Catalogue of the papers and correspondence of

Sir John Cowdery Kendrew FRS

(b. 1917)

VOLUME I

List of Contents

Foreword

General Introduction

Sections A - F

by Jeannine Alton
NCUACS catalogue no. 11/4/89

Title:	Catalogue of the papers and correspondence of Sir John Cowdery Kendrew FRS (b. 1917), molecular biologist
Compiled by:	Jeannine Alton
Description level:	Fonds
Date of material:	1927-1988
Extent of material:	ca 2000 items
Deposited in:	Bodleian Library, Oxford
Reference code:	GB 161

© National Cataloguing Unit for the Archives of Contemporary Scientists, University of Bath.

NCUACS catalogue no. 11/4/89

The assembling of the material, and the compilation and production of this catalogue, have been made possible by a generous subvention from

THE LEVERHULME TRUST

SOME OF THE MATERIAL IN THE COLLECTION MAY BE SUBJECT TO RESTRICTED ACCESS.

ENQUIRIES SHOULD BE ADDRESSED IN THE FIRST INSTANCE TO:

The Keeper of Western Manuscripts
The Bodleian Library
Oxford OX1 3BG

LIST OF CONTENTS

			Page
FOREWORD			14
GENERAL INTRODUCTION			15
SECTION A	*NOTEBOOKS, NOTES AND ESSAYS*	*A.1-A.120*	26
INTRODUCTION			27
NOTEBOOKS			29
A.1-A.25	School		29
A.26	War service		32
A.27	University (postwar)		32
NOTES AND ESSAYS			33
A.28-A.31	School		33
A.32-A.118	University		33
A.119	War service		47
A.120	Later miscellaneous notes		47
SECTION B	*SECOND WORLD WAR*	*B.1-B.60*	48
INTRODUCTION			49
CAREER AND CORRESPONDENCE			51
B.1	Career		51
B.2-B.24	Correspondence and papers 1941-46		51
NOTES			55
B.25	Notes		55

		Page
REPORTS		56
B.26, B.27	Coastal Command	56
B.28	Bomber Command	56
B.29	Anti-submarine warfare	56
B.30	Combined Operations	57
B.31	Methodology	57
B.32-B.41	Middle East Command	57
B.42-B.47	South East Asia Command	59
B.48-B.53	Postwar papers	60
HISTORY OF OPERATIONAL RESEARCH		61
B.54-B.60	Correspondence, papers, drafts	61
SECTION C	***RESEARCH***	***C.1-C.308*** 62
INTRODUCTION		65
EARLY RESEARCH		68
C.1	Reaction kinetics	68
INFORMATION RETRIEVAL/DATA PROCESSING		69
C.2-C.5	Information retrieval	69
C.6-C.15	Computation on EDSAC I	70
PROTEIN ANALYSIS PROJECTS		72
C.16	Adult and foetal sheep haemoglobin 1946-58	72
C.17	Muscle 1947-54	72
C.18	Protein solubility c.1949	72
C.19	Procollagen 1951-52	72
C.20	Controlled shrinkage of protein crystals 1952	73
C.21	Polypeptide configuration 1953	73

		Page
C.22	X-ray experiments 1953	73
C.23	Not used. Material transferred to C.1	73
C.24	Chymotrypsinogen c.1956	73
C.25, C.26	Correspondence "New proteins" 1947-69	73
EARLY RESEARCH REPORTS		74
C.27	Reports 1946-53	74
	MYOGLOBIN	75
NOTEBOOKS (Kendrew and collaborators)		75
C.28-C.40	Preliminary work	75
C.41-C.100	Main myoglobin programme	81
C.101-C.116	Collaborators' notebooks	90
C.117-C.125	Atomic co-ordinates/amino-acid sequencing	93
C.126-C.129	Miscellaneous	97
NOTES AND DATA (Kendrew and collaborators)		101
C.130-C.169	Preliminary work	101
C.170-C.189	Main myoglobin programme	106
C.190-C.195	Collaborators' notes and data	108
C.196-C.198	Miscellaneous	110
MATERIALS AND APPARATUS		111
C.199-C.202	Supplies and specimens	111
C.203	Optical diffractometer	111
C.204	Microcamera	112
C.205-C.207	Densitometer	112
C.208,C.209	Computer time	112

		Page
COLLABORATORS AND STAFF		113
C.210-C.238	Individual files	113
C.239-C.247	Chronological files	117
CORRESPONDENCE		118
C.248-C.272	Aspects of myoglobin	118
C.273-C.277	Atomic co-ordinates/amino-acid sequencing	121
C.278-C.291	Publications	122
MODELS		126
C.292	Skeletal model	126
C.293-C.297	Ball-and-spoke model	126
C.298	Science Museum London	127
C.299-C.307	Correspondence	127
MISCELLANEOUS		128
C.308	Pantographs	128
SECTION D	***MRC LABORATORY OF MOLECULAR BIOLOGY CAMBRIDGE D.1-D.39***	129
INTRODUCTION		130
D.1-D.5	Buildings	131
D.6-D.12	Apparatus and equipment	131
D.13-D.32	Staff	133
D.33-D.38	Research and administration	134
D.39	Historical	135

Page

SECTION E CAMBRIDGE : UNIVERSITY AND COLLEGE E.1-E.16 136

INTRODUCTION 137

CAMBRIDGE UNIVERSITY 138

E.1, E.2 Teaching and curriculum 138
E.3-E.5 Committees 138
E.6 Electoral and Advisory Boards 139

PETERHOUSE 140

E.7-E.10 Scholarship and entrance examinations 140
E.11-E.13 Supervision 141
E.14 Prizes 141
E.15, E.16 Mastership elections 141

EUROPEAN MOLECULAR BIOLOGY:
INTRODUCTION TO SECTIONS F, G AND H 142

SECTION F EUROPEAN MOLECULAR BIOLOGY ORGANISATION (EMBO) F.1-F.232 146

INTRODUCTION 148

EARLY HISTORY 151

F.1-F.9 Preliminary meetings and correspondence 1963 151
F.10-F.15 Formal constitution and statutes 152
F.16-F.33 Relations with other organisations 153
F.34-F.42 Policy document 156
F.43-F.56 Funding 158
F.57-F.60 Miscellaneous correspondence 160

			Page
MEMBERSHIP			161
F.61-F.77	Nominations and elections	1963-82	161
F.78,F.79	Circulars and lists	1964-75	162
COUNCIL			163
F.80-F.118A	Correspondence and meetings	1964-80	163
F.119-F.127	Membership and elections	1963-74	167
F.128,F.129	Minutes and circulars	1963-81	168
FUND COMMITTEE			169
F.130-F.132	Membership	1965-74	169
F.133-F.140	Correspondence and papers	1964-74	169
F.141-F.149	Fellowship applications	1964-74	170
F.150	Minutes	1965-73	170
COURSE COMMITTEE			171
F.151-F.153	Membership	1965-74	171
F.154-F.167	Correspondence and papers	1965-74	171
F.168	Minutes and circulars	1966-69	173
LABORATORY COMMITTEE			174
F.169-F.208	Meetings, correspondence and papers	1963-73	174
ADMINISTRATION			181
F.209,F.210	Appointments		181
F.211-F.213	Finance and accounts		181
F.216-F.220	General administrative correspondence		182
SYMPOSIUM COMMITTEE			183
F.221-F.228	Correspondence and papers	1974-81	183
F.229	Minutes	1974-80	183

		Page
MISCELLANEOUS		184
F.230,F.231	Press releases, articles, comments 1963-71	184
F.232	Annual reports 1966-81	184
SECTION G	*EUROPEAN MOLECULAR BIOLOGY CONFERENCE (EMBC) G.1-G.150*	185
INTRODUCTION		186
EARLY HISTORY		188
G.1-G.13	"Swiss Initiative" 1964-67	188
G.14-G.28	Intergovernmental meetings and negotiations 1967-69	190
G.29-G.35	Signing and ratification of Agreement 1969-70	192
GENERAL CORRESPONDENCE AND PAPERS		193
G.36-G.55	1969-79	193
MEMBERSHIP		196
G.56-G.64	1968-76	196
SUBCOMMITTEES AND WORKING GROUPS		197
G.65	Laboratory Working Group I Role of the laboratory	197
G.66-G.73	Laboratory Working Group II Organisation, structure, administration	197
G.74-G.87	Laboratory Working Group III Site of the laboratory	198
G.88-G.91	Laboratory Working Group IV Financial aspects	200
G.92-G.102	Steering Group of Laboratory Working Groups	200
G.103-G.106	Enlarged legal sub-group	201
G.107-G.114	"Andres" Working Group on future of Conference	202

		Page
CONFERENCE AND COMMITTEE PAPERS		204
G.115-G.150	1967-81	204
SECTION H	***EUROPEAN MOLECULAR BIOLOGY LABORATORY (EMBL)*** ***H.1-H.417***	207
INTRODUCTION		210
AGREEMENTS		212
H.1-H.6	Laboratory Agreement	212
H.7,H.8	Headquarters Agreement	213
THE BUILDING OF THE LABORATORY		214
H.9-H.12	Temporary accommodation in Heidelberg	214
H.13-H.20	Early planning and costing	214
H.21-H.34	Building Committee	215
H.35-H.46	Architects, tenders, plans	217
H.47-H.49	Furnishing and interior design	218
H.50-H.55	Inauguration	219
RESEARCH COMMITTEES AND WORKING GROUPS		221
H.56-H.68	Provisional Scientific Advisory Committee (PSAC)	222
H.69-H.97	Scientific Advisory Committee (SAC)	223
H.98	Nuclear Magnetic Resonance (NMR) Working Group	226
H.99	Computer Policy Working Group	226
H.100-H.102	Recombinant DNA (rDNA) Committee	226
H.103-H.140	Scientific Purchases Committee	227
H.141-H.151	Workshops	230
RESEARCH DIVISIONS - HEIDELBERG		232
H.152-H.177	Cell Biology	232
H.178-H.182	Biological Structures	235
H.183-H.202	Instrumentation	235

		Page
OUTSTATION AT DEUTSCHES ELEKTRONEN SYNCHROTRON (DESY) - HAMBURG		240
H.203-H.205	Early History	240
H.206-H.210	Relations with DESY	241
H.211-H.213	DESY Committees	241
H.214-H.217	Staff	242
H.218-H.220	Equipment	242
H.221-H.237	Research	243
OUTSTATION AT INSTITUT MAX VON LAUE - PAUL LANGEVIN (ILL) - GRENOBLE		245
H.238-H.246	Early History	246
H.247	ILL - EMBL Building	247
H.248-H.254	ILL Scientific Council	247
H.255	Staff	248
H.256	Equipment	248
H.257-H.262	Research	248
RESEARCH PROGRAMMES		249
H.263-H.265	Laboratory Research Programmes 1975-87	249
SEMINARS, LECTURES, COURSES		250
H.266-H.273	Seminars	250
H.274-H.279	Lectures	251
H.280	Courses	251
VISITORS AND STAFF		252
H.281-H.291	Visitors	252
H.292-H.296	Staff	253
MEMBERSHIP		254
H.297-H.304	Existing, continuing, proposed new membership	254

			Page
ADMINISTRATION			255
	H.305-H.311	Organisation and planning	255
	H.312-H.318	Committees	256
	H.319-H.324	Finance	258
	H.325,H.326	Staff Association	259
	H.327-H.333	Miscellaneous	259
	H.334-H.344	Appointments	260
DIRECTOR-GENERAL'S NOTES AND CORRESPONDENCE			262
	H.345-H.358	Notes	262
	H.359-H.367	Kendrew's appointments and career at EMBL	263
	H.368,H.369	Personal correspondence	265
	H.370-H.377	Director-General's correspondence	265
FINANCE COMMITTEE AND COUNCIL MINUTES			266
	H.378-H.417	1973-81	266
SECTION J	*UK SOCIETIES, ORGANISATIONS, CONSULTANCIES*	*J.1-J.176*	*269*
SECTION K	*INTERNATIONAL SOCIETIES, ORGANISATIONS, CONSULTANCIES*	*K.1-K.119*	*308*
SECTION L	*LECTURES, PUBLICATIONS, BROADCASTS*	*L.1-L.149*	339
INTRODUCTION			340
	L.1-L.77	Lectures, publications, reviews	342
	L.78-L.98	Radio, televison, films	353
	L.99-L.144	Correspondence with publishers and editors	357
	L.145-L.149	Addenda : Lectures 1946-87	364

			Page
SECTION M	*JOURNAL OF MOLECULAR BIOLOGY*	*M.1-M.37*	384
INTRODUCTION			385
M.1,M.2	Founding papers 1957-59		387
M.3-M.19	Correspondence with editors and authors		388
M.20-M.37	Correspondence with Academic Press		390
SECTION N	*VISITS AND CONFERENCES*	*N.1-N.71*	393
INTRODUCTION			393
SECTION O	*CORRESPONDENCE*	*O.1-O.31*	404
INTRODUCTION			404
SECTION P	*REFERENCES AND RECOMMENDATIONS*	*P.1-P.42*	409
P.1-P.3	Theses and higher degrees		410
P.4-P.17	Appointments and staffing		410
P.18-P.40	Grant applications/research funding		411
P.41,P.42	Miscellaneous		412
SECTION R	*BIOGRAPHICAL*	*R.1-R.51*	413
BIBLIOGRAPHY			423
INDEX OF CORRESPONDENTS AND ORGANISATIONS			435

FOREWORD

The completion of this Catalogue of the personal papers of Sir John Kendrew is a significant event in the work of the National Cataloguing Unit for the Archives of Contemporary Scientists, both in the nature of its subject matter and in the manner of its achievement.

This is not the only occasion on which we have undertaken the task of working on the papers of a living scientist. But it is the first time that an opportunity has been taken to examine such a large collection at a time when the subject was retiring from his major scientific and academic commitments, and was still available to guide us in our analysis of its contents. We are extremely grateful to Sir John for his ready co-operation in this task.

The project has also been significant because it has provided an excellent opportunity to engage the experience and expertise of Mrs Jeannine Alton, the former Executive Director of the Contemporary Scientific Archives Centre. It is difficult to imagine how the task could have been completed within the time available to us without the dedication of Mrs Alton. All researchers in the history of molecular biology will be greatly in her debt.

Finally, the project could not have been tackled without the generous and understanding help of the Leverhulme Trust. On behalf of NCUACS I would like to record our gratitude to the Director, Sir Rex Richards, and the Trustees of the Leverhulme Trust, for their support.

R.A. Buchanan
Director, NCUACS
June 1989

GENERAL INTRODUCTION

PROVENANCE

The material was received from Kendrew at various dates April 1987 to April 1989. Certain additional papers, chiefly those relating to his personal life or to ongoing concerns, remain in his charge during his lifetime.

OUTLINE OF THE LIFE AND CAREER OF SIR JOHN KENDREW

John Cowdery Kendrew was born on 24 March 1917. His mother, Evelyn Sandberg, was a distinguished art historian; she lived in Italy and the boy was brought up by his father Wilfred George Kendrew, tutor of St. Catherine's and Reader in Climatology at Oxford University. They lived in Oxford and also at Bladon near Woodstock; walking and cycling expeditions were frequent, with early interests in natural history, birds and flowers, buildings and (later) photography. Kendrew was educated at the Dragon School Oxford (1923-1930) and Clifton College Bristol (Scholar, 1930-1936), of both of which he became a Governor. In 1936 he went to Trinity College Cambridge as a Major Scholar. While his main subject was chemistry he made it his business to profit as widely as possible from the range of subjects available; he studied and attended lectures in physics, mathematics and biochemistry, taking the last two as half-subjects in Part 1 of the Tripos. He kept up his skills as a photographer and added a growing love of music; these, with architecture and archaeology, remain permanent features of his life. In June 1939 he graduated with First-Class Honours in chemistry and immediately began research in reaction kinetics in the Department of Physical Chemistry. By December 1939, following up an undergraduate interest in radio developed in the Signals Unit of the Cambridge OTC, he was appointed as a Junior Scientific Officer at the Air Ministry and worked first on radar and from 1940 on operational research with special reference to anti-submarine warfare, bombing accuracy and radio aids. Most of his war service was spent abroad, in Cairo with Middle East Command and then in India and Ceylon with South-East Asia Command where he was

officer in charge of operational research and Scientific Adviser to the Allied Air Commander-in-Chief, holding the honorary rank of Wing Commander.

Wartime travels and encounters were to have major effects on his future career. J.D. Bernal, met in Cairo, India and Ceylon, persuaded him of the importance of research into protein, and this was reinforced by a meeting with L.C. Pauling in the course of a roundabout journey home via Australia and America in the spring of 1945. Though he hesitated for some time and explored the possibility of remaining in Government service to continue operational research and planning for peacetime policies, he decided to return to Cambridge, and began a collaboration with M.F. Perutz under the direction of Sir Lawrence Bragg at the Cavendish Laboratory.

Thus began a heroic period: in Kendrew's career and in those of his collaborators, in the subject of research - X-ray crystallographic analysis of protein structure - , in the Cavendish Laboratory and the University of Cambridge. In October 1947 the Medical Research Council set up a Unit for the Study of the Molecular Structure of Biological Systems with Perutz and Kendrew as its total staff; this was the origin of the now famous Laboratory of Molecular Biology, currently more spaciously housed than in the cramped quarters and huts where such brilliant work was achieved in the 1950s. After exploring many possible problems and materials Kendrew chose myoglobin and in particular sperm-whale myoglobin as the most suitable for analysis by X-ray crystallography; he and his collaborators eventually succeeded in producing a three-dimensional model at a resolution of 6-Å in 1957 and 2-Å in 1959. This long and often tedious haul, requiring much manual experimentation as well as increasingly sophisticated computing resources to handle large amounts of data, was rewarded when he shared the Nobel Prize in Chemistry with Perutz (who had continued to work on haemoglobin) in 1962, that *annus mirabilis* when F.H.C. Crick and J.D. Watson (both of the MRC Unit) shared the Prize in Physiology or Medicine with M.H.F. Wilkins for the determination of the structure of DNA.

Alongside the laboratory work, Kendrew had maintained his links with university life principally through Peterhouse which had welcomed him during the early postwar years as a Research Fellow 1947-1953 and later as a Supernumerary Fellow. He was Director of Studies in Natural Sciences for many years with responsibility for selection and tuition of undergraduate members, as well as holding several College offices. He later became an Honorary Fellow of Peterhouse, as also of his undergraduate college, Trinity.

