yamamoto and S. Sato (Department of Anatomy, Tohoku University School of Medicine, Sendai): An Electron Microscope Study of the Innervation of Rat Intracranial Arteries.
4. Y. Takeshige (Department of Anatomy, School of Medicine, Kurume University, Kurume): Anatomical and Physiological Studies on the Sinus and Veins in Human Brain.

5. K. Kageyama et al. (Department of Pathology, Keio University School of Medicine, Tokyo): The Specificity and Permeability of the Venules in the Peripheral Circulatory Units, (i) of the Guinea Pig Mesentery, (ii) in the Lymph Node.
6. K. Mori (Department of Anatomy, Nagoya City University Medical School, Nagoya): Diffusion of the Dye Fluids through the Walls of Small Blood and Lymph Vessels and the Interstitial Tissue.
7. I. Matsubara and K. Matsuda (Department of Physiology, Faculty of Medicine, University of Tokyo, Tokyo): Increase in Calf Tissue Volume after Water Drinking.
8. H. Hayashi (Department of Pathology, Medical School, Kumamoto University, Kumamoto): Permeability Factors of Rabbit Skin Associated with the Delayed Vascular Response in Arthus Reaction and Thermal Injury.
9. Y. Takeshige (Department of Anatomy, School of Medicine, Kurume University, Kurume): Experimental Studies of the Permeability of the Blood Vessel in the Rabbit Auricle.
10. Y. Nishimaru (ABCC, Laboratories of Angiology, Kure): The Structure and Function of the Lymphatic System.
11. K. Kageyama *et al.* (Department of Pathology, Keio University School of Medicine, Tokyo): On the Specific Aspect of Lymph Flow, (i) Lymph Flow of the Mesenterial Connective Tissue in Pathological Conditions, (ii) the Interrelation between Lymph Flow and Blood Flow within the Lymph Node.
12. K. Seki (First Department of Internal Medicine, University of Tokyo School of Medicine, Tokyo): Experimental and Clinical Study of the Lymph Circulation.
13. T. Azuma (Department of Physiology, Faculty of Medicine, Shinshu University, Matsumoto): Vasomotor Regulation of Renal Circulation.
14. H. Irisawa and I. Ninomiya (Department of Physiology, School of Medicine, Hiroshima University, Hiroshima): Evaluation of Integrating Method for the Recordings of Vasomotor Nerve Impulses.
15. M. Asano (Department of Physiological Hygiene, the Institute of Public Health, Tokyo): Spontaneous Rhythmic Fluctuations and Microcirculation Observed by the Rabbit Ear Chamber Technique.
16. M. Tsuchiya, M. Yasuda and Y. Kiryu (Department of Internal Medicine, Keio University, Tokyo): Effects of Several Hormones on the Microcirculation.
17. S. Oka (Department of Physics, Tokyo Metropolitan University, Tokyo): Some Theoretical Studies on Hemorheology.
18. Y. Hashimoto (Department of Surgery, Nagoya University School of Medicine, Nagoya): Rheological Consideration on Peripheral Circulation with Special Reference to Blood Viscosity.
19. H. Okino (Medical Transducer Division, Research Institute of Applied Electricity, Hokkaido University, Sapporo): The Pressure Flow Relationships of Human Brachial Artery.
20. M. Saito (Department of Electronic Engineering, University of Tokyo, Tokyo) and T. Furukawa (Nippon Electric Co. Ltd., Tokyo): Some Analysis of the Forces Acting on a Particle in the Liquid Flow.
21. K. Ishikawa (Department of Surgery, University of Tokyo School of Medicine, Tokyo): Accordion-like Arterial Waves.
22. E. Fukada (Biopolymer Physics Laboratory, Institute of Physical and Chemical

Research, Tokyo): Non-Newtonian Viscosity of Blood and Dynamic Viscoelasticity of Blood During Clotting.

