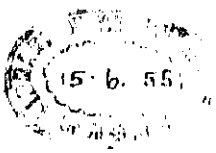
STUDIES IN THE DYNAMICS OF BLOOD IN VESSELS OF CAPILLARY CALIBRE

by

MICHAEL TAYLOR



A thesis

submitted for the degree of

Doctor of Medicine

in the University of Adelaide

From the Department of Pathology

University of Adelaide

October 1954

TABLE OF CONTENTS

PART II. STUDIES ON THE FLOW OF SUSPENSIONS THROUGH NARROW TUBES, WITH PARTICULAR REFERENCE TO BLOOD.

PREFACE

The matter of this thesis falls into two sections; the first deals with capillary endothelial behaviour and the rabbit ear chamber, the second with the hydrodynamics of suspensions and the flow of blood through narrow tubes. At first sight these may not seem to be related topics, but the second was suggested by observations made in the course of the ear chamber experiments. In the capillaries and small vessels the blood was seen to flow as a clear marginal zone with the cells collected in an axial stream. This appearance was one which had been described by many authors, but the cause of the partition did not seem to be well understood. The appearance of a fluctuating bright line in the centre of vessels where the flow was pulsatile suggested that orientation of the cells was taking place in the flowing blood. It was therefore decided to investigate these two phenomena, and to explore the relevant literature in the field of physical chemistry. This work is presented as Part II.

The ear chamber studies have led to the conclusion that the technique has grave defects when employed to observe vascular behaviour, although it remains excellent for morphological work. The

experiments with sympathetic stimulation have provided no evidence that the capillaries were directly responsive. Any changes seen were explicable on mechanical grounds.

The studies of flow are admittedly incomplete, as they have raised problems which could well occupy many years of investigation, but it is thought justifiable to present them at this stage, as they have established foundations upon which future work may be built. I hope that my next project will be an investigation into the amount of mixing which occurs in a flowing suspension. The theory of this and its biological implications have been discussed in this thesis, but it awaits practical investigation.

The observations on the changes in optical density of streams of flowing red blood cells have established that a marginal zone is formed, and have demonstrated the compensatory changes which occur in the axial stream. Some theoretical analysis of the situation has also been undertaken, as an aid in sorting out the factors involved.

The main features of the ear chamber studies have been published (Taylor, 1953); two papers on the capillary tube experiments are in press. (Taylor and Robertson, 1954; Taylor, 1954.)

It may here be appropriate to acknowledge the assistance I have had from many people. Principally I am indebted to Professor J. S. Robertson, in whose Department I have worked while holding a Research Fellowship in Medicine. His many stimulating discussions of this work have been of the greatest assistance to me, and I owe to him not only the ear chamber technique which he taught me, but the original idea of making the optical density measurements.

I must also express my gratitude to the Faculty of Medicine for supporting this work by its grant to me, and to Professor H. N. Robson, of the Department of Medicine, for graciously waiving his rights to me.

To my colleague, Mr. John Dineen, B.Sc., I must record my thanks for the patience with which he has heard me out in times of crisis, and for the keen criticism to which he has subjected my ideas. Dr. Keith Sutherland, of the Division of Industrial Chemistry, C. S. I. R. O., Melbourne, has also been more than kind in discussing my problems with me, both in person and by letter, and I owe much to him.

I have also received helpful advice from Professor H. S. Green, of the Department of Mathematical Physics; Professor A. E. Alexander, of the University of Technology, Sydney; Mr. E. H. Medlin, B.Sc. of the Department of Physics; Dr. R. B. Potts, of the

Department of Mathematics; and Dr. Alan James, of the Division of Statistics, C. S. I. R. O., Adelaide.

Mr. Alan Humphrys made the ear chambers for me, and Mr. Robert Jones has made, and helped me to make the apparatus for the capillary tube experiments in the workshop of the Department of Pathology. Most of the apparatus was designed by the author, but I must acknowledge the valuable suggestions of Professor Robertson, of which I have freely made use.

For technical aid my thanks are due to Miss Jeanette Inns, who gave excellent anaesthetics, and again to Mr. Alan Humphrys, who assisted with the insertion of the ear chambers; also to other members of the Department of Pathology, who have helped me at other times.

The photographs and tables for this thesis were prepared by the author, but my most grateful thanks are extended to Miss Dorothy Miller who spent so much care and time on typing the final copies of the MS.