To this period also belongs Kendrew's marriage to Elizabeth Jarvie 1948 and subsequent divorce 1956. J.D. Watson, who was under Kendrew's supervision as a research student, lodged at their home during his early days in Cambridge.

From about the late 1950s Kendrew became more involved in scientific matters in the wider world. He was a founding member and first Honorary Secretary of the British Biophysical Society; in 1959 he undertook the Editorship of the new *Journal of Molecular Biology* which he retained until 1987; he was Deputy Chief Scientific Adviser Ministry of Defence 1960-1963; and he served on committees and advisory boards of the Royal Society where he had been elected to the Fellowship in 1960. With the award of the Nobel Prize this involvement gained momentum and an altogether new dimension in international terms with the development of the European Molecular Biology Organisation (EMBO) and its Laboratory (EMBL); the first exploratory talks seem indeed to have coincided with the journey to Stockholm at the end of 1962. Here too the way was to be long and hard. The formation of an active international association of scientists working in molecular biology (EMBO) was relatively easily achieved during 1963 and 1964, but the formal funding and organisation of such a body required intergovernmental political agreement and did not come until 1969 when the European Molecular Biology Conference (EMBC) was established by agreement by thirteen West European states. The Laboratory project, which was especially dear to Kendrew, was even longer in reaching an agreement (1973), a secretariat and research programme in place (1974) and a formal opening (1978). In all these developments Kendrew was closely involved, on the Council of EMBO, as Chairman of its Laboratory Committee and later its Secretary-General, as Secretary-General of EMBC, and as Project Leader and first Director-General of the EMBL.

Many other commitments to national and international science policy also belong to these years. In Britain they include service on the Council for Scientific Policy and chairmanship of some of its committees and working parties 1964-1972, service on the Defence Scientific Advisory Council 1969-1974, continuing service on the Council and other committees of the Royal Society and on other learned societies in particular the British Biophysical Society and the Institute of Biology. Examples of increasing involvement in international science and scientific policy can be seen in his appointment as Governor of the Weizmann Institute Israel 1964 and the Vice-Presidency and Presidency of the International Union of Pure and Applied Biophysics 1964-1972.

During the 1960s Kendrew continued his research on myoglobin, refining the resolution to 1.4-Å and determining the co-ordinates of virtually all the 2500 atoms in the molecule. In the later 1960s however his other commitments increasingly absorbed his time and energy and his official move to Heidelberg as Director-General of EMBL in 1975 marked the end of active research. The creation of the EMBL as a physical entity and more importantly as an international centre of excellence where several teams and research projects could co-exist and collaborate was a lasting achievement. In addition, or in consequence, Kendrew's diplomatic skills, mastery of detail and experience in chairmanship made him constantly in demand on a wider stage. He served, often as chairman, on the scientific councils or advisory boards of laboratories or research institutions in Naples, Basel, Brussels, Stockholm, Heidelberg and others, on various UNESCO committees, and on many electoral boards for honours and appointments in Britain and abroad. His formal association with science at the international level may be said to have culminated in his service with the International Council of Scientific Unions (ICSU) as Secretary-General 1974-1980 and President 1983-1988.

Kendrew's original contract of secondment from the Medical Research Council and appointment as Director-General of the EMBL was renewed twice, until 1982 when he retired on reaching the age of 65. His last appointment brought him back to Oxford as President of St. John's College until 1987. Since then he has lived in his house near Cambridge, maintaining his connections or continuing active involvement with many organisations, notably as Past-President and Member of the Executive Board of ICSU, as Chairman of the Board of Governors of the Joint Research Centre of the European Economic Communities, and other international associations.

DESCRIPTION OF THE COLLECTION

The material is very extensive and provides information not only on virtually all aspects of Kendrew's own career but on many of the individuals and organisations connected with it. The papers are presented as shown in the List of Contents. Additional explanatory notes or information accompany the separate sections and many of the sub-sections and individual entries in the body of the catalogue. The following paragraphs are intended only to draw attention to material of particular interest.

It should be said at the outset that the entire collection reflects on almost every page what are probably the best-known features of Kendrew's personality: on the one hand his methodical and analytical power, his meticulous not to say obsessive insistence on accuracy and comprehensive documentation, shown in his lifelong interest in record-keeping and the devising of recondite systems for information storage and retrieval; on the other hand, an aloofness or elusiveness of temperament which sets certain limits to personal relations. There are a steadiness and control, a detachment combined with seemingly tireless application which constitute a formidable intellectual armoury and which are present from the earliest records.

Thus, Section A (Notebooks, Notes and Essays) though mainly covering early school and undergraduate work 1930-39 is remarkable for its maturity and for the quantity and quality alike of the content. It is classified under a system of Kendrew's own devising which, though intrinsically clear and flexible, involved careful pagination with at least two referents, and an appreciable measure of cross-referencing in order to amalgamate school and university work; as there are some 9000 manuscript pages of notes, not counting notebooks and essays, the degree of labour required would not have been contemplated, let alone undertaken and carried through, by many. A modern historian of intellectual or educational development will be grateful for the scrupulous indexing of topics, the very full notes of lecture courses and the careful identification of lecturers. The latter included most of the leading figures in Cambridge science immediately before and after the Second World War and some visiting lecturers (J.E. Lennard-Jones, F.W. Aston, R.G.W. Norrish, E.K. Rideal, F.P. Bowden, J.A. Ratcliffe, W. Cochran, F.G. Hopkins, M. Dixon, F.G. Mann, W.J. Pope, D.D. Woods, J. Needham, A. Neuberger, D Keilin, K. Bailey, I. Langmuir may be cited among very many others). The total sequence therefore provides an exceptionally comprehensive picture of the education available at that time at a well-run school science department and a major "science" university.

Section B (Second World War) chronicles Kendrew's overseas service and contributions to operational research, and contains original reports from various commands by him and others. It also includes several letters or private reports on his analysis of the war situation at various dates, of the current and future state of operational research and of his own career plans, his suggestions and proposals for the postwar organisation of government science, and a punched card, designed by him, to be used by aircraft patrol

crews to record incidents.

Section C (Research) is one of the major components of the collection and furnishes a very full record of Kendrew's research, including some of his collaborators' work. It is concerned almost entirely with protein structure analysis, beginning in 1946, and includes the devising of computer programs to handle and process data on machines of progressive sophistication (EDSAC I, EDSAC II, Mercury, IBM 7090 and others), the many years of experimentation with types of myoglobin until in December 1952 sperm-whale emerged as the most promising crystal source, and the ensuing protracted sequence of diffraction pictures, phase determination, scaling, manual and computer calculations leading up to the establishment of contour maps and the final three-dimensional picture at successive Angström resolutions. There is also material on the concurrent and subsequent work on amino-acid sequencing by chemical methods in correlation with the crystallographic analysis. In addition to the main sequence of notebooks, notes and data, there is material relating to specimens, apparatus and models, and correspondence with collaborators and colleagues extending over more than twenty years. The progress of the work can thus be followed in great technical detail. On a more immediately accessible level, there are reports, project diaries, summaries of experimental findings, charts of progress, work-allocations and the like written from the bench or in correspondence throughout the period, and covering key points such as the identification of the best crystalline protein, the excitement of the eventual syntheses and their publication. Attention is drawn to these and other items of interest in the introduction to Section C and at various points in the body of the text.

Section D (The MRC Laboratory Cambridge) is a relatively short section, but contains correspondence on the new building and its extension conducted by the Director M.F. Perutz, and some material on equipment and staff. There are also agendas, minutes and research proposals for Laboratory Board meetings, and a full record of committee meetings of Kendrew's own Structural Studies Division from 1969 (no.1) until his secondment to Heidelberg in 1975.

Section E (Cambridge: University and College) is another short section and does not fully reflect Kendrew's work as lecturer and teacher, or his committee service at Cambridge. His own extremely detailed notes on entrance and scholarship examinations for Peterhouse and the "King's Group" of

colleges in the 1950s are again of interest for the history of education.

Sections F, G and H are all devoted to the history of European molecular biology and constitute another major component of the collection, covering twenty years 1962-82. The extent of the material made it expedient to present it in separate sections for the Organisation EMBO (Section F), the Conference EMBC (Section G) and the Laboratory EMBL (Section H). A general introduction to the topic and to the material has been prepared as well as the specific introductions preceding each section. As has already been stated, Kendrew was closely involved in the movement from its earliest inception; he held high office in its key committees and secretariat and was also active in several channels of the science policy establishment in Britain such as the Council for Scientific Policy and the International Relations Committee of the Royal Society. His unique place at or near the centre of events makes his record of special value in several regards. It is remarkably complete and contains the early history or "founding papers" of all three European bodies, many of them in the form of manuscript or informal letters exchanged with distinguished colleagues throughout Europe as well as in Britain where the Cambridge MRC Laboratory itself provided the first Chairman of EMBO, M.F. Perutz, and many founder members such as S. Brenner, H.E. Huxley, F.H.C. Crick and A. Klug. In addition, the first Secretary-General of EMBO, J. Wyman, has at Kendrew's request made over his own papers and correspondence on the subject for incorporation in the present collection. All aspects of the European molecular biology movement are thus covered: negotiations, discussions and agreements at personal, official, national and international level; research projects, membership and elections; buildings and staffing; budgets, costings and funding - made dangerously unpredictable for the laboratory project by the global inflation and fluctuating European exchange rates in the 1970s; and as time advances a proliferation of committees and working parties. The element of doubt, unfavourable comment and hostility is not neglected; the efforts of founder members to keep the project alive by personal contacts is evident in many contexts. Kendrew's own notes of discussions, planning and problems at all stages are of the greatest interest, especially for the laboratory project; Section H also includes documentation of his own career at EMBL.

Sections J and K are concerned respectively with UK and with international societies and organisations. Each has an alphabetical list of contents and most of the items have a descriptive entry or introductory note.

Of special interest in Section J are the "founding papers" of the British Biophysical Society, papers of the Council for Scientific Policy including those of the Working Groups on molecular biology, on the proposal for EMBL and on the Dainton and Rothschild reports on the organisation of research, and the Council's Standing Committee on International Relations. There is also a full record of the High Energy Particle Physics Review Group chaired by Kendrew, and material relating to various committees and sub-committees of the Royal Society. Correspondence with W.L. Bragg and others at the Royal Institution provides useful links with Kendrew's research career during the myoglobin project; material for the Design Research Unit shows him in an unexpected role in the 1940s submitting ideas for industrial and design applications of scientific advances.

On the international scene (Section K) there are records of Kendrew's extensive service on the councils or advisory boards of institutions and laboratories and of their research programmes - examples among others are the Basel Institute for Immunology, the Laboratory of Molecular Embryology Naples, the Max-Planck-Gesellschaft Munich, the Molecular Biology Department Free University of Brussels, the United Nations University Tokyo - and good documentation for his long and continuing association, begun in 1963, with the Weizmann Institute Israel. The international scientific unions are represented by Biochemistry (IUB) and Pure and Applied Biophysics (IUPAB), but chiefly by the International Council of Scientific Unions (ICSU) which remains one of Kendrew's most important commitments and in which he held high office from 1974.

Section L (Lectures, Publications, Reviews) was considerably expanded at a late stage in the compilation of the catalogue by Kendrew's decision to include his folders of lectures and talks 1946-1987. These appear as addenda and have been extensively cross-referenced to related material, conferences, invitations and other events elsewhere in the collection. They contain many more lectures than previously available and include substantial courses given in America and Japan, and various special invitation lectures.

Section M (*Journal of Molecular Biology*) has been treated separately from other publications because of Kendrew's long involvement with the journal as Editor-in-Chief from its inception and as a Director of Academic Press. Once again there are "founding papers", careful notes and analyses by Kendrew, and miscellaneous material on the fortunes and vicissitudes of the journal and

its publishers over a time-span of thirty years.

Section N (Visits and Conferences) is not extensive and is far from reflecting the extent of Kendrew's travels. His notoriously peripatetic existence becomes apparent by the accumulation throughout the collection of references to journeys in connection for example with European molecular biology, or on behalf of ICSU and its constituent unions, or the official visits for the Council for Scientific Policy, or the regular visits and meetings at other laboratories and institutions.

Sections O, P and R are all short sections. Section O (Correspondence) is not extensive since Kendrew kept almost all his correspondence in the files or notebooks to which it related. One touches here on the reticent element in his temperament; the correspondence is open and friendly yet rarely develops into long-term exchanges. Section P (References and Recommendations) covers a long period and is international in range; some is subject to restricted access. Section R (Biographical) contains some interesting material on Kendrew's career and appointments, including many offers of posts in Britain and abroad. Unsurprisingly, it contains little of a personal nature.

A Bibliography and an extensive index of correspondents complete the catalogue.

It will be seen that the collection comprises material of very different nature and of potential interest in several fields of enquiry. There is the full history of a major scientific discovery as such (the structure of myoglobin) and, in the many research proposals put forward by individuals and institutions including EMBL, examples of how leading scientists saw the key developments in their subject at a particular time. There is material on intellectual training and the diffusion of changing scientific concepts by filtering to a wider public awareness through the educational process at various levels. The international aspects of science can be studied in the organisation, assemblies, membership and evolving preoccupations of the scientific unions and especially of their central body ICSU; while there is exceptional coverage of one field of European co-operation in the history of EMBO, EMBC and EMBL. The material relating to the *Journal of Molecular Biology* reflects an important aspect of the scientific process: the evaluation and

communication of research findings and the criterion of peer-judgment. Of perhaps more specialised interest is the evidence of the scientific contribution to the war effort during the Second World War, seen here in the correspondence and reports on operational research in several fields of hostilities and in the responsibility exercised by people still in their early twenties. It should be recalled that the documents on all these topics include both official papers in the shape of minutes, reports and the like, and also Kendrew's own meticulous notes, drafts and comments which greatly supplement the official material, and background correspondence and discussions which rarely form any part of them.

Some sections or items in the collection may be subject to restricted access.

ACKNOWLEDGEMENTS

Thanks are due primarily to Sir John Kendrew for initially allowing his papers to go forward for cataloguing, and for his continuing invaluable interest in the process. He has made himself freely available for consultation at every stage and placed his almost total recall at the disposal of the compiler. At his instance, Dr. R.G. Parrish and Professor J. Wyman have also made relevant material available from their own records.

Professor Sir David Phillips has kindly given advice and information and helped to identify material on the joint Royal Institution - MRC Unit research.

Dr. E.A. Leedham-Green of Cambridge University Archives and Dr. R.W. Lovatt of Peterhouse have helped with information on Kendrew's Cambridge years.

Members and former members of the staff of the Department of Western Manuscripts Bodleian Library and of NCUACS have been unfailing sources of information, advice and encouragement.

Hazel Gott has faced the processing and revising of the catalogue with remarkable resilience and aplomb.

SECTION A NOTEBOOKS, NOTES AND ESSAYS A.1-A.120

INTRODUCTION

NOTEBOOKS

A.1-A.25	School
A.26	War service
A.27	University (postwar)

NOTES AND ESSAYS

A.28-A.31	School
A.32-A.118	University
A.119	War service
A.120	Later miscellaneous notes

INTRODUCTION

This section includes early school and university notebooks, notes and essays from 1930 to 1939, and one notebook each from Kendrew's war service (A.26) and his later Cambridge career (A.27). There are also some later miscellaneous research notes and postwar lecture notes (A.120). The laboratory notebooks, observations and notes relating to his principal postwar research on myoglobin and other proteins are in Section C.

The most remarkable feature of the material presented here is the diligent care with which Kendrew wrote up his work even from the earliest stages of his career, culminating in the major indexed series of notes at A.40-A.117 which incorporates material from lectures, literature searches and laboratory experiments, drawing on school work as well as Cambridge sources, all classified under a system of his own devising.

The school notebooks are of the standard hardback type, all paginated, bearing not only contemporary legends such as "Set 4" but later inscriptions in red ink showing where they fall into the major indexed series. No notebooks of this kind survive from Cambridge, Kendrew having come to prefer loose pages of small quarto format from his school sixth form period onwards.

Although Kendrew's own talents and diligence were the essential factors in building his career, mention should be made of the high level of work expected and attained at Clifton. The head of Science 1920-40 was the historian of science and later scientific editor E.J. Holmyard. Kendrew recalls (private communication August 1988) that when he entered the sixth form Holmyard prescribed not one of his own many textbooks which were widely used in schools at the time but a German text; no translation was available and the set had rapidly to acquire a reading knowledge of scientific German. The head of physics was W.C. Badcock, whom Kendrew recalls as a particularly good teacher. Comments by these and other masters can be seen on the class exercises in the notebooks and in the essays at A.29. The general essays at A.30, often very thoughtful and marked with critical care, were written for Holmyard and for the Headmaster N. Whatley.

Kendrew did not reach Cambridge until 1936 and the war was to disrupt his and many other lives in 1939. But he had three years of exposure to some of the country's most distinguished scientific minds and used the opportunity fully, offering Chemistry, Physics, Biochemistry and Advanced Mathematics in Part I of the Natural Sciences Tripos and Chemistry in Part II. His extensive reading, assiduous lecture attendance and note-taking are dauntingly documented in the major indexed series, and the careful recording of lecturers' and supervisors' names is valuable for the history of education. On his return to Cambridge in 1946, the focussing of his interest in biochemical and crystallographic studies can be seen in the continuing meticulous lecture notes from 1946. His own work as lecturer and college supervisor and director of studies, for which equally careful records were kept, can be seen in Section E.

NOTEBOOKS

SCHOOL

Physics

A.1 Notebook "Physics" with red ink indications for main index on cover and front page. Paginated 1-140.

pp.1-56, "Electricity", 1930
pp.58-84, "Mechanics" "Hydrostatics", 1931
pp.86-119, "Light"

A.2 Notebook "Physics", with red ink indications for main index on cover and front page. Paginated 1-140.

pp.1-87 used, "Heat", 1931

A.3 Notebook "Physics. Electricity and Magnetism. Lab", with red ink indications for main index on cover and front page. Paginated 1-70. All pages used. 1932.

A.4 Notebook "Physics. Mechanics and the properties of matter. Lab", with red ink indications for main index on cover and front page. Paginated 2-134. All pages used. 1932.

A.5 Notebook "Physics. Electricity and magnetism. Lecture". Paginated 2-70. pp.2-38 used. 1932.

A.6 Notebook "Physics. Mechanics and the properties of matter. Lecture". Paginated 2-50. Not all pages used.

pp.2-8, 1932
pp.9-10, 1933

A.7 Notebook "Sound. Lab.", with red ink indications for main index on cover and front page. Paginated 1-10.

pp.1-4 used, 1933.