23. K. TAKAGI *et al.* (Department of Physiology, Nagoya University School of Medicine, Nagoya): Indirect Blood Pressure Measurement Device not Based on the Korotokov's Principle (An Analysis of the Relationship between Pulse Wave Velocity and Intravascular Pressure).
24. M. Goto *et al.* (Department of Physiology, Kyushu University, Fukuoka): Mechanical Properties of the Different Blood Vessels of the Rabbit and Their Changes with Growth.
25. K. Baba *et al.* (Department of Pathology, Keio University School of Medicine, Tokyo): Relationship between Viscosity and Fluorescence-Polarization.

The program of the informal meeting at the Laboratories of Angiology was as follows:

1. Y. Ogawa: Structure of Blood Capillaries.
2. T. Semba (Department of Physiology, Hiroshima University, Hiroshima): Vasomotor Nerves to Blood Capillaries.
3. Y. Nishida (Department of Physiology, Hiroshima University, Hiroshima): Fluid Flow in the Cell and Tissue Spaces.
4. Y. Nishimaru (ABCC, Laboratories of Angiology, Kure): Contrectility and Regulation of Fluid Flow in the Blood and Lymph Capillaries.

The field covered by the seminar was a wide one but six of the papers were of particular biorheological interest. Only these contributions will be briefly mentioned here.

After introducing various rheological aspects, Dr. Wayland gave an excellent critical review on the flow properties of blood plasma and blood. The experiments performed by the M.I.T. group to try to elucidate the yield stress of blood were discussed in detail. It seems quite apparent that the effect of fibrinogen on the flow properties of blood cannot be related to fibrinogen content alone. Fibrinolytic products along with fibrinogen may be important in determining the ability of fibrinogen to act as a cement in forming red cell aggregates which are important in determining the rheological properties of blood.

After introducing the experimental results about components of large blood vessels and vessel wall structures, Dr. Frasher discussed the experimental methods to obtain the stress-strain curve of the arterial wall and gave an excellent critical review on the mechanical properties of large vessels. The dynamic modulus of large vessels was discussed in detail in relation to the frequency of oscillation. He emphasized that the results in the *in vivo* and *in vitro* studies are quantitatively significantly different. Mechanical properties of microscopic vessels were also discussed and the significance of the state of the smooth muscle was stressed. With regard to capillaries, he emphasized the suggestion by FUNG *et al.* that capillaries should be considered not as discrete tubular structures, but alternatively as endothelial lined tunnels in a gel (the tissue matrix).

Dr. Oka discussed theoretically the influence of the plasmatic zone on the apparent viscosity of blood flowing in a capillary tube. Under the assumption that the central core obeys Casson's equation, an exact formula for the apparent viscosity was derived. This formula may be modified when slippage occurs at the wall.

Dr. Hashimoto discussed the non-Newtonian behavior of blood shown particularly at very low shear rate. He used a cone in cone viscometer and examined the dependence of blood viscosity upon various factors, that is, temperature, hematocrit, plasma protein concentration, molecular weight of plasma protein and molecular weight of dextran in

the serum. He discussed also the variation of the viscosity of human blood in the cases of various diseases.

Using Stokes' approximation, Dr. Satto made an analysis of the forces acting on a rigid sphere placed in a Poiseuille flow where the sphere is executing arbitrary given translational and rotational movements. He obtained the solution of the equations of motion which satisfies the boundary conditions on the surface of the sphere and converges to Poiseuille flow at infinity in a closed form. It is shown that the radial force disappears even if the rotational motion of the sphere is permitted.

Dr. Fukada presented an apparatus for measuring the viscosity and flow curve of blood in a range of shear rate from 2 to 100 sec^{-1}. He also presented an apparatus for measuring dynamic elastic modulus and dynamic viscosity of blood during clotting as functions of time. A considerable variation in the clotting curve is noticed with respect to the storage time after taking the blood. The clotting times become longer and the elasticity and viscosity in the final stage decreases with the increase in the storage time.

SYOTEN OKA