A.8 Notebook "Light. Lab.", with red ink indications for main index on cover and front page. Pagination added later to conform with main index system 41(b)-90(b).

pp.41(b)-86(b), 1933

A.9 Notebook "Heat. Lab.", with red ink indications for main index on cover and front page. Pagination added later to conform with main index system 61(c)-110(c).

pp.61(c)-106(c), 1933

A.10 Notebook "Sound. Lec[ture]", paginated 1-30.

pp.1-15 used, 1933

Chemistry

A.11 Notebook "Chemistry Lecture", paginated 1-68.

pp.1-53 used, with Index at rear, 1931.

A.12 Notebook "Chemistry Lecture", paginated 1-68. Dated on front page 1931 but work continues to 1932 and includes revision work for Clifton internal and School Certificate examinations.

A.13 Notebook "Laboratory notebook", with red ink indications for main index on cover and front page and index (probably added later) on front page. Paginated 1-40.

pp.1-38 used, 1931.

A.14 Small format notebook "Chemistry", probably not part of the school sequence. Paginated 1-97. Mainly concerned with classification of elements and periodic table. Undated, but press cuttings stuck at rear, on latest discoveries in physics, are dated 1932.

A.15 Notebook "Chemistry. Extra Lab. 1932", paginated 1-30.

pp.1-25 used, 1932.

A.16 Notebook "Inorganic Chemistry Lecture". Paginated 3-139 (index on front page). Undated but 1932 (see A.17).

A.17 Notebook "Inorganic Chemistry Lecture II", paginated 3-69. Not all pages used. 1932.

A.18 Notebook "Chemistry Organic Lecture", paginated 2-72.

pp.2-62 used, 1932.

A.19 Notebook "Chemistry Organic Practical", with red ink indications for main index on cover and front page. Paginated 1-60.

pp.1-33, 1932
pp.34-54, 1933.

A.20 Notebook "Inorganic Lab.", with red ink indications for main index on cover and front page, and index (probably added later) on front page. Paginated 1-64. 1933.

pp.1-41, Analyses, 1933
pp.42-60, Volumetric analysis, 1933-34
pp.61-64, Qualitative analysis [1933]

A.21 Notebook "Inorganic Lab.", with red ink indications for main index on cover and front page, and index (probably added later) on front page. Paginated 71-137.

pp.71-112, 1934
pp.113-137, 1935.

A.22 Notebook "Chem. Lab.", with red ink indications for main index on cover and front page, and index (probably added later) on front page. Paginated (probably added later) 241-260.

pp.241-259, Analyses, 1935.

A.23 Notebook "Inorganic Analysis", paginated 2-43. Undated; handwriting suggests a date 1932-33.

A.24 Notebook (not standard school sequence format) "Organic Chemistry". Paginated 2-61. Not all pages used. Undated but c.1932.

Analyses, notes on the literature.

A.25 Notebook "Geography Notes", undated and probably very early during Kendrew's time at the Dragon School, Oxford.

Notes, maps, mnemonics. (Kendrew's father was Reader in Climatology, Oxford University and he was attracted to the study of geography at one time.)

WAR SERVICE

A.26 Kendrew's S.O. Book 135, signed and headed "Summary notes".

Material runs 22 November 1940 to 14 March 1941 and covers a wide range of topics on radar and coastal air defence, including diagrams of circuits and installations, lists of air stations and their equipment, notes of visits to coastal squadrons, comments on personnel and equipment. The visits were mainly to squadrons in Scotland and in Northern Ireland, and the material was the basis of Kendrew's reports at B.26.

UNIVERSITY (POSTWAR)

A.27 Binder of "Filofax" pages inscribed "Peterhouse Cambridge", with index of topics as follows:

Mathematical formulae	Sociology
Mathematics	Archaeology
Physics	Geography
Statistics and probability	Botany
General biology	Photography
Psychology	Chronology

Own notes, and notes on books and articles read. Undated but post 1947.

NOTES AND ESSAYS

SCHOOL

A.28 Demonstrations and notes on explosives.

A.29 Essays and questions on scientific topics, some written to time limits as revision or preparation for examinations. A few dated, various dates 1933-35.

A.30 General essays written for E.J. Holmyard and N. Whatley.

A.31 Miscellaneous shorter notes.

Included here are two letters received by Kendrew at Clifton in reply to enquiries by him: 1932 from K. Sisam about word omitted from Concise OED; 1935 from J. Read on a phenomenon omitted from textbook on organic chemistry.

UNIVERSITY

Essays and questions

A.32 "Supervision with Dr Mann 1937" (F.G. Mann, Trinity, Reader in organic chemistry).

A.33 "Supervision with Dr Feather 1937, 1938" (N. Feather, Trinity, University Lecturer in physics).

A.34 "Supervision with Dr Feather 1938".

A.35 Miscellaneous essays, some for F.G. Mann, most for "Dr Hoar" [T.P. Hoar], others without attribution.

A.32-A.34 are on the small quarto pages used for the main indexed series of notes. A.35 is on the large quarto often used in Cambridge in the 1930s.

Teaching material

A.36 Practical biochemistry, Michaelmas Term 1937.

Material for 24 classes.

A.37 Practical biochemistry, Lent Term 1938.

Material for 22 classes.

A.38 Practical biochemistry, Easter Term 1938.

Material for 5 classes.

Examinations

A.39 Natural Sciences Tripos question papers: Preliminary 1937, Part I 1938 (Chemistry, Biochemistry, Physics, Mathematics), Part II 1936, 1939 (Chemistry).

Some papers annotated by Kendrew.

Major indexed series of notes and lectures

This consists of almost 9,000 manuscript pages of small quarto format. The main period covered is Kendrew's undergraduate career 1936-39, but school notes and lecture notes are also included and the Cambridge lectures extend to postwar courses 1946-50 (see A.49, A.61, A.91-A.93, A.104-A.107, A.111).

Kendrew's method of classification is preserved separately at A.40 in the "code-book", also written on the same format on loose pages. It is clear and flexible. There are four basic topics: chemistry, physics, biology, mathematics, each with a code prefix. For chemistry this is upper case letters A-D, for physics lower case letters a-h, for biology Greek characters α-δ and for mathematics Roman numerals I-IV.

Within each topic the organisation is as follows:

code prefix followed by numbered pages - systematic notes and notes on the literature eg. C.1-C.172.

numbered pages followed by code prefix - lecture notes eg. 113C-320C.

numbered pages followed by code prefix in brackets - laboratory notes eg. 1(C)-70(C).

Almost all the sequences have an index of contents. In addition the "code-book" contains a detailed subject index of elements, compounds, methods, definitions, apparatus and instruments etc. Cambridge lecturers are always named and some of the main source books for the notes are also identified. A few invitation lectures outside the routine university teaching programme are also included. The total sequence thus provides an exceptionally full conspectus of the intellectual training then available, though it may be doubted how many took such diligent advantage of it.

A.40 "Code-book", explaining classification system and including subject index.

Chemistry

Code-prefix upper case letters, subdivided into:

A. Systematic inorganic chemistry.

B. Theoretical and general chemistry.

C. Physical chemistry.

D. Organic chemistry.

A. Systematic inorganic chemistry

A.41 Systematic inorganic chemistry notes, arranged by groups, each group indexed, the whole paginated A0-A473 with some pages sub-divided.

A.42 Part I Lecture course "Inorganic chemistry", by H. McCombie, Lent and Easter terms 1938, paginated 0A-33A. Index on first page.

B. Theoretical and general chemistry

A.43 General notes and notes on the literature (school and university material), index on front page, paginated B0-B165, some pages sub-divided.

A.44 Part II lecture course "Theoretical Chemistry" by J.E. Lennard-Jones, Michaelmas 1938, Lent 1939, index on front page, paginated 0B-77B.

A.45 Part II lecture course "Thermodynamics" by J.K. Roberts, Michaelmas 1938, index on front page, paginated 78B-142B.

A.46 Part II lecture course "Crystal Chemistry" by R.C. Evans, Lent 1939, index on front page, paginated 143B-218B.

A.47 Part II lecture course "Valency" by W.C. Price, Easter 1939, index on front page, paginated 219B-243B.

A.48 Chemical Society lecture "Fireworks" by Dr R.E.D. Clark, paginated 244B-247B.

A.49 "Theories of molecular structure" by J.E. Lennard-Jones, Lent and Easter terms 1950, index on front page, paginated 248B-412B.

A.50 Laboratory notes, mainly Cambridge work 1937-39 but includes a little earlier school work, paginated 1(B)-202(B).

C. Physical chemistry

A.51 General notes and notes on the literature, mainly university but some school material, indexes on pp.C0, C60, C160, paginated C0-C187, some pages sub-divided.

A.52 Part I lecture course "Physical chemistry" by R.G.W. Norrish, Michaelmas 1937, index on front page, paginated 0C-111C.

A.53 Part II lecture course "General physical chemistry", Michaelmas 1938 (by F.P. Bowden) Lent 1939 (by E.K. Rideal), index on front pages, paginated 113C-320C.

A.54 Part II lecture course "Colloids", Michaelmas 1938, by E.K. Rideal, index on front page, paginated 321C-374C.

A.55 Part II lecture course "Surface reactions", Michaelmas 1938, by E.K. Rideal, index on front page, paginated 375C-432C.

A.56 Part II lecture course "Some aspects of biocolloids", Michaelmas 1938, by E.K. Rideal, index on front page, paginated 433C-475C.

A.57 Part II lecture course "Electrochemistry", by F.P. Bowden, Lent 1939, index on front page, paginated 476C-530C.

A.58 Part II lecture course "The structure of molecules" by C.B. Allsopp, Lent 1939, index on front page, paginated 531C-582C.

A.59 Part II lecture course "Reactions in solution" by E.A. Moelwyn-Hughes, Easter 1939, index on front page, paginated 583C-615C.

A.60 Lecture "Recent developments in the study of films. By Dr Langmuir of the GEC" [Irving Langmuir], 13 October 1937, paginated 616C-617C.

A.61 "Modern theoretical aspects (polymers)", Summer 1946, by F. Eirich, paginated 618C-636C.

A.62 Laboratory notes and experiments October 1937 - February 1939, paginated 1(C)-169(C).

D. Organic chemistry

A.63 Systematic organic chemistry notes on acrylic compounds, index on front pages, mainly university but includes a little school material, paginated D1-D335, many pages sub-divided, some re-numbered and a jump in numeration at D130.

A.64 Systematic organic chemistry notes on cyclic compounds (benzenoid rings), index on front pages, includes a little school material, paginated D400-D698.

A.65 Systematic organic chemistry notes on cyclic compounds (quinonoid rings), alicyclic, and others, indexes on D700, D760, paginated D700-D947 with a jump in numeration at D812.

A.66 "Organic chemistry - general", notes and notes on the literature, school and university material, index on first page, paginated D1000-D1147.

A.67 Part I three-term lecture course "Organic chemistry" by W.J. Pope, Michaelmas 1936, Lent and Easter 1937, P. Maitland, Easter 1937, index on front pages, notes for Lent 1937 only, paginated 1D-5D, pages much sub-divided.

A.68 Part II three-term lecture course "Organic chemistry" by F.G. Mann, Michaelmas 1938, Lent and Easter 1939, index on front page, lectures all dated, very full notes paginated 6D-351D.

A.69 Part II lecture course "Stereochemistry", by W.J. Pope, Lent 1939, index on front page, paginated 352D-397D.

A.70 "Some aromatic compounds", lecture to Chemical Society 22 October 1937 by F.B. Kipping, paginated 398D-404D.

A.71 Laboratory notes, analyses and experiments 1936-39, paginated 1(D)-179(D). Pp.78(D)-92(D) are "Report of work carried out at ICI Laboratory, Blackley, Manchester August 1938".

Physics

Code-prefix lower case letters, sub-divided into:

a Electricity

b Light

c Heat

d Mechanics: properties of matter

e Sound

f Atomic physics: general

g Crystal physics

h Philosophy and scientific method

a Electricity

A.72 Notes and notes on the literature, mainly university (to 1939) but includes a little school material, indexes on a0, a115, paginated a0-a158, several pages sub-divided.

A.73 Part I lecture course "Electricity" by J.A. Ratcliffe, Michaelmas 1937, Easter 1938, index on front pages, paginated 0a-204a.

A.74 Practical electricity, laboratory notes and experiments at Clifton, 1935-36, some initialled W.C.B. [Badcock], paginated 131(a)-239(a); earlier pages to be supplied from notebooks at A.1, A.3

A.75 Practical electricity, laboratory notes and experiments, Cambridge 1937-38, paginated 241(a)-404(a).

b Light

A.76 General notes, school and university material, indexes on b0 and b152, paginated b0-b234.

A.77 Part I lecture course, by A. Wood, Lent and Easter 1937, index on front pages, paginated 1b-114b.

A.78 Practical light, laboratory notes and experiments, at school 1935 paginated 91(b)-110(b), earlier pages to be supplied from notebooks at A.1, A.2, A.8, and university 1937-38 paginated 117(b)-222(b).

c Heat

A.79 General notes, school and university material, indexes on c0 and c36, paginated c0-c97, several pages much sub-divided.

A.80 Part I lecture course "Heat", by Dr H. Carmichael, Lent 1938, index on front page, paginated 0c-112c.

A.81 Practical heat, laboratory notes and experiments, at school 1935 paginated 111(c)-134(c), earlier pages to be supplied from notebooks at A.2, A.9, and university 1936-37 paginated 141(c)-198(c).

d Mechanics: properties of matter

A.82 General notes, school and university material, index on front page, paginated d0-d125.

A.83 Part I lecture course "Mechanics" by A. Wood, Michaelmas 1936, index on front pages, paginated 1d-100d.

A.84 Practical mechanics, laboratory notes and experiments, at school 1935 paginated 71(d)-100(d), earlier pages to be supplied from notebooks at A.1, A.4, and university 1936-38 paginated 101(d)-204(d).

e Sound

A.85 General notes, index on front page, paginated e0-e22.

A.86 Part I lecture course "Sound", by A. Wood, Lent and Easter 1937, index on front page, paginated 1e-39e.

A.87 Practical sound, laboratory notes and experiments 1936 paginated 11(e)-23(e); pp.1(e)-10(e), referring to school work, to be supplied from notebook at A.7

f Atomic physics

A.88 General notes and notes on the literature, index on front page, school and university material, paginated f0-f103, some pages sub-divided.

A.89 Part I lecture course "Isotopes", by F.W. Aston, Michaelmas 1936, index on front page, paginated 0f-22f.

g Crystal physics

Most of this material is postwar.

A.90 Notes on the literature, index on front page, paginated g0-g51.

A.91 Lectures on "Crystal Physics: selected topics" by W.H. Taylor, Lent and Easter 1946, index on front pages, paginated 0g-101g.

A.92 Lectures on "Fourier methods" by H.D. Megaw, Lent 1948, index on front page, paginated 102g-147g.

A.93 Lectures on "Some properties of the reciprocal lattice", by W. Cochran, Lent 1950, paginated 148g-179g.

h Philosophy and scientific method

A.94 Notes on the literature (made in last terms at school 1936) paginated h1-h23.

Biology

Code-prefix Greek characters, sub-divided into:

α Biochemistry

β Zoology

γ Botany

δ Physiology

α Biochemistry

Much of this material is postgraduate or postwar.

A.95 Notes on the literature, university and postwar, index on front page, paginated α0-α75.

A.96 Part I three-term lecture course "Biochemistry", Michaelmas 1937, Lent and Easter 1938, index on front pages. Given by a series of lecturers; names include F.G. Hopkins, D.J. Bell, E. Holmes, T.R. Parsons, E.H.F. Baldwin, D. Needham, J. Needham, M. Dixon, D.D. Woods. Paginated 0α-353α, some pages sub-divided.

A.97 "Cell respiration and biological oxidations", by M. Dixon, Michaelmas 1939, index on front page, paginated 354α-417α.

A.98 "Some aspects of intermediary metabolism", by Dr Holmes, Michaelmas 1939, index on front page, paginated 418α-432α.

A.99 "Biochemistry of carbohydrates", by D.J. Bell, Michaelmas 1939, index on front page, paginated 433α-483α.

A.100 "Enzymes", by M. Dixon, Michaelmas 1939, index on front page, paginated 484α-535α.

A.101 "Plant biochemistry", by N.F. Hill, Michaelmas 1939, index on front page, paginated 536α-587α.

A.102 "Organisation and physical chemistry of amino-acids and proteins", by A. Neuberger, Michaelmas 1939, index on front page, paginated 587α-620α.

A.103 "Some aspects of protein chemistry", by Professor Ferry (visiting lecturer from Harvard), 23 November 1937, paginated 621α-623α.

A.104 "Respiration and respiratory carriers", by D. Keilin, Lent 1946, index on front page, paginated 624α-669α.

A.105 "Methods of X-ray analysis and their application to biological problems", by M.F. Perutz, Lent 1946, index on front page, paginated 670α-699α.

A.106 "Protein and enzyme kinetics", by P. George, Easter 1946, index on front page, paginated 700α-736α.

A.107 "Proteins", by K. Bailey, Michaelmas 1946, index on front page, paginated 737α-766α (last note reads "course abandoned").

A.108 Practical biochemistry, laboratory notes and experiments, Michaelmas 1937, Lent 1938, index on front pages, paginated 0(α)-151(α).

β Zoology

A.109 Notes on lectures at Clifton 1936, index on front page, paginated 0β-118β.

γ Botany

A.110 Notes on lectures at Clifton 1936, index on front page, paginated 0γ-145γ.

δ Physiology

A.111 Part II lecture course "Cell Physiology" by E.N. Willmer, A.L. Hodgkin, D.K. Hill, Michaelmas 1946, Lent 1947, index on front page, paginated 0δ-129δ.

Mathematics

Code-prefix Roman numerals, sub-divided into:

I General notes

II Analysis

III Vectors and statistics

IV Differential equations

I General notes

A.112 Miscellaneous mathematical notes, algebra, trigonometry, calculus, mechanics, index on front pages, paginated I 0-I 74.

II Analysis

A.113 "Analysis", by H.M. Taylor, Lent 1937, index on front pages, paginated II 1-II 151.

III Vectors and statistics

A.114 "Vectors, tensors, numerical methods, interpolation statistics", by R.S. Stoneley, Michaelmas 1937, Easter 1938, index on front pages, paginated III 0-III 172.

A.115 Unpaginated notes and calculations on tensors.

A.116 Statistics. Notes and calculations, undated but probably done during war (on poorer quality paper). Includes on pp.III 225-III 232 a "Summary of ORS (B.C.) Report 113 Note on the comparison of loss rates" dated 1 November 1944. Index on front page, paginated III 174-III 232.

IV Differential equations

A.117 Part I lecture course "Differential equations, special functions, integrals", by F.C. Powell, Lent 1938, index on front pages, paginated IV 0-IV 133.

Other University notes

A.118 Notes, experiments, laboratory work, abstracts and notes on the literature, July 1939 - January 1940, on mutarotation, Kendrew's first research work with E.A. Moelwyn-Hughes. See also C.1.

A.119 Notes on radar research carried out with TRE (Telecommunications Research Establishment, Malvern) February-June 1940 on Barkhausen-Kurz oscillators, aerials, valves etc. Also notes on the literature. Made on same format as main university notes but not paginated.

A.120 Bundle of small format "Filofax" notes on scientific subjects but miscellaneous content and date. Includes:

Notes on the literature (proteins, X-ray diffraction).

Notes taken at lectures, mainly special lectures at Cambridge 1946-49.

Notes taken at visits and conferences, papers and discussions, visits to laboratories and research in progress, including visits to USA 1951, 1953. Material extends to 1962.

SECTION B SECOND WORLD WAR B.1-B.60

INTRODUCTION

CAREER AND CORRESPONDENCE

B.1	Career
B.2-B.24	Correspondence and papers 1941-46

NOTES

B.25	Notes

REPORTS

B.26, B.27	Coastal Command
B.28	Bomber Command
B.29	Anti-submarine warfare
B.30	Combined Operations
B.31	Methodology
B.32-B.41	Middle East Command
B.42-B.47	South East Asia Command
B.48-B.53	Postwar papers

HISTORY OF OPERATIONAL RESEARCH

B.54-B.60	Correspondence, papers, drafts

INTRODUCTION

Kendrew (private communication July 1988) describes how he came to be involved with radio research in prewar Cambridge as follows:

> "Being a contrary character, at my public school where almost everyone joined the OTC I refused to do so; at Cambridge, where almost no one joined, I proceeded to do it. I joined the Signals Unit, of which W.B. Lewis was - I think - Commanding Officer. Having joined, a friend (Jim Wilkins) and I discovered that Lewis had a contract with the War Office to develop ultra-shortwave two-way radio, and that he needed spare-time help with this. The work was non-secret and had no connexion with radar; the wavelengths involved were 3m and 66cm - very short by the standards of those days; but it meant that we could evade some uniformed parades and various tedious chores by enrolling ourselves with him in what I think was known as the Research Section - and as far as I remember we were the only members of it. As a consequence I had my picture in the newspaper relaying results from the track to the scoreboard at an athletic meeting at the White City (the headline read 'Meet the walking wireless man'). When the War came I was interviewed by the Cambridge Recruiting Board and told to continue my academic research, which I did not find very satisfying with all my friends going off to the armed services. I had <u>no</u> idea about radar but I had heard a rumour that Lewis was involved in something interesting and I wrote to him with the result that I was recruited into TRE."

His wartime career began in December 1939 when he was appointed a Junior Scientific Officer at the Air Ministry and he remained a Temporary Civil Servant with Honorary commissioned rank throughout. He worked on Operational Research (OR) with special reference to anti-submarine warfare, bombing accuracy and radio aids. During the early months of 1940 he worked as an officer of TRE (see A.119) and in the autumn of that year was seconded to Coastal Command to study and advise on the installation and operation of ASV (Air Detection of Surface Vessel) equipment (B.26). In September 1941 he was posted with the rank of Squadron Leader to Middle East Command, visiting Malta in October and December to instruct aircrew and controllers in the use of ASV; from December 1941 he was stationed in Cairo at Headquarters RAF Middle East,

concerned with coastal, bomber and army co-operation matters. During this period he produced a very successful "Handbook for aircrews and controllers", often referred to as a "Bible" (B.35). In December 1943, after a period of home leave, his rank was raised to Wing Commander on his move to South East Asia Command where he served in India and Ceylon as officer in charge of OR and, from June 1944, as Scientific Adviser to the Allied Air Commander-in-Chief South East Asia. His long period of overseas service ended when he handed over his command in February 1945 and returned via Australia, the South West Pacific and USA to London where he rejoined the Air Ministry in June 1945. After considerable thought about the prospects of remaining in government service, Kendrew accepted a Senior Department of Scientific and Industrial Research grant to continue his academic career at Cambridge and resigned from the Ministry with effect from 10 January 1946.

The essential requirement of detailed and accurate data for the compilation of official OR reports chimed well with Kendrew's meticulous temperament and fostered, if it did not inspire, a continuing interest in the indexing and organisation of information (B.25, B.36, B.37, B.52).

An account of operational research in the RAF and of Kendrew's wartime contributions can be found in Air Ministry Air Publication 3368, *The Origins and Development of Operational Research in the Royal Air Force*, London HMSO, 1963.

CAREER AND CORRESPONDENCE

Career

B.1 Miscellaneous documents on Kendrew's wartime career: appointment as Junior Scientific Officer Air Ministry December 1939, notification of commissions as Squadron Leader September 1941, Wing Commander December 1943.

Correspondence and Papers 1941-46

These are the contents of Kendrew's "Personal" or "D/O" (Demi-Official) files and consist of letters, carbon copies, memoranda and shorter communications sent or received by him, principally during his overseas service at HQ RAF Middle East and with South East Asia Command. The documents had been numbered and tagged by him, a new file being opened when the total reached about one hundred items. The files thus created were bulky and in poor condition, and have been replaced with the contents divided into more manageable units while retaining their original order; it should be noted that this numerical order does not correspond to the chronological order of writing, reflecting the postal and administrative delays often referred to in the letters themselves.

The documents cover all aspects of Kendrew's service career during this extensive period:- postings and promotions of self and colleagues, preparation and circulation of OR reports, personal news of friends serving elsewhere, visits to or with Kendrew by others, testing of equipment, data collection etc. A leit-motif is delays and inadequacy of supplies and personnel. Some indication is given in the entries of material of special interest, but there has been no attempt to calendar the full range of the correspondence.

15 December 1941 - 19 May 1943

B.2 15 December 1941 - 11 September 1942 (numbered 1-25).

Setting up OR in Cairo; Kendrew's manual for pilots (R.17, see B.35); proposal (July) to transfer him to India to initiate an OR Section (strongly resisted because of pressure of work and shortage of personnel in Cairo); includes several letters from Kendrew to R.A. Watson-Watt on OR matters.

6 June - 23 August 1944

B.11 6-25 June (numbered 1-25).

B.12 17-30 June (numbered 26-50). N.B. Letters go up to 17 July.

Kendrew's letter of 17 July is a full analysis of the war situation in South East Asia, the future of OR in the Pacific theatre, and his own career for the remainder of the war and subsequently.

B.13 20 July - 7 August (numbered 51-75).

B.14 3-23 August (numbered 76-100).

22 August - 5 December 1944

B.15 22 August - 5 September (numbered 1-25).

B.16 28 August - 16 September (numbered 26-50). N.B. Letters go up to 21 October.

Reports and information on SEAC and Pacific theatre, move of ORS to Kandy, Ceylon, visit by J.D. Bernal, proposed visit by A.C. Menzies.

B.17 22 September - 8 November (numbered 51-75).

Work on night vision, acclimatisation, reports, visit by J.D. Bernal, A.C. Menzies.

B.18 15 November - 5 December (numbered 76-100).

Visits by J.D. Bernal, A.C. Menzies, C.H. Waddington. Kendrew's letter of 17 November (no. 78) refers to the opportunity offered him to return to UK as Officer in charge of ORS Fighter Command, and his view that the commitments of the Command had by then been so reduced that the posting was not attractive to him.

23 November 1944 - 27 February 1945

B.19 23 November - 20 December 1944 (numbered 1-30). N.B. Letters go up to 5 January 1945.

B.20 2-16 January 1945 (numbered 31-60). N.B. Letters go up to 29 January.

B.21 29 January - 27 February (numbered 61-90).

Kendrew handed over OR Section to his successor, G.A. Roberts, on 27 February, leaving on 4 March to return to UK via Australia, New Guinea, the Philippines, USA and Canada.

B.22 Arrangements for tour of Australia, South West Pacific Area and USA, January-April 1945. Mainly official signals, passes etc.

B.23 Miscellaneous correspondence December 1944 - 4 March 1946.

These are the unnumbered contents of a "D/O" file and include continuing correspondence on Kendrew's Pacific and American tour before returning to UK, exchanges with staff members, continuing work on OR and on postwar career plans, testimonials for former serving officers.

B.24 Shorter correspondence on pay, allowances, taxation during overseas service in SEAC, December 1943 - October 1945.

NOTES

B.25 Miscellaneous manuscript notes.

This is an assemblage of tightly written notes on a series of small format (17mm x 9mm) early "Filofax" lined and graph pages, with dividers. They are not in chronological or alphabetical order but follow the coded "Arrangement of notes" devised by Kendrew and laid out on the first two pages of the sequence.

The material is divided into two main areas "Operational" and "Technical". It contains, often in very condensed form, information on a wide variety of topics relating to air power, allied and hostile, in all theatres of war, radar and navigation aids, bombing and detection devices, circuits and equipment, anti-submarine warfare, analyses of performance in defence and attack etc. It derives variously from a study of official documents or published reports, Kendrew's own activity in operational research and visits to air stations, committee or policy decisions. Most entries are dated, the main coverage being July 1939 - May 1945, but there are sections under "TRE" and "RDF Hist." which incorporate material going back to 1930.

See A.119 for Kendrew's notes on radar research February-June 1940, A.26 for his S.O. Book of notes on radar and coastal air defence November 1940 - March 1941, A.116 for notes on OR.

REPORTS

Most of these bear the wartime classification "Secret" or "Most Secret". Several are by Kendrew, or by members of his OR units who feature in the correspondence files. Some are of interest in bearing notes by Kendrew about their history (see B.27, B.28 and also B.60) and there are copies of two papers by P.M.S. Blackett (B.31) described as "classics" by H.M. Barkla (private communication November 1987).

The material is duplicated typescript, sometimes with manuscript additions or corrections.

Coastal Command

B.26 Reports by Kendrew on arrangements for ASV (Air Detection of Surface Vessel) installation and use in Coastal Command squadrons, visits, inspections and flights to test equipment. Various dates January-September 1941.

B.27 Kendrew's folder of Coastal Command reports (not a complete set), June 1941 - March 1943, with running classification ORS/CC.

Nos. 125, 127, 128, 130 (by Kendrew), 131 (by Kendrew), 132, 133, 134 (undated report and diagrams by Kendrew on U-boat hunts carried out off Ireland), 135, 142, 143, unnumbered, 144, 145, 146, unnumbered, 150, 160 (undated report and diagrams by Kendrew), 181, 186, 192 (with manuscript diagrams by Kendrew), 204, 210, 212A, 218 (with manuscript note by Kendrew "Draft of unpublished ORS/CC Report No. 218"), 222.

Bomber Command

B.28 ORS (B.C.) Reports nos. 14, 40, 52, S.176 (with a manuscript note by Kendrew "Officially destroyed"); reports dated 1942, 1944 and an undated report.

Anti-Submarine Warfare

B.29 Miscellaneous reports and manuals 1941-42, 1944.

Combined Operations

B.30 Miscellaneous papers 1942.

OR Methodology

B.31 Two papers by P.M.S. Blackett October 1941, "Scientists at the Operational Level" (ORS/CC 154), and "Note on certain aspects of the methodology of Operational Research" (incorrectly dated October 1942).

Middle East Command

B.32 Kendrew's binder inscribed "ORS/ME Routine Reports on A/S [anti-submarine] and anti-shipping operations", with his manuscript index.

Reports run December 1941 - July 1943, not necessarily in numerical or chronological order, as follows: R4 (missing), 5, 8, 11, 14, 15, 20, 22, 29, 28, 37, 33, 35, 45.

B.33 Kendrew's binder inscribed "ORS (ME) Bomber operations. Close-support operations. Defensive ground RDF" [Radio Direction Finding], with his manuscript indexes for each topic.

The papers are variously classified as M [Memorandum], R [Report], V [Visit] and are not necessarily in numerical or chronological order.

Bomber operations February-July 1943: M.27, R.34, M.28-32, R.41, R.30, R.32, R.36, R.39, R.43.

Close-support December 1942 - August 1943: V.4, V.8, M.29, R.40, R.48.

Defensive ground RDF February 1942 - August 1943: M.8, R.16, R.18, R.19, M.17, M.18, R.21, M.19, R.25, V.5, M.26, R.47.

B.34 Kendrew's binder inscribed "ORS (ME) Miscellaneous papers by J.C.K. and Coastal Section". There are four sections each with his manuscript index.

continued

Miscellaneous reports on sea operations January 1941 - August 1943: unnumbered, M.1, M.3, M.5, M.15, R.24, R.26 (missing), M.25, unnumbered, M.33, R.42.

Miscellaneous short reports on sea operations (by Kendrew), without official numbers, March 1942 - June 1943.

Papers on close-support and radio aids, January-September 1942: M.6, M.7, M.9, unnumbered, R.7, unnumbered. See B.40 for correspondence and memoranda about R.7.

Miscellaneous papers (by Kendrew), without official numbers, March-November 1942. Paper listed for 12 September is missing.

B.35 "The operational employment of ASV Mk.II: a handbook for aircrews and controllers."

This was originally ORS (ME) Report no.17 of 1 July 1942, by Kendrew, which was very favourably received and issued separately. It is referred to in the correspondence, often as Kendrew's "Bible". Folder includes copy of R.17 as first issued, revised edition of 1 August 1943 and version issued by RAAF Headquarters Melbourne n.d.

B.36 Miscellaneous reports part or all by Kendrew March, May, June 1943.

B.37 Miscellaneous reports by ORS (ME) additional to those in Kendrew's binders. Includes R.49, Education Publication no.1 (Glossary of technical terms and abbreviations), but mainly related to Instruction no.34 (Operational and intelligence summaries and reports), preparation and design of log sheets, card indexes (some annotations by Kendrew and others).

See B.60 for a historical report by ORS ME.

B.38 Coastal Command Tactical Instructions (CCTI), circulated by HQ, RAF, ME but not produced by them. Not a complete set.

Nos. 15, 18, 22-27, 29, 30, 32-37, 41.

B.39 Coastal Command Tactical Memoranda (CCTM), circulated by HQ, RAF, ME but not produced by them. Not a complete set.

Nos. 2, 13, 20-23, 25-29, 31-35, 41, 44-46, 49, 50, 54, 57-59.

B.39A Miscellaneous naval reports and memoranda.

B.40 Correspondence and memoranda 1942 about Kendrew's report "Some aspects of air co-operation with the army and possible radio aids thereto" (R.7 at B.34) suggesting wider use of "Rebecca" RDF system.

B.41 Small format photographs of Italian submarine hit off Tobruk November 1942 (3) and tank hit in Western desert April 1943 (2).

South-East Asia Command

B.42 Progress reports of ORS Air Command, by Kendrew, nos. 4-7, January-December 1944.

B.43 "Miscellaneous papers produced by self", November 1943, October 1944 and n.d. ("Pacific Report" - incomplete), a few miscellaneous notes, calculations, graphs.

B.44 ORS Air Command Reports nos. 6-11, 13-21 February-December 1944 (no.6 by Kendrew and others).

B.45 ORS Air Command Memoranda nos. N.7, 9-12, January-December 1944 (no. 12, on bomb and depth charge trials in Ceylon jungle, is by Kendrew and includes photographs of him on site after explosions).

B.46 ORS Air Command Memoranda nos. NB 16, 17 April, June 1944; unnumbered report April 1944; two papers from Jungle Targets Research Unit February 1945 on bomb and napalm trials.

B.47 Folder of reports assembled by Kendrew from Australian and American sources on various topics in preparation for continuation of hostilities in Pacific theatre April 1944 - May 1945: radar and weapons requirements, flame-thrower fuel, fatigue in tropical conditions etc. Some are referred to in the correspondence files.

Postwar Papers

Reports, suggestions and plans by Kendrew on specific OR matters and on the organisation of government science.

Operational research

B.48 "Notes on a project for the compilation of a comprehensive manual of bombing data . . . ", 16 May 1945 written during Kendrew's visit to Washington on his way back from SEAC, with correspondence August 1945.

B.49 "Operational research in RAF Commands", December 1945 with a note "written for the Joint Sciences Committee, A.Sc.W" [Association of Scientific Workers].

Organisation of Science

B.50 "Notes on the national organization of science" August 1945.

B.51 Ideas on government science, and on own career, in the form of a letter to C. Gordon (Air Ministry) August 1945.

B.52 "On the application of mechanical indexing systems to the Central Register" (of scientific manpower) September 1945. Included here is an example of a punched card for aircraft patrol report, designed by Kendrew, probably at an early stage of his war service.

B.53 "The post-war strength of scientific staffs in the defence ministries, and its relation to post-war staffing of government research generally" n.d.

HISTORY OF OPERATIONAL RESEARCH

Correspondence, Papers, Drafts

B.54 Correspondence 1948 with official historian of early ASV, including Kendrew's recollections and comments on his own OR work in Coastal Command and Middle East.

B.55 "Wise remarks on OR", notes for a talk or article, part in short-hand which Kendrew taught himself during the war, n.d.

B.56 Kendrew's review (for *Endeavour*) of A.P. Rowe's *One story of radar*, 1948.

B.57 "Operational Research".

Part-typed, part manuscript draft for extensive (14 pp) article requested for *Science and Mankind*, the journal of the World Federation of Scientific Workers, but not submitted because it was thought unlikely to obtain security clearance. Includes correspondence 1948-49.

B.58 Proposed research project on OR 1974.

B.59 Brief correspondence 1986 on commemorative lunch for 50th anniversary of OR in RAF

B.60 "The air-sea war in the Mediterranean January 1942 - May 1943", an ORS ME report, no author, date or number, with a note by Kendrew "Unpublished draft".

SECTION C RESEARCH C.1-C.308

INTRODUCTION

EARLY RESEARCH

C.1	Reaction kinetics

INFORMATION RETRIEVAL/DATA PROCESSING

C.2-C.5	Information retrieval
C.6-C.15	Computation on EDSAC I

PROTEIN ANALYSIS PROJECTS

C.16	Adult and foetal sheep haemoglobin 1946-58
C.17	Muscle 1947-54
C.18	Protein solubility c.1949
C.19	Procollagen 1951-52
C.20	Controlled shrinkage of protein crystals 1952
C.21	Polypeptide configuration 1953
C.22	X-ray experiments 1953
C.23	Not used. Material transferred to C.1
C.24	Chymotrypsinogen c.1956
C.25, C.26	Correspondence "New proteins" 1947-69

EARLY RESEARCH REPORTS

C.27	Reports 1946-53

MYOGLOBIN

NOTEBOOKS (Kendrew and collaborators)

C.28-C.40	Preliminary work
C.41-C.100	Main myoglobin programme
C.101-C.116	Collaborators' notebooks
C.117-C.125	Atomic co-ordinates/amino-acid sequencing
C.126-C.129	Miscellaneous

NOTES AND DATA (Kendrew and collaborators)

C.130-C.169	Preliminary work
C.170-C.189	Main myoglobin programme
C.190-C.195	Collaborators' notes and data
C.196-C.198	Miscellaneous

MATERIALS AND APPARATUS

C.199-C.202	Supplies and specimens
C.203	Optical diffractometer
C.204	Microcamera
C.205-C.207	Densitometer
C.208, C.209	Computer time

COLLABORATORS AND STAFF

C.210-C.238	Individual files
C.239-C.247	Chronological files

CORRESPONDENCE

C.248-C.272	Aspects of myoglobin
C.273-C.277	Atomic co-ordinates/amino-acid sequencing
C.278-C.291	Publications

MODELS

C.292	Skeletal model
C.293-C.297	Ball-and-spoke model
C.298	Science Museum London
C.299-C.307	Correspondence

MISCELLANEOUS

C.308	Pantographs

INTRODUCTION

The keystone of Kendrew's research is the three-dimensional analysis of the structure of myoglobin for which he shared with M.F. Perutz the Nobel Prize in Chemistry in 1962. His Nobel Lecture, and the adapted version published in *Science*, **139**, 1963, give a clear account of the stages of the research, the particular problems encountered and the techniques evolved to deal with them. The lecture also makes plain that Kendrew's overriding interest in the structure of protein ("I had no doubt that this problem above all others deserved the attention of anyone concerned with fundamental aspects of biology" *art.cit.*, p.1259) dates from the later part of the Second World War (see L.149 for a lecture given by Kendrew at Clifton in which he recalls his talks on the subject with J.D. Bernal during the war, probably on one of Bernal's visits to South-East Asia Command mentioned in Section B). Thus the early prewar research on reaction kinetics (C.1) had no sequel and the remainder of the material is all related to some aspect of protein analysis.

From the first, and long before the choice of a suitable material had been achieved, Kendrew realised how important a factor would be the rapid handling of very large amounts of data and information. It is interesting to see the fascination with note-keeping, filing and organisation present in the schoolboy (Section A) and fostered by operational research in war (Section B) finding a kind of bureaucratic apotheosis in the sustained effort of accuracy required for the long haul to the final successful three-dimensional picture - a task which Kendrew himself said he would not wish to undertake a second time. Be that as it may, Kendrew was certainly ahead of many of his colleagues in seeing the necessity to harness the full range of automatic information handling techniques.

This perception shows itself in two lines of enquiry. One, immediately after his return to Cambridge in 1946, is the organisation of his, and later his team's, rapid access to all the relevant literature via a system (then relatively new) of punched cards; these cards, and the punch, both of which he designed himself, remained in use for many years (C.2-C.5). The other is the investigation of computation and data processing, dating from 1949 and aimed in the first instance at the resources of the EDSAC I machine at the Cambridge University Mathematical Laboratory (C.6-C.15). As the research

developed, more sophisticated machines became available and were put to use in Cambridge and elsewhere, so that the work was always going forward at the limit of technical practicability.

The material presented under the heading "Protein Analysis Projects" at C.16-C.24 generally antedates the main myoglobin programme; it may include projects that were not taken further by Kendrew and his team, or the application of X-ray diffraction techniques to other research topics. Of considerable interest is the correspondence at C.25, C.26 which shows Kendrew's search, over a long period of time, for suitable protein material and his work with new materials referred to him by others. This provides in many ways a bridge between the preliminary work and the launch of the main programme.

The Nobel Lecture already mentioned is of course a retrospective discussion of a completed project, when lines of strategy may be more easily discerned from the final eminence of success. It is of special interest therefore to have the brief annual reports which Kendrew sent to the Master of Peterhouse during his tenure of a Research Fellowship; these are at C.27 and chronicle the slow steps towards the goal as they were actually being taken. They confirm two of the principal problems: the choice of a suitable protein for analysis in adequately sized crystals, and the devising of high-speed computational techniques to process the data. The reports, which run from 1947 to 1953, conclude in very positive terms both on a personal level with the granting to Kendrew of "unlimited tenure" by the Medical Research Council, and on the professional level with the sense that technical difficulties had been overcome, experimental material identified and the way cleared for the main diffraction programme. (The identification of sperm whale as the most promising source of myoglobin crystals occurred in December 1952 and is referred to in appropriately enthusiastic terms in Kendrew's correspondence of that date; see especially C.17, C.25, C.199).

Optimistic as this may have later appeared, it was sufficiently the case for it to be taken here to mark the end of the preliminary work and the opening of the assault on the myoglobin molecule which is very fully documented, presented in the order shown in the list of contents, and including notebooks, data, observations, diagrams and charts, calculations, draft routines, printouts and corrections, correspondence and "think-pieces" by Kendrew and the team of short- and long-term collaborators at Cambridge and the Royal Institution in London. The main lines of the work are clear from the

Nobel Lecture and other publications: the narrowing of choice of material to Type A sperm whale myoglobin; the progressively more complex analysis at 6-Å (approximately 1955-57, using EDSAC I), 2-Å (1959, using EDSAC II and Mercury), and 1.4-Å (begun 1960 using IBM 7090), and the use of X-ray evidence in correlation with chemical data for amino-acid sequencing. In addition to the published papers which marked the progress of the research (particularly the collaborative communications in *Nature*, **181**, 1958, **185**, 1960, **190**, 1961 and, for the earlier work, the extended follow-up papers in *Proc. Roy. Soc.*), several of the notebooks include project diaries, charts of progress, allocations of responsibility and the like, written "from the bench" or in correspondence. Examples of such can be found at C.59, C.63, C.77, C.117, C.126, C.127, C.169 and also in some of the informal talks at L.145.

It may be appropriate here to point out that for all the stress laid on mechanical computation, and indeed the presence of EDSAC and other printouts, the notebooks are remarkable for the sheer quantity of calculations and tabulations, phase diagrams, electron density maps and the rest laboriously worked by hand, by Kendrew as well as his collaborators, not to mention the careful logging and summaries of experimental programmes which were always his personal charge.

The excitement of the final complete syntheses at 6-Å and 2-Å and their publication is well captured in the correspondence at C.288, C.289. W.L. Bragg contributes characteristically warm-hearted letters and Kendrew's own letter of thanks and congratulation to his collaborators (C.288) is enthusiastic as well as informative.

EARLY RESEARCH

Reaction kinetics

C.1 Material relating to research with E.A. Moelwyn-Hughes, July 1939 - January 1940; the results were published as a collaborative paper "The kinetics of mutarotation in solution" in *Proc. Roy. Soc.* **176**, 1940.

Material includes brief statement of research, "the experimental investigation of certain enzyme reactions ... in the first instance the enzymic hydrolysis of non-reducing disaccharides ... the technique employed will be the polymetric one, using the very sensitive instrument equipped in this Department [Physical Chemistry, Cambridge] by the late Professor Lowry", charts and graphs of mutarotation and heat reactions of arabinose, lactose, maltose, mannose, xylose.

Also included here are two manuscript and typescript drafts for a paper on "The mechanism of unimolecular gas reactions" by Kendrew and M.H.J. Webb (a research student of Kendrew), one set dated April 1953, the other April 1954, with brief calculations in the hand of J.M. Bennett and a letter from I.F. Trotter. No paper of this title is listed in the Bibliography. (Material originally found with "Protein Analysis Projects" and transferred here on Kendrew's advice.)

See also A.118.

INFORMATION RETRIEVAL/DATA PROCESSING

Information Retrieval

C.2 Correspondence with colleagues on sorting and classification methods, with special reference to punched cards 1946-49, 1951, 1969.

Includes letter December 1946 to E. Orowan (then working at the Cavendish Laboratory) from J. von Neumann on research on electronic searching device and on his own electronic computer project, and correspondence 1947-51 on abstracting and indexing systems at UNESCO, American Chemical Society and elsewhere in USA.

C.3 Correspondence 1946-52 with manufacturers of punched card systems on supply of cards to Kendrew's design (his letter of 17 April 1950 also mentions J.M. Mitchison as involved in design). A little correspondence with colleagues interested in the system is also included.

C.4 Correspondence 1949-50 with manufacturers on supply of punch for cards to Kendrew's design (drawings and diagrams included); also included is letter 1973 from a colleague still using one of the punches.

C.5 Miscellaneous manuscript notes and diagrams by Kendrew, on "Classification schemes", "Punching schemes", punched card applications, topics to be referenced etc.

Specimens of punched cards for various purposes, some annotated or designed by Kendrew.

Computation on EDSAC I

The material concerns methods of using the EDSAC machine (Electronic Delay Storage Automatic Computer) for the computation of 2- and 3-dimensional Fourier and Patterson syntheses. Kendrew's early collaborator on this work was J.W. Bennett whom he met at Cambridge through H.E. Huxley and who later worked at Ferranti; they published papers on the topic in *Acta crystallogr.*, **5**, 1952 and in the official publication of the Inaugural Conference of the Manchester University Computer, 1951.

See C.196 for the end of the work on EDSAC I before its replacement by EDSAC II, and also C.80, C.208, C.209.

Notes and calculations

C.6 "Miscellaneous programming ideas", n.d. c.1949 some on verso of contribution to Barcroft volume published 1949.

C.7 "Two-dimensional low symmetry", n.d., some on EDSAC programme sheets, some on verso of 1948, 1949 publications.

C.8 "EDSAC 2-dimensional Patterson programme", some dated 1950, 1952 and later "modification" by D.W. Green 1955.

C.9 "EDSAC 3-D programme", EDSAC sheets dated 1953, 1954, undated notes.

C.10 "EDSAC 2-dimensional Patterson Fourier programmes". Notes, calculations, programmes and narratives by Kendrew, D.M. Blow and another, some sheets dated 1954, 1956, 1957.

C.11 Miscellaneous notes, graphs, narratives on Patterson peaks, some dated 1952 and referring to work on Pauling helix calculated by F.H.C. Crick.

Work with J.W. Bennett

C.12 Notes and calculations (some by H.E. Huxley), short report by Bennett on "EDSAC Crystallographic Computations".

C.13 "Fourier methods", notes, calculations, letter from Bennett, note by another on "probable error in synthesis ... "

C.14 Correspondence, arrangements, drafts etc. for conferences, papers and publications. Includes Institute of Physics X-ray Analysis Group, November 1950 (Kendrew and Bennett presented a paper on "Some crystallographic calculations with EDSAC"), Symposium on Advanced Techniques in Structure Determination Stockholm July 1951 (Kendrew and Bennett's paper "Crystallographic computations with a high-speed digital electronic computer" was accepted but it is not clear whether they attended), Inaugural Conference of the Manchester University Digital Computer July 1951. Some additional notes and calculations are included.

See L.145 for texts of papers.

Related material

C.15 Research proposal for X-ray Analogue Computer for Crystal Structure Analysis, Pennsylvania 1949-50.

"The Anisograph", correspondence and information 1950.

EDSAC order codes.

PROTEIN ANALYSIS PROJECTS

These are presented in chronological order, with Kendrew's titles or descriptions. Many refer to materials or experiments which feature in the notebooks at C.30-C.34.

Adult and foetal sheep haemoglobin

C.16 Correspondence 1946-58 on research results, supplies, publications, some addressed to M.F. Perutz including letter 18 August 1947 from D.C. Hodgkin commenting critically on a draft paper on foetal haemoglobin (the joint paper by Kendrew and Perutz later published in *Proc. Roy. Soc.*, **194**, 1948).

Muscle

C.17 Correspondence 1947, 1950-54 with colleagues on methods, materials, results etc. Much of the material relates to collaborative work with H.E. Huxley and includes reference to their joint paper in *Nature*, **170**, 1952 and to Huxley's work as Commonwealth Fund Fellow at MIT 1952-54 (see also C.220). Kendrew's letter of 23 December 1952 announces the successful crystallisation of "the most marvellous myoglobin crystals, from sperm whale of all odd places" (see also C.25).

See C.20 for other collaborative work with Huxley.

Protein solubility

C.18 Graphs and diagrams, n.d., c.1949.

Procollagen

C.19 Brief correspondence 1951-52.

Controlled shrinkage of protein crystals

C.20 Mainly 1952, relating to collaborative papers by Kendrew and Huxley. Includes manuscript draft of paper given to Chemical Society Symposium, 7 February, on "Stepwise lattice changes in haemoglobin crystals", Huxley's heavily-corrected manuscript on "Discontinuous lattice changes in haemoglobin crystals" and final agreed draft for version published under that title in *Acta crystallogr.*, **6**, 1953. A later letter (1965) on the work is also included.

See also C.17.

Polypeptide chain configuration

C.21 Brief correspondence 1953, 1973.

X-ray experiments

C.22 Correspondence 1953 on request for Kendrew to take X-ray pictures of bacterial spores.

C.23 Not used. Material transferred to C.1.

Chymotrypsinogen

C.24 Data and calculations, mainly by M.M. Bluhm, related to collaborative paper with Kendrew published in *Biochim. biophys. Acta*, **20**, 1956.

Correspondence "New proteins"

Kendrew's own description on the folder is "New proteins". The material is correspondence 1947-69 with colleagues on various proteins and their suitability for X-ray analysis, some, particularly in the early years, initiated by Kendrew in the search for suitable crystalline materials for the X-ray diffraction programme, some sent by others for his interest or attention.

C.25 1947.

1952. Includes a letter to H. Neurath from Kendrew 22 December 1952, writing enthusiastically about whale myoglobin: "we recently struck an absolute gold-mine in the shape of whale myoglobins of various species. One form - from sperm whale - is one of the most favourable protein crystals yet ... " (See also C.17).

C.26 1953-69.

EARLY RESEARCH REPORTS

C.27 Reports by Kendrew on his research, teaching and publications 1946-53.

"Report on crystallographic studies of protein carried out during 1946", addressed from Cavendish and Molteno Laboratories and perhaps intended for departmental annual report, January 1947.

Report to Master of Peterhouse on first year of Research Fellowship July 1947 - June 1948; refers to "formation of MRC's Unit for the Study of the Fine Structure of Biological Systems, with Dr M.F. Perutz as Director and myself as an independent part-time member", research on foetal haemoglobin, horse myoglobin etc. August 1948.

Molteno Institute report June 1947 - June 1948.

Reports to Master of Peterhouse 1948-49, 1949-50 (refers to work on EDSAC), 1950-51, 1951-52 (papers with J.M. Bennett, H.E. Huxley, continuing difficulty in obtaining suitable crystals), 1952-53 (final report on termination of Research Fellowship, granting of "unlimited tenure" by MRC, successful identification of "a very wide choice of experimental material, and all that remains is to exploit it.")

MYOGLOBIN

NOTEBOOKS (Kendrew and collaborators)

Preliminary work

C.28 Binder of "Filofax" pages inscribed "Peterhouse Cambridge" (same format as A.27) with index of topics as follows:

Mathematics

Physics Photography

Chemistry

Biochemistry

Crystallography

Physical methods of investigation

EDSAC

Protein structure

Structure of other biological macromolecules

Haemoglobin Myoglobin

Current research

Material runs c.1946-53 and includes own notes, notes on the literature, notes and information from colleagues' research (Huxley, Crick, Perutz) etc.

C.29 Similar "Filofax" binder, inscribed with address of Kendrew's house at Linton, but material is mainly 1940s. Includes notes on books and articles read (extensive notes on Szent-Györgyi's *Nature of life*), lectures and conference papers, "Haemoglobin meeting" 1946 etc. and a little later (1970) material.

C.30 Loose-leaf notebook of small quarto pages (same format as main indexed series of earlier university notes at A.40-A.117). The material, which is extensive, covers various dates 1946-53; there is an index listing the "Research notes - project numbers" which run 10-25, each with a numbered thumb index card. The projects are:

10 Adult sheep methaemoglobin

Experiments, data, crystallisation November 1946 - "Summer" 1947.

11 Foetal sheep methaemoglobin

Experiments, crystallisation, dialysis November 1946 - July 1947.

12 Horse myoglobin

Removed for extended treatment in separate notebooks. See C.31, C.32.

13 Foetal human methaemoglobin

Crystallisation of various samples November-December 1946, January-July 1948.

14 Horse methaemoglobin - shrinkage

Refractive index measurements, crystal preparation November-December 1946.

15 Whale myoglobin

Removed for extended treatment in separate notebooks. See C.33, C.34.

16 Miscellaneous X-ray experiments

January 1947, January 1948, August 1949.

17 Ox myoglobin

Experiments January-July 1947, February-March 1951.

18 Microcamera

Attempts to take fibre photographs, camera adjustments, calculations of absorption coefficients, April-June 1947.

19 Theoretical calculations - chain configurations

July 1949 - February 1950.

20 Miscellaneous biochemical work

Tests on rat haemoglobin July 1949, gelatin November 1951.

21 Chymotrypsinogen

Removed and kept with work on whale myoglobin. See C.34.

22 Lamprey haemoglobin

Experiments November-December 1951.

23 Muscle

Calculations and diagram June-July 1952, with a "Note : November 1952. These are very bad notes. However the paper is now published and is the best source of information." The reference is to the joint paper with H.E. Huxley "Extractability of the Lotmar-Picken material from dried muscle", *Nature*, **170**, 1952. See C.17.

24 Sea-lion myoglobin

Brief notes only, March 1953.

25 Penguin myoglobin

Brief notes only, March 1953.

Note

Preceding the "project numbers" as listed above is a series of "Notes from January 1946 - August 1946" which have no project numbers, presumably because they antedate the system. They deal with work on adult and foetal sheep methaemoglobin (nos. 10 and 11 of the main list) and are given a separate index of cross-references. Among the experiments is one dated July 1946 on the "Identity of monoclinic and orthorhombic forms of foetal methaemoglobin - the crucial experiment!".

C.31 Horse myoglobin

This is no. 12 of the projects listed in C.30, which developed into a major research topic. It has its own index running 12-1 to 12-34, 12-40, of which 12-29 to 12-34 appear separately at C.32.

The work is on specimens received from various sources, crystallisation, X-ray examinations, Patterson and Fourier projections, phase calculations etc. mainly October 1946 - March 1949, re-examined November 1952.

C.32 Horse myoglobin

Continuation of C.31, index numbers 12-29 to 12-34.

Preparation and crystallisation February 1950 - January 1952 using various methods and apparatus, and with various collaborators (including J.D. Watson).

C.33 Whale myoglobin

This is no. 15 of the projects listed in C.30. Whale myoglobin became eventually the material of choice for the main programme after further narrowing down of various types of whale (blue whale, finback etc. analysed elsewhere in the notebooks and notes) to the sperm whale. The notebook has its own index running 15-1 to 15-59. Work in this book covers 15-1 to 15-29 only, the continuation having been transferred to a separate notebook (C.34).

Experiments on specimens prepared by J. Keilin (then working in Molteno Institute Cambridge), crystallisation, diffraction pictures etc., December 1946 - October 1952, with an occasional later note 1953, 1954.

At rear of book are notes on preparations and methods.

C.34 Continuation of C.33 with index running 15-30 to 15-55 (and some further subdivisions). There is a separate list of references to work on the sperm whale material (the eventual choice) and the book also includes tests on many types of myoglobin other than whale: porpoise, seal, dolphin, penguin, tortoise, carp, and some mixed crystals.

The work is mainly the "1952 Programme" for "Crystallisation of whale myoglobin", with M.M. Bluhm and R.G. Parrish, beginning October 1952. Entries continue to August 1954.

At rear of book is work on chymotrypsinogen September-October 1951, September-October 1953 (project no. 21 in the numbered list in C.30).

Note

C.34 is the last of the early notebooks to use small quarto format pages. The following notebooks C.35 *et seq.* in the preliminary and main series are all large quarto loose leaf binders. Most have labelled divider cards to separate sequences of material, and many have an outline index at the front or for each sub-division. There is a system of pagination with a code of letters and/or numbers but no explanatory codebook appears to survive.

The material dates from 1953 i.e. when initial problems of obtaining suitable crystals were largely solved and the main concern was with the determination of ligands for the attachment of heavy atoms and the final selection of "Type A" sperm whale myoglobin. Within each notebook the material may extend over a period of years, and is also diverse in character, including notes and calculations, charts, graphs, printouts, densitometer diagrams, electron density contour maps, narratives or summaries of work in progress, and correspondence. While the great majority of the work continues to be in Kendrew's own hand, there are also notes, calculations, letters and memoranda by members of the Cambridge and Royal Institution teams or by colleagues elsewhere. Attention is drawn to these and to other matters of special interest wherever possible.

C.35 Pleochroism of monoclinic and sperm whale crystals.

Index at front, listing topics 1-11, and pages numbered accordingly. Extensive notes, calculations, graphs and diagrams, ideas and critiques in pencil and ink with corrections and comments in red ink, March 1953 - May 1957. Topic 11 in the index is "Paramagnetic resonance results" and the material incorporates correspondence, results and collaborative research with D.J.E. Ingram with whom Kendrew published a note on "Electron spin resonance in myoglobin and haemoglobin", *Nature*, **178**, 1956. See also O.16.

C.36 Work on myoglobin and haemoglobin of sperm and finback whale, and of horse, subdivided into:

"Intensity distribution", charts, observations, calculations, notes 1954-56, correspondence J. Donohue, F.H.C. Crick (see also O.7), V. Luzzati.

"Rotary dispersion", charts, correspondence P. Doty 1957.

"Finback 3-D", Pattersons, notes, progress sheets 1954.

"Fourier theory", Kendrew's notes on a course of lectures by J. Cochran, Michaelmas term 1957.

"Magnetic properties of haem proteins", Kendrew's notes on a course of lectures by J. Griffith, Lent term 1958.

C.37 Data, analyses, diagrams, photographs of various types of myoglobin, identified as Type A through to Type L, some pages with dates 1953-56. Included in the section on "Type D" (blue whale) is a manuscript draft perhaps for an outline programme of work titled "Rod directions in sperm monoclinic and blue whale myoglobins. An attempt to establish the directions by looking for projected rods in Patterson projections, and correlating these. Also a comparison between sperm monoclinic and blue whales", 3 August 1953.

At rear of book, brief note on chymotrypsinogen.

C.38 Miscellaneous work, subdivided into:

"Heavy atom - chemical work", including "Imidazole programme" (undated notes), "Isocyanide programme" (Kendrew's narrative and notes on progress 1954-55), "Nitroso-compound programme" (narrative and notes 1955), "Dyes" (1955, by Dintzis and Bodo, re-examined 1959).

"Standard intensities", charts and calculations for finback whale myoglobin.

"Experimental", mainly on camera settings, correspondence, 1956.

"X-ray pictures", detailed charts and observations 1954-57 on various types of myoglobin and ligands.

"Preparations", notes on preparation of king penguin, finback and sperm whale, 1955.

C.39 "Type C heavy-atom". Work on seal myoglobin, which Kendrew refers to in his 1963 *Science* article as a close runner-up to the final choice of sperm whale. Material includes notes, calculations, data, EDSAC sheets, electron density contour maps etc., most by Kendrew but including contributions and/or correspondence from R. Hart and R.E. Dickerson at Cambridge and from H. Scouloudi who continued to work on seal myoglobin for many years at the Royal Institution and later at the Molecular Biophysics Laboratory Oxford. There are two main periods of work, February-November 1956, May-July 1958. See also J.121.

C.40 Work on type D; heavy atom attachment, densitometer diagrams at various exposures, X-ray precession camera photographs. Not all in Kendrew's hand. Only one page dated (January 1957).

Main myoglobin programme

This is a sequence of stiff-backed looseleaf binders, all with a number and (from C.63 onwards) a descriptive title on the spine. They begin on 5 May 1954 with the attachment of heavy atoms to type A crystals, and continue to November 1963, covering the X-ray analysis programme at 6-Å, 2-Å, 1.5-Å and 1.4-Å. Kendrew numbered the first 39 books in Roman numerals from I to XXXIX and this order is preserved (C.41-C.79); the last of these contains work dated October 1959. Subsequent books are presented in chronological order as far as possible; they include a much higher proportion of collaborators' work.

With very few exceptions, the books are meticulously kept, with labelled sub-dividers, usually an index or list of contents and pagination with code letters and figures. A very substantial proportion of the work (up to C.79) is in Kendrew's own hand and, when collaborators' work or data are included, they have usually been checked through by him.

The notebooks are here presented as a separate sequence mainly for archival convenience and partly because they represent the final research record assembled by Kendrew. Other records on the same topics, antedating or concurrent with these but kept in a different format, are preserved among the collaborators' notebooks (C.101-C.116) and the notes and data (C.170-C.195) and should be consulted as supplementary documentation.

Although the catalogue entries attempt to give dates for the work in each book, these can be no more than an approximation. In fact few dates are used except in Kendrew's narrative logs of experiments, on some of the contour maps and EDSAC printouts, and in correspondence; the main identification lies in the code letters and numerals used as pagination; it is these which constitute the chronology of the multiple projects which were going forward simultaneously.

C.41 Type A heavy atom (Book I). Narratives, observations, calculations, scaling, contour maps, printouts. Includes some work by Bodo. May 1954 - September 1957.

C.42 Type A heavy atom (Book II). Work on met-myoglobin standard intensities. Measurements, calculations, scaling and rescaling, radial distribution. Narrative at front of book runs July 1955 - June 1956.

C.43 Type A heavy atom (Book III). Index of topics at front. Includes some work by Dintzis and others. Measurements, scaling factors, contour maps, printouts. July 1955 - April 1957.

C.44 Type A heavy atom (Book IV). Index of topics at front. Includes some work by Dintzis, Bodo and others. Narratives, calculations, contour maps, radial distribution charts, temperature and scaling factors, printouts. September 1955 - June 1957.

C.45 Type A heavy atom (Book V). Index of topics at front. Includes some work by Dintzis and others. Narratives, calculations, tables of signs, scaling, contour maps. October 1955 - May 1958.

C.46 Type A heavy atom (Book VI). Index of topics at front. Includes some work by Dintzis and others. Calculations, scaling, structure factors, sign determination, contour maps, graphs, printouts. June 1956 - Decmber 1957.

C.47 Type A heavy atom (Book VII). Index of topics at front: a and c projection with ligands at 2.7 Å. Includes collaborators' work. Summaries, charts of observations, scaling, Pattersons, graphs, contour map. Few pages dated, July 1956 - June 1957.

C.48 Type A (Book VIII). Three-dimensional data 6-Å. Includes some collaborators' work. Summaries, data, Lorenz corrections, radiation effects, difference Fouriers, scaling, contour maps, graphs. Few pages dated, May-September 1956.

C.49 Type A (Book IX). Three-dimensional data 6-Å. Index and summaries at front. Includes collaborators' work. Charts, calculations, scaling, Fouriers, contour maps, correspondence and data from D.C. Phillips. Few pages dated, June 1956 - May 1957.

C.50 Relative b co-ordinate - methods involving single h/a derivatives (Book X). Index and summaries at front. Includes collaborators' work. Divider card 23.6 "Theory" includes notes by H. Wyckoff (a principal collaborator in this work) and F.H.C. Crick. Calculations, structure factors, printouts, charts, phase circles, graphs, contour maps. Few pages dated, June-November 1956.

C.51 Type A heavy atom (Book XI). Calculations of D, D_1, D_2. Index and summary at front. Includes collaborators' work. Calculations, results, graphs. Few pages dated, February-June 1957.

C.52 Type A heavy atom (Book XII). Work on H_g succinate and H_g diammine derivatives. Index and summary for both topics. Includes work by Wyckoff and others. Calculations, Fouriers, structure factors, printouts, contour maps, graphs. Few pages dated, May 1956 - May 1958.

C.53 Type A heavy atom (Book XIII). Work on $H_g I_2$. Index and summary at front. Includes collaborators' work, in particular by H. Wyckoff, who also contributed a note on the previous history of the computations. Intensity data, scaling, radial distribution, Pattersons, repeat computations, graphs, printouts, contour maps. One printout dated November 1956.

C.54 Type A heavy atom (Book XIV). Work on porpoise and sperm whale (main collaborator J. Kraut) 1956; PCMS and $H_g am_2$: index and summary, scaling and structure factors, radial distribution, contour maps, printouts, graphs January-December 1956; PCMA: index and summary, scaling, Fouriers, radial distribution, contour maps, summary dated January 1957.

C.55 Type A heavy atom (Book XV). Work on PCMS and Au. Index for each topic. Includes collaborators' work. a and c projections, intensities, calculations, Pattersons, printouts, contour maps, b projections, scaling, contour maps. Few pages dated January-May 1957.

C.56 Type A heavy atom (Book XVI). Work on Au/PCMS b, a and c projections. Index for each topic. Includes collaborators' work. Data, scaling, structure factors, printouts, contour maps, Pattersons, graphs. Few pages dated, March-May 1957.

C.57 Type A heavy atom (Book XVII). Work with various heavy atoms and projections. Index for each topic. Includes collaborators' work. Data, calculations, Fouriers, contour maps, graphs. Only one page dated May 1957.

C.58 Type A heavy atom (Book XVIII). Work with various heavy atoms in 3D. Index for each topic. Includes collaborators' work. Intensities, scaling, contour maps, tables of 3D data for specific crystals. Only one page dated May 1957.

C.59 Type A heavy atom (Book XIX). Work on 6-Å 3D Fourier synthesis. Includes collaborators' work but much is by Kendrew himself including summaries or reflections on methods and results. Index for each topic as follows:

"Relative y". Notes, diagrams, graphs, calculations, reflections by Kendrew on various structure factors, part related to suggestions by W.L. Bragg with whom correspondence is included. In his letter to Bragg of 21 July Kendrew writes: "Phase determination out to 6-Å is virtually complete ... I am very pleased with the way this has gone, and think there will be very few major ambiguities of phase indeed ... While I am away phase diagrams out to 2.8-Å will be drawn for hk0 and 0kl reflexions, just to see whether it is practical politics to extend the isomorphous replacement technique to 3-Å with our present methods." April-July 1957. (See C.61, C.61A for the phase diagrams referred to.)

"Structure factors". Notes, calculations, tables and charts for various heavy atoms. Only one page dated March 1957.

"F values". Data, calculations, phase angles, Kendrew's queries for checking.

"Scaling". Calculations, radial distribution, correspondence from W.L. Bragg February 1957, summary by Kendrew of "Scaling investigations" April 1957.

N.B. Work continues in next book.

C.60 Type A heavy atom (Book XX). Work on 6-Å 3D Fourier synthesis (continuation of Book XIX, C.59). Index for each topic as follows:

"z Fourier projection". Notes, calculations, phase circles, printouts. Some pages dated, March 1956 - June 1957.

"3D Fourier synthesis of myoglobin - 6-Å". Tables, calculations and revisions (many by Kendrew), printouts. Includes collaborators' work. Various dates July 1957 - October 1958 and a later note on "Testing of myoglobin 7090 [IBM computer] Fourier routine" by C.L Coulter, October 1961.

"Fourier synthesis including heavy atoms". Extensive tables and charts, Kendrew's notes on heavy atom peaks November 1957 - January 1958.

C.61 Book XXI. Phase circle determinations, heavy atoms colour-coded, n.d. (1957, see C.59).

C.61A Unnumbered Book XXII. a and c projection phase circles. Work by W. Hoppe, M.M. Bluhm, n.d., (1957 see C.59). All these were laboriously drawn by hand, before computerised methods had been introduced.

C.62 Book XXIII. Co-ordinates of heavy atoms. Index and summary at front. Includes collaborators' work. Tables, calculations, printouts, contour maps, refinement programme. May-August 1958.

Note The remainder of the sequence bears a title as well as a number on the spine, and these are used in the entries.

C.63 "2-Å data processing" (Book XXIV). Data sheets and printouts, calculations and graphs. Includes work by Dickerson and others, and, at front of book, charts on "State of project" March, April 1959.

C.64 "2-Å hol refinement" (Book XXV), with Dickerson's name on inside front cover. Much of the work is in his hand, including summaries of work, descriptions of programs, notes, calculations, graphs. Various dates November 1958, March-July 1959.

C.65 "2-Å Gold. diff F. radiation" (Book XXVI). Work mainly by Dickerson. Graphs, calculations, data, contour maps, printout (dated April 1958). The last section on "radiation damage" is dated January 1958, January 1959 and includes a letter on the subject from Kendrew to D.C. Phillips June 1960.

C.66 "Comparison program" (Book XXVII). Work by Dickerson. Statement of program, graphs, calculations, printouts for various heavy atoms. June-July 1959.

C.67 "Scaling - met" (Book XXVIII). Printouts, calculations, by Dickerson and others, comparison of 6-Å and 2-Å data, most work checked by Kendrew. May-June 1959.

C.68 "Scaling PCMS $H_g am_2$" (Book XXIX). Printouts, calculations, graphs, by Dickerson and others. June 1959.

C.69 "Scaling Au Double" (Book XXX). Printouts, calculations, graphs by Dickerson and others, with extensive checks and comments and a graph by Kendrew. May-June 1959.

C.70 "Scaling - corrections" (Book XXXI). Calculations and graph, n.d.

C.71 "Correlation results" (Book XXXII). Printouts (M. Rossmann's program), calculations, extensive electron density and contour maps, by Dickerson and others n.d.

C.72 "Correlation results" (Book XXXIII). Extensive calculations, diagrams, in several hands including Dickerson's. Few pages dated, July 1959.

C.73 "2-Å - Least squares" (Book XXXIV). Printouts, (M. Rossmann's program), calculations by Dickerson and others, densitometer diagrams, scaling tests, charts, graphs. March-August 1959.

C.74 "Phase refinement" (Book XXXV). Printouts, data, calculations, graphs, mainly by Dickerson, program routine by Strandberg. July 1959.

C.75 "2-Å Phase Refinements 3/8/59" (Book XXXVI). Programming for random sampling, printouts, calculations, mainly by Dickerson, some checking by Kendrew. August 1959.

C.76 "2-Å Myoglobin Phases 5 Int. Run (1) 1959" (Numbered in error Book XXXVI. See C.75). Mainly printouts with a very few notes. August 1959.

C.77 "2-Å Fourier F_{obs} F_{best}" (Book XXXVII). Mainly printouts (M. Rossmann's program) with annotations, on attempt to achieve finer resolution. At front of book are charts of progress, names of those involved, work being done at Royal Institution, August 1959.

C.78 "2-Å Fourier F_{best} sharp" (Book XXXVIII). Similar material, n.d. (August 1959).

C.79 "6 and 5.5-Å Fourier (2-Å data)" (Book XXXIX). Mainly printouts (M. Rossmann's program) with some annotations. October 1959.

Note This is the last book in Kendrew's numbered sequence. The remaining books C.80-C.100, in the same format of stiff-backed looseleaf binders and bearing a descriptive title on the spine, are presented in chronological order as far as possible. Some contain work similar or closely related to that in Kendrew's numbered sequence, and may overlap chronologically with it and with each other.

C.80 "EDSAC: non current". Programs, tests, notes and calculations, printouts and checking for scaling factors and Lorenz corrections to be run on EDSAC II. Almost all the routines were written by R. Hart who was a principal collaborator in this work until he left the laboratory in August 1958. Calculations and notes by Dickerson and others, January-July 1958. At rear of book are 42pp. notes by Kendrew on a course of lectures "Programming for EDSAC II" by H.P.F. Swinnerton-Dyer September-October 1957.

C.81 "EDSAC program Roger Hart". Programs and routines for refinement programme, phase determination, Lorenz-polarisation correction, by Hart, with some revisions by Dickerson and others. Some printouts dated February 1958. Also included are notes by A.L. Patterson on alternative method of calculating Lorenz corrections, March 1958.

C.82 "Scaling Program". Instructions, routines, printouts, tests, checking, almost all by Dickerson, some by Strandberg and others. March-May 1959.

C.83 "Correlation function Input program". Routines and tests, by Dickerson and Strandberg. July 1959.

C.84 "7-10 August 1959". Work on phase refinement, random sampling using M. Rossmann's program. Calculations, notes, graphs, printouts, corrections and checking. Almost all by Dickerson, a little by Strandberg.

This was a particularly critical period of the research programme, when several important aspects were coming to a point and Dickerson (a principal collaborator) was about to return to America. See C.73-C.78 and also correspondence at C.234.

C.85 "2-Å Myoglobin Phases 5 Int. Run (2) 1959" (See C.76). Mainly printouts, all checked, with a few notes. Some graphs, notes, comments by Kendrew. Some annotations by Dickerson and others, n.d. (August 1959).

C.86 "M.T. Load Program. 2-Å Phase Program 1959". Detailed routines for EDSAC II, test printouts and checks, graphs. Almost all by Dickerson, a few later additions or revisions. Few pages only dated, June-September 1959.

C.87 "2-Å Myoglobin 1959. Fourier Input Program". Routines, printouts, checks, notes, revisions. Routines devised and used August-November 1959 by Dickerson and others, modified August 1960 to allow for phase output by Strandberg and others.

C.88 "Dickerson Aug. 60 Heavy atom adjustments". Loading procedures, routines for phase runs, printouts, checks, calculations, density charts, contour maps. Routines by Dickerson August 1960, with reference back to "2-Å Phase Program Aug 1959"; some notes and calculations by H.C. Watson, Fourier programs by Rossmann.

C.89 "1.5-Å Myoglobin 1960. Absorption corrections". Detailed data, printouts, diagrams, charts, calibrations for myoglobin crystal (no. 145) in 3-D. This was collaborative work between H.C. Watson in Cambridge and D.C. Phillips at the Royal Institution and includes correspondence and data exchanged. Begins August 1960, but mainly December 1960 - June 1961. This work was complicated by the need to interchange EDSAC and Mercury tapes (see also C.90, C.92).

C.90 "1.5-Å Myoglobin 1961 Absorption corrections". Similar material, with correspondence and data from Phillips to Watson, mainly on myoglobin crystal no. 145, but includes a little work on seal myoglobin and lysozyme. Work mainly by Phillips and Watson, but a little in other hands. July 1961 - May 1962.

C.91 "2-Å Myoglobin phases. 5 Int. Run (4) Jan 1961". Printouts.

C.92 "1.5-Å Myoglobin March 1961. Scaling and merging data". Continuing collaborative work between Phillips and Watson, including extensive comparisons, tests and merging between EDSAC and Mercury tapes. February-May 1961.

C.93 "1.5-Å Myoglobin 1961. Refinement details". Graphs and plots, tables, calculations, notes, in several hands including Watson, C.L. Coulter. Various dates August 1961 - November 1963.

C.94 "Refinement of Heavy Atom Parameters 1961 and 1961" *(sic)*. Notes, calculations, routines, printouts, data runs, almost all by Watson. October 1960 - December 1962.

C.95 "2-Å Myoglobin Phases 5 Int. Run (5) Feb '62". Printouts.

C.96 "2-Å Myoglobin Phases 5 Int. Run (3) Aug '62". Checked printouts, a few notes.

C.97 "2-Å Myoglobin Special Sections (1)". Calculations, tables, printouts (Rossmann's program) electron density and contour maps. Few pages dated, December 1960, January 1961.

C.98 "2-Å Myoglobin Special Sections (2)". Similar material, mainly on helices. Earliest work November 1959, mainly April-July 1960.

C.99 "2-Å Myoglobin Data Block layout". Printouts.

C.100 "1.5-Å Myoglobin Data Block layout". Printouts.

Collaborators' notebooks

These are laboratory notebooks, presented in alphabetical order, of some (not all) of the collaborators in the myoglobin research. The work is sometimes preliminary to, or concurrent with, the material later incorporated in the main sequence, or kept as notes and data at C.190-C.195.

Information about the members of the team and the nature and duration of their participation in the work can be found in the "Staff" folders at C.210-C.238.

M.M. Bluhm

C.101 "Bluhm - chemical work". Preparation and crystallisation of various types of myoglobin (horse, seal, blue, finback and sperm whale), chrymotrypsinogen. 7 October 1952 - 16 February 1955.

C.102 "Bluhm - diary". Laboratory diary 1953 (kept daily to 8 June, later more sporadically).

G. Bodo

C.103 "Spectra etc.". Calculations and graphs. Few pages used. n.d.

C.104 "Bodo - xtal growing 300-539". Detailed notes, calculations, diagrams on various types of myoglobin and attachment of heavy atoms. Entries run 3 May 1955 - 10 October 1957; there are a few entries November 1955 - January 1956 in the hand of J. Kraut, and some annotations and identifications by Dickerson. Last entry is a note by Dickerson 18 February 1958 when he was re-working some of the material. (See next book C.105.)

R.E. Dickerson

C.105 "I Register of gold tubes (Bodo and Dintzis) II PCMS". Entries run 21 February - 10 March 1958 and are a re-working of the crystals with heavy atoms Au and PCMS made by Bodo and Dintzis 1955-57 with comments, diagrams etc. and a note on cover of material received from Royal Institution 11 March 1958.

C.106 "Photography Book I". Both ends of book used and paginated. Indexes of material received, numbering conventions. Tables, diagrams, calculations etc. 3 January - 26 September 1958.

C.107 "2-Å Photography of Myoglobin Book II". Similar material, indexed and paginated. 26 September 1958 - 14 July 1959.

H.M. Dintzis

C.108 Tables and calculations of photographs of myoglobin crystals and heavy atoms 19 September 1955 - 1 July 1956. The book is inscribed "Book I" but no later books survive.

J. Kraut

C.109 "Blue - porpoise". Preparations and experiments on blue whale and porpoise myoglobin. Few pages used. June-July (1956).

R.G. Parrish

C.110, C.111 Two notebooks sent by Parrish to Kendrew at his request for the present collection. In an accompanying note of October 1986 (attached in C.110) Parrish writes: "although the imidazole derivative crystallization experiments are covered in the present books, the resultant effect on isomorphous intensity changes is not mentioned. Also covered are various efforts toward insertion of iodine and other heavy atoms, none successful. Anyway, the period covered is Sept. 1952 to May 1954 during which time we did the species survey, identified the sperm whale crystals as preferred, showed that isomorphous derivatization (even without heavy atoms) could produce significant intensity changes and began the program to get heavy atoms into the structure."

Parrish published a collaborative paper with Kendrew and others on "Species specificity of myoglobin", *Nature*, **174**, 1954, and a paper with Kendrew on "Imidazole complexes of myoglobin and the position of the haem group", *Nature*, **175**, 1955.

P.J. Pauling

C.111A Bulky looseleaf binder of collaborative work with Kendrew on finback whale myoglobin, related to their joint paper "The crystal structure of myoglobin II Finback whale myoglobin", *Proc. Roy. Soc.*, **237**, 1956.

Data, graphs, contour maps, electron density charts, sub-divided into:

Intensity data
c projection Fourier
b projection Fourier
a projection Fourier
Origins and scaling
Error in film measurement

There are notes, revisions and checking by Kendrew, interspersed with Pauling's work; they are paginated but are allocated as to topic and are not in numerical order. The period covered is 20 August 1954 - 12 December 1955, not in chronological order.

B. Strandberg

C.112 "Photography. Book I". Records, diagrams, graphs, n.d. (1958).

C.113 "Photography. Book II". Similar material. Relates to work with Dickerson n.d. (1959).

H. Wyckoff

C.114 "Wyckoff X-ray notes 1956". April-July.

Unidentified

C.115 Notes on 3-D planes. Some notes in German. August-November 1957.

C.116 Miscellaneous notes and records, mainly on smoothing, scaling and structure factors, some related to haemoglobin analysis. Various dates January 1956 - 1958.

Atomic co-ordinates/amino-acid sequencing

This is a series of stiff-backed looseleaf binders like those used for the main myoglobin programme, but unnumbered and usually untitled. They relate to a two-pronged analysis of the structure of the myoglobin molecule using organic chemical methods in conjunction with X-ray crystallography. The determination of the amino-acid sequence of myoglobin had been suggested as a timely research project by Kendrew as early as 1955 to Stanford Moore and W.B. Stein at the Rockefeller Institute for Medical Research New York (C.273), and from 1956 A.B. Edmundson pursued this research first in America and then from 1961 to 1964 at the MRC Unit in Cambridge (C.219). For the crystallographers, the achievement of the high 2-Å resolution and later the even finer 1.4-Å made it possible to identify many more side-chains than previously, and to assign spatial co-ordinates to many of the atoms in the molecule. By the time of his Nobel Lecture Kendrew was able to say: "From the results of the X-ray and chemical studies, today some 120 amino acid residues are known with almost complete certainty and many of the remaining 30 are known with a fair degree of probability" (*Science, art cit.* 1963).

Kendrew collaborated in papers on the amino-acid sequence of myoglobin (1961) and haemoglobin (1965) and also wrote on side-chain interactions (1962). With H.C. Watson, his chief collaborator on the atomic co-ordinate determination, he circulated lists, successively revised, of sequences (C.274) which were in constant demand (C.275-C.277). The full 1.4-Å resolution analyses, however, were not published; a collaborative paper "Progress with the 1.4-Å resolution myoglobin structure" was delivered by H.C. Watson at the Sixth International Congress of the International Union of Crystallography, Rome, 9-18 September 1963 and an abstract appears in the supplement to *Acta crystallogr.*, **16**, 1963. A photocopy of the abstract is included by courtesy of D.C. Phillips at C.289.

The material covers a long period of time from June 1956 when Kendrew and Edmundson began work on the project to 1967 and the circulation of the lists of co-ordinates; there is also a little later work 1968, 1970. The content and timespan of each binder may also be very diverse even within the labelled sub-dividers. They include correspondence and work or results from colleagues and collaborators, in particular Edmundson and Watson. A high proportion, however, is in Kendrew's own hand and shows the considerable detailed work undertaken and his careful checking at all stages. See especially C.120-C.123, C.125.

C.117 "Myoglobin structure old material". Miscellaneous material, sub-divided as follows:

"Chemical data". Tables and notes by Kendrew, correspondence with A.B. Edmundson on peptide analysis; this is an interesting record of work in progress at the bench sometimes "bad news", sometimes "booming success", on one occasion "paydirt". March 1960 - May 1964.

"S/C [side-chain] identification". Detailed notes and tables, drafts and revisions for lists. March 1960 - July 1964.

"Interactions etc.". Tables, diagrams, notes. December 1960 - May 1962.

"Sequence data". Annotated material and sequence data received from conferences December 1960, June 1961, correspondence and data from R. Hill March-August 1962.

"Homology". Notes, correspondence with Watson, mainly on homology of haemoglobin and myoglobin and probably related to collaborative paper "Comparison between the amino-acid sequences of sperm whale myoglobin and of human haemoglobin" *Nature*, **190**, 1961. December 1960 - July 1963.

"Notes pre 6-Å Fourier". Early notes on heavy atom attachment in type A and also types B, D, C, F myoglobins. June 1956 - January 1958.

"Interpretation of 6-Å Fourier". Notes and diagrams n.d.

C.118 "Myoglobin structure current". Miscellaneous material, sub-divided as follows:

"Bond lengths, models". Notes, charts, colour codes. Few pages dated, 1961.

"General features". Notes and diagrams, some by Watson and others. May 1960 - September 1964.

"Chemical data". Notes and charts.

"S/C identification". Detailed notes and revision of tables, February 1962 to "Final allocation November 1964 153 residues".

"Interactions etc". Detailed notes and charts, correspondence and data on leucines from D.C. Phillips 1961, and from other colleagues on configurations 1962.

"Sequence data". Miscellaneous charts, October 1962 - March 1963.

"Homology". Charts, data, correspondence. May 1964 - March 1968.

C.119 "H.C. Watson. Myoglobin notebook". Miscellaneous material, sub-divided as follows:

At front of book, untitled - miscellaneous notes, data, electron density charts, contour maps, December 1959 - April 1960.

"Least squares". Notes and printouts June-September 1960 (not all by Watson and includes printout by Dickerson June 1959).

"Holes in Fourier". Notes and charts.

"Sequence data". Notes and charts, including material from Edmundson.

"Myoglobin co-ords". Charts (not by Watson).

"Complete myoglobin co-ordinates". Tables, electron density charts.

C.120 Untitled. Notes by Kendrew for the 3-D co-ordinates of the 153 amino-acids in myoglobin, n.d., c.1961.

The notes were originally made in a small format notebook unlike any elsewhere in the collection; according to Kendrew (private communication July 1987) they were probably jotted down from a direct sight of the 2-Å model in the laboratory. The book was subsequently taken apart and each page stuck on to a separate sheet to fit into a standard looseleaf binder.

The notes are in three sections, setting out co-ordinates for $\rho 2$, $\rho 3$ and $\rho 4$. Within each section the co-ordinates are based on the eight helices (numbered A-H) of the 2-Å myoglobin molecule. Each section is separately paginated:

$\rho 2$ pp.1-53
$\rho 3$ pp.1-30
$\rho 4$ pp.1-13

C.121 "2-Å Side-chains co-ordinates". Three sets of work, sub-divided as follows:

"Summary notes on S/Cs". Tables for identification of 151 amino-acids in helices A-H. All in Kendrew's hand.

"Notes on side-chains". Probably preliminary work for above. Notes on each amino-acid and likely identification, by Kendrew, with some later notes and corroboration by Watson.

"Co-ordinates". Tables and calculations.

C.122 "1.5-Å Side-chains".

This is a detailed examination of 152 amino-acids and the haem group, one to a page, the helices A-H being separated by sub-dividers.

The top half of each page gives the chemical identification, and the lower half has notes on the X-ray findings first at 2-Å and then with reworkings and modifications at 1.5-Å. The final identification is in upper right corner. A few notes have dates in April, May 1962.

At rear of book "ρ4 co-ordinates plotted on 2-Å Fourier". 15pp. list and comments dated October 1965.

C.123 Untitled. Printouts of co-ordinates, many checked and annotated by Kendrew and with a front page list "Proposed changes in co-ordinates for Coulter least squares program" 1 March 1962.

At rear of book 14pp. charts and notes of "Co-ordinate revisions" 25 April 1962.

C.124 Untitled. Printouts of co-ordinates on EDSAC, with notes and checking in several hands but mainly by Watson. Electron density charts and contour maps. Few pages only dated 1962-64.

C.125 Untitled. Later work 1966-67, almost all in Kendrew's hand; includes letter from R. Diamond July 1966 on his listings of myoglobin co-ordinates and a little work by Watson. Work is mainly manuscript lists and tables of factors in myoglobin co-ordinates related to preparation and circulation of Kendrew's and Watson's "Myoglobin orthogonal coordinate and dihedral angle listing dated 1 April 1967" which was circulated 18 August 1967 with the warning that "further revisions will undoubtedly be required and the present set should not be regarded as final". A later revised version 8 October 1967 is also included and there is a manuscript note of material to be listed dated 1970. (See also C.274). Also included are manuscript lists of "Tabulations for papers", perhaps for other projected publications on co-ordinates.

Miscellaneous

These notebooks are so designated because they are more heterogeneous in content than those of the main myoglobin series or because they cover a wider timespan. C.126, C.127 nevertheless are part of the myoglobin research and include some of the most accessible explanatory material and correspondence. C.128, C.129 have more general reference.

C.126 "General notes". Miscellaneous notes, data, correspondence etc. by Kendrew and several collaborators relating to the myoglobin programme, earliest date 1955 but mainly 1957-58, sub-divided as follows:

"Exp." Notes and diagrams for camera settings for 3-D pictures, densitometer data (1955), several series of wedge tests (1958) annotated by Kendrew, comparison of Cambridge and Royal Institution results, correspondence or notes by Dintzis, P.J. Pauling, T. Deeley, D.C. Phillips, Dickerson.

"Theo." Notes and calculations on number of reflections required at various Angström resolutions (1958), phases, scaling by Wyckoff (1956) and others, electron density charts, contour maps, phase determination (1957 by D.M. Blow).

Untitled, at rear of book, project diary by Kendrew 24 April 1957 - 10 December 1958 intercalated with related correspondence and notes from or to collaborators and various charts on "State of project". Of special interest are his "Notes on the myoglobin programme" written for W.L. Bragg 27 April 1958. These outline the future programme, the probable timespan, the methods and equipment required and the division of labour between Cambridge and the Royal Institution. He writes: "Stage II will be a 3-dimensional Fourier synthesis with resolution 3 or 2-Å, obtained by the method of isomorphous replacement. Stage III will be a synthesis going as far out in reciprocal space as we can - probably to 1.5-Å - preferably by the heavy-atom method."

C.127 Untitled. Miscellaneous notes, data, correspondence etc. by Kendrew and collaborators. Earliest date 1958 but mainly 1960-61, sub-divided but not always labelled, as follows:

Untitled. Kendrew's notes on "Cochran's Fourier Transform lectures", manuscript notes October 1961, correspondence on computer programs from C.L. Coulter 1961.

Untitled. Brief note on visitors to Unit September 1962.

Untitled. Contour maps for 6-Å Fourier, correspondence on Fourier transform, notes on "American trip" by Perutz, lectures by Brenner, Antonini, and on Fortran 1960-61.

"Structure". Photographs of "Myoglobin 2-Å R1 model April 1960", of Fourier syntheses, and of helices. Electron density charts, haem group and special section diagrams with a letter from Watson on side-chains January 1961, miscellaneous notes by Kendrew some dated 1958.

"Amino acid comp." Notes and tables of various protein sequences 1958-61.

"Journal". Project diary 3 February 1959 - 10 July 1961, intercalated with correspondence and notes from or to collaborators and various charts on "State of project" (similar material to project diary at C.126). Mainly related to final stages of work and publication of paper on 2-Å model (*Nature*, **185**, 1960), but also includes from 1 August 1960 plans to refine the resolution to 1.5-Å. Includes data or correspondence from Coulter, Dickerson, Phillips, L.H. Jensen.

C.128 "Conference notes and lectures".

This is a chronological sequence of material 1959-71, all in Kendrew's hand, consisting of his notes of papers, lectures, questions and discussions at meetings attended by him or by other members of the MRC Unit, talks and seminars given in the Unit by visitors or by staff members during its Open Days, and also of the papers given at the 1969 EMBO meeting at Konstanz on the scientific programme of the proposed European Molecular Biology Laboratory. The content, though primarily on protein structure, is thus not exclusively on myoglobin.

This item was a late addition to the collection and has been kept as an entity, though its contents are often an essential complement to Sections D (MRC Unit), F (EMBO), L (Lectures) and N (Visits and conferences). The work is sub-divided as follows:

1959-62

D. Davies	Polynucleotides	30 October 1959
Gierer	TMV	20 January 1960
Anfinsen	no title	n.d.

First International Symposium on poly-α-amino acids and polypeptides, Madison Wisconsin, 19-23 June 1961 (programme, participants, notes). See L.147

Gordon Conference on proteins, New Hampshire 26-30 June 1961 (programme, participants, 12pp.notes). See L.147, N.14.

Gurd	Chemical Studies of myoglobin	11 July 1960
Brenner	Replicon	n.d.
Krimm	Feather	18 February 1963
O'Brien	no title	25 February 1963
Brandén	no title	25 March 1963
Green	Lactoglobulin	13 May 1963
Luzzati	Synthetic polypeptides	11 February 1963
D. Blow	Chymotrypsin	28 May 1963

1963-65

Weizmann Conference, June 1963. See L.147, N.17.

Crickday		7 October 1963
Bonner	Regulation of chromosome activity	24 January 1964

Holland visit to laboratories, February 1964
see also L.148

Structural Studies Division,
account of work in hand 12-13 October 1964

Perutz	Molecular interpretation of Bohr effect	4 February 1965
Klug	Turnip crinkle virus	25 February 1965

Conformation workshop, National Institutes of Health, Bethesda, 24-25 June 1965 (7 pp. notes). See L.148, N.19.

Gordon Conference on proteins, New Hampshire 28 June - 2 July 1965 (31pp. notes). See L.148, N.20.

Crick	Talk to lab.	12 October 1965

1967-68

Blow	Travels in USA	17 August 1967
Perutz	no title	23 May 1968
McLachlan	Gordon Conference 1968	19 July 1968

Nobel Symposium on symmetry and function of biological systems at the macromolecular level, Stockholm, 26-29 August 1968 (23pp. notes). See L.148, N.29.

1969

Diamond	Real space refinement of myoglobin	8 July 1969
Clark	tRNA crystals	29 September 1969

EMBO Konstanz discussion 27-29 November 1969 (notes on scientific part) (9pp. notes). See F.190-F.194.

Crick	Chromosome structure	19 October 1971

C.129 Notes on the literature, mainly 1961-68, sub-divided as follows:

Indexing
Proteins - general
Proteins - part[icular]
Haemoglobin
DNA
Miscellaneous

NOTES AND DATA (Kendrew and collaborators)

These are more miscellaneous in character, and less rigorously dated and paginated than the documentation selected for preservation in the "official" sequence of notebooks, though the work is often concurrent and therefore follows a similar order. C.130-C.169 deal with research methods and techniques, species specificity and the quest for the material best suited to X-ray diffraction analysis; C.170-C.187 relate to the main myoglobin programme. The "collaborators' notes and data" at C.190-C.195 also contain material relative to the main programme, but not exclusively so in topic or date.

Preliminary work

Horse haemoglobin and myoglobin

C.130 Brief notes, electron density charts on haemoglobin.

C.131 "Haemoglobin - Low resolution 3D Patterson (EDSAC)". Notes, calculations, printouts, December 1950 - January 1951.

C.132 "Horse myoglobin. Papers on molecular shape". Diagrams, lattices, calculations. n.d. Includes a note from W.L. Bragg, February 1949.

C.133 Horse myoglobin. Diagrams, lattices, ideas on structure, some headed "Pseudo-orthorhombic" and perhaps related to joint paper with I.F. Trotter "A pseudo-orthorhombic form of horse myoglobin", *Acta crystallogr.*, 7, 1954.

C.134 "Horse myoglobin. Pepinsky machine". Correspondence and photographs of myoglobin Fourier syntheses by R. Pepinski.

Blue whale

C.135 "Blue whale myoglobin in $(NH_4)_2SO_4$", a, b, c projections, Edsac sheets, calculations, density charts, all checked by Kendrew May 1952.

C.136 Blue whale in phosphate, a, b, c Patterson. Similar material December 1952.

Penguin

C.137 "Penguin imidazole orthorhombic". Printouts, density charts, contour maps, intensity calculations October 1953.

C.138 Penguin a, b, c Patterson. Similar material n.d.

Carp

C.139 "Carp non-principal projection". Diagram of "Intensity strip November 1952". Early X-ray diffraction picture.

C.140 Carp myoglobin a, b, c projection. Printouts, density charts, lattices. Some dated July, September 1954.

Seal

C.141 "Centred seal". Lattices A2, B′ diagrams.

C.142 "Centred seal b, c face diagonals". Printouts, density charts, diagram October 1954.

C.143 "Wash seal a, c". Similar material October 1953.

C.144 "Wash seal b". Similar material October 1953.

C.145 "Wash seal monoclinic a". Similar material October 1953.

C.146 "Monoclinic seal Lattice A". Similar material February, June 1954.

C.147 "Seal myoglobin Lattice A' b patterson". Similar material n.d.

C.148 "Seal 'Nodes and loops' ". Graphs, radial distribution and scaling charts, using above data.

Finback whale

This was the subject of extensive study 1950-54. Much of the work (C.149-C.160) is in Kendrew's own hand, and some is by M.M. Bluhm (C.161-C.164) and P.J. Pauling (C.165, C.166).

Work by Kendrew

C.149 Printouts, contour maps, density sheets, calculations, lattices, graphs, ideas for structure etc., some dated November 1950, July 1951.

C.150 "Fly's eye work Manchester 1952". Notes, graphs, lattices, photographs, some dated May 1952 using optical diffraction methods developed by H.S. Lipson. (See also C.203.)

C.151 "Inequalities. 'Manual' application of Cochran's rule". Notes, graphs, calculations, adaptation for EDSAC program etc. (only one set dated 25 April 1953) based on paper by W. Cochran "A relation between the signs of structure factors" 1952, a draft of which is enclosed.

C.152 "EDSAC Finback whale May 1953". Routines and tables, applying Cochran's rule. Includes 9pp. summary of results.

C.153 "Fouriers of Finback. (EDSAC inequalities) May 1953". Similar material, continues to June 1953.

C.154 "Finback whale 3-dimensional Patterson". Printouts (checked), density charts, contour maps, calculations etc., some dated February, April, July 1954.

C.155 "Type F Inequalities". This is a substantial file of material, punched, paginated and with a summary of contents, of the same format and organisation as the stiff-backed binders but kept instead as loose papers in a folder. The material runs December 1953 to December 1954 and covers various attempts using Cochran's methods and other programmes to obtain good Fouriers for finback whale.

C.156-C.160 Five folders of contour maps and printouts for Fouriers of finback, 1954, 1955.

Work by M.M. Bluhm

C.161, C.162 Two folders of calculations and charts for scaling factors, camera setting, intensities etc. for 3-dimensional structure of finback whale. Few dates.

C.163, C.164 Two folders of density sheets and contour maps.

Work by P.J. Pauling

This is work similar to that at C.111A on salt water changes in finback whale myoglobin, related to the joint paper in *Proc. Roy. Soc.*, **237**, 1956.

C.165 Calculations and notes on a, b, c projections, November 1954 - March 1955.

C.166 Miscellaneous notes, calculations, contour maps etc., various dates August 1954 - March 1955.

Whale - Structure factors

Notes, calculations and diagrams, all by Kendrew. Early work on whale crystals (not all the "type A" finally selected) in attempt to explore research techniques and results.

C.167 "Whale Patterson fitting". Various diagrams and graphs of crystals at different angles, early contour maps. The folder is dated 1948-49 but one of the sets of drawings is dated 3 May 1952.

C.168 "Whale Structure Factors and Fouriers". Detailed calculations, graphs, tables of structure factors for various models. Most have a note by Kendrew summarising the results e.g. "not good enough to justify a Fourier", "no absolutely decisive improvement was obtained", "this looks pretty good" etc. Some sets of notes bear dates in February, March, May 1952.

C.169 "Whale Series a-n, IVC, D. Structure factor calculations". Similar material, in the order described. Also includes a project diary of work 13 June - 9 July, no year given. Perhaps 1952.

Main Myoglobin programme

Orthorhombic sperm whale

C.170 Notes and diagrams by Kendrew on "packing" and crystal lattices of Types A and B orthorhombic sperm whale, some dated March 1953.

C.171 "Sperm orthorhombic met-imidazole". Notes, graphs, density sheets, contour maps, a, b, c projections, some by Kendrew, some by R.G. Parrish, related to joint paper in *Nature*, **175**, 1955.

C.172 "Sperm orthorhombic 'end-on' Fouriers". Work by Parrish and Kendrew n.d.

C.173 "Sperm orthorhombic a Patterson", November 1952, January 1953.

C.174 "Sperm orthorhombic b Patterson". Printouts, calculations, density sheets, n.d. With a later note 21 May 1955 by Kendrew "Because of inconsistencies in the ψ origins I have checked through the whole computation of the b projection from the photographs to the check totals of the Edsac. Everything seems to be in order."

Monoclinic sperm whale

C.175 "Sperm monoclinic met-imidazole". Calculations, density sheets, contour maps, some dated June 1954. Work by Parrish and Kendrew.

C.176 "Reflections on Wissenberg Patterns". Charts and notes by Bluhm February-April 1953.

C.177 "Sections through 3-dim. Patterson of sperm monoclinic". Notes and calculations by Bluhm, only one page dated October 1953.

C.178 Scaling factors and checks by Bluhm.

C.179 "Sperm whale myoglobin. 3-dimensional synthesis". Notes, calculations, graphs, printouts (one dated 16 July 1953), including note on "Reconciliation of 3-dimensional results with 2-dimensional projections". Work almost all by Kendrew, a little by Bluhm.

C.180 "End-on Fourier". Notes and calculations, almost all by Kendrew, a little by Bluhm. June 1953 and a later note November 1953.

C.181-C.183 Three folders of calculations, density charts, printouts and checks for Pattersons.

C.184 "Sperm whale myoglobin. 3-dimensional Patterson. EDSAC sheets". Large scale charts by Bluhm checked by Kendrew, numbered 1-12 and some additional, of values to be used on EDSAC tapes.

C.185 "Sperm monoclinic EDSAC outputs. 3-D Patterson". Printouts and calculations, all checked and corrected by Kendrew.

C.186 Miscellaneous calculations, density sheets, contour maps and projections, by Bluhm, some with Kendrew's checks and corrections dated October 1954.

C.187 Work on radial distribution. Includes data on intensity distribution for haemoglobin, myoglobin and ribonuclease sent by V. Luzzati 1954 (see C.36), graphs, notes and calculations by Bluhm.

C.188 Later work on radial distribution, charts, diagrams etc. in various hands n.d.

C.189 "3-D Fourier a and special sections". Contour maps and diagrams, including haem group n.d.

Collaborators' notes and data

In alphabetical order

R.E. Dickerson and others

C.190 Notes, calculations, preparation methods etc., mainly by Dickerson but also by others and relating to collaborative work with Royal Institution; includes notes on verso of letter from Kendrew to Phillips 12 May 1958 and an undated note from Dickerson to V. Shore. December 1957 - December 1958.

H.M. Dintzis

C.191 "HgI_4 Difference syntheses". Notes, calculations, density charts, densitometer readings etc. 1955.

J. Kraut

C.192 "Type F Joe Kraut's work 1955-56". Notes, scaling factors, tables, contour maps etc. Includes brief notes by Kendrew on Kraut's work on Type D and Type F. The material is in the standard format of the loose-leaf binders but was kept as loose pages.

D.C. Phillips

C.193 Work on haem group. Extensive notes, narratives, graphs, printouts etc., paginated 1-121 but not in numerical order, some dated 1960.

H. Wyckoff

C.194 "H. Wyckoff - miscellaneous notes". Includes densitometer tests, irradiation tests, 3M CsCl densitometer tests.

Unidentified

C.195 Work on isocyanide spectra 1954-55. File cover has a manuscript note in unidentified hand "Interesting early work on the combination of myoglobin with isocyanide".

Miscellaneous

C.196 Correspondence, data, printouts, density sheets, contour maps, 1957, relating to checking 6-Å 3-dimensional Fourier synthesis obtained on EDSAC I against DEUCE computer at National Physical Laboratory. Includes EDSAC programs by D.W. Green, correspondence with J.S. Rollett July-October on 3-dimensional analysis, and a letter from Kendrew 7 December 1957 on 2-dimensional analysis explaining that "EDSAC 1 will be going off the air permanently any time now ... EDSAC 2 is at present in small pieces".

C.197 "An examination of the helices in myoglobin". Manuscript draft for a paper so titled, with 6 tables and 3 figures, in the hand of H.C. Watson, n.d. but 1960 or later.

Also included is a brief outline by Kendrew for the paper under the title "The helical segments of polypeptide in myoglobin" and a note of two major collaborative papers intended for the series on "Structure of myoglobin" in *Proc. Roy. Soc.* of which I-V had been published 1950-59. The two mentioned in the note are "VII a three-dimensional Fourier synthesis of sperm whale crystals at 2-Å resolution by Kendrew, Dickerson, Strandberg, Phillips and Shore" and "VIII Interpretation of a 2-Å Fourier by Kendrew, Phillips, Strandberg, Watson and ? Dickerson, Shore". These papers did not in fact appear and the work was published only in the shorter form of communications in *Nature*.

C.198 Material on computer generated models for interpretation of three-dimensional syntheses. Mainly exchanges with M.O. Dayhoff on research proposal "Aids to interpretation of protein crystallography" 1962 (with comments by Watson and Bränden) and renewal 1965, publication of *Atlas of Protein Sequence & Structure*, later correspondence on probability research 1971.

MATERIALS AND APPARATUS

Supplies and specimens

Correspondence with whaling stations, shippers, fisheries, colleagues and individuals on the supply and transport of suitable samples of myoglobin, particularly of sperm whale but also of various other species. The earliest exchanges date from December 1952 when Kendrew and his team discovered the special suitability of sperm whale meat and no time was lost in trying to locate supplies; Perutz joined the initial quest by writing to a colleague in Peru, cables were sent to and from ships at sea and other members of the laboratory were despatched at various times to collect specimens from cold stores, overnight fish trains and airports.

C.199 1952-53.

C.200 1954.

C.201 1955-58.

C.202 1960-65 (much of this relates to the investigation of porpoise myoglobin by R.H. Kretsinger), 1972.

Optical diffractometer

C.203 Correspondence, drawings and notes on the "Fly's Eye" lamp, related to optical apparatus devised by H.S. Lipson whom Kendrew approached on the matter on the advice of W.L. Bragg. Also includes correspondence with commercial suppliers of high intensity light sources.

Examples of masks and "pantographs" on optical diffractometer are at C.308. See also C.150.

Microcamera

C.204 Drawings and diagrams by Kendrew and others.

Densitometer

C.205 "Scanning densitometers design data". Drawings, blueprints, correspondence with suppliers, paper (no author or date) on "flying-spot" densitometer, correspondence with M.H.F. Wilkins 1957, A.C.T. North 1958.

C.206 "Bluhm Densitometer". Correspondence with commercial firms, notes, calculations, graphs by Bluhm October-December 1953, information on photometer from F.H.C. Crick.

C.207 Correspondence with supplier and colleagues on microdensitometer 1957-59. Miscellaneous rules and scales for use on densitometer in Kendrew's laboratory.

Computer time

C.208 Use of time on IBM 7090 at AWRE Aldermaston. Correspondence 1959-61, routines and information on myoglobin work on 7090 by C.L. Coulter 1960-62.

C.209 Miscellaneous correspondence on use/hire of computer time on various machines and at various institutions 1959-67, especially 1960-61 when EDSAC 2 was no longer capable of the fast computing required.

COLLABORATORS AND STAFF

Correspondence and papers relating to doctoral, postdoctoral and other research posts with the protein crystallography team. Applications come from UK and Europe, but mainly from USA, funded from various grant-giving institutions and foundations; there are also some MRC staff members on long or short-term contracts.

The material may include applications and recommendations for work in team, arrangements for funding, supply or importation of equipment, publications, advanced degrees, visits of varying duration, research proposals, progress and results, exchanges of information, related correspondence with other colleagues etc. Some are brief exchanges, others extend over a considerable period and include news of subsequent career.

Individual files

C.210 Banaszak, L.J. 1962-66

Work on guanidated myoglobin and GPDH.

C.211 Bluhm, M.M. and others 1951-60

Bluhm was an MRC staff member, working as Scientific Assistant to Kendrew 1952-55. Includes a little correspondence 1951 when it had been hoped to make the appointment, and Kendrew's analysis and material for 1952 appointment.

C.212 Bodo, G and others 1957-60

Correspondence conducted after Bodo had left MRC laboratory and returned to Austria, on myoglobin research, heavy atom attachment etc.

C.213 Brändén, C-I 1962

Brändén spent a year as a temporary MRC staff member. Brief correspondence only, on arrangements.

C.214 Bretscher, P.A. and others 1968, 1973

C.215 Coulter, C.L. and others 1959-66

Coulter worked 1960-62 on the 1.5-Å Fourier synthesis computed on IBM 7090, funded by US National Institutes of Health. Includes abstracts of papers given by Coulter at American Crystallographic Association meeting June 1962 on "Recent work on the structure of myoglobin" and "Refinement methods for protein structures" which discuss the work at 1.4-Å.

C.216 Creighton, T.E. and others 1965-68

C.217 Dickerson, R.E. and others 1957-68

Dickerson worked at the laboratory, funded by US National Science Foundation, from January 1958 to 21 August 1959 and for a shorter visit July-August 1960. Correspondence on funding, joint and other publications, research plans and results, myoglobin co-ordinates etc.

C.218 Dintzis, H.M. and others 1955-63

Dintzis worked at the laboratory as a Rockefeller Fellow 1954-55, making important contributions to the isomorphous replacement work.

C.219 Edmundson, A.B. and others 1959-71

After some delays, Edmundson came to work in the laboratory on amino-acid sequencing, funded by US National Institutes of Health, from October 1960 to September 1964. Correspondence and material about special equipment provided for the work by the Rockefeller Foundation, and subsequently (February 1965) made over indefinitely to the laboratory, are also included.

After returning to America, Edmundson developed an illness attributed to prolonged contact with solvents (in particular methyl-cellosolve) and was obliged to discontinue work on protein chemistry.

C.220 Hart, R.G. 1957-58

C.221 Hoppe, W. 1958-64

Structure factors, phase circles, equipment, other research projects.

C.222 Huxley, H.E. and others 1950-55

Research and recommendations, mainly related to Huxley's period at M.I.T. as Commonwealth Research Fellow, his return to the MRC Unit and provision of an electron microscope for his research.

C.223 Jensen, L.H. and others 1959-62

Helices in 2-Å and 1.5-Å resolutions. See also C.127.

C.224 Kraut, J. and others 1954-59

C.225 Kretsinger, R.H. and others 1963-73

Research and joint publication, draft paper on "The structure of porpoise myoglobin".

C.226 Levitt, M. and others 1967-70

Levitt held an MRC Training Scholarship at the laboratory from 1968 until the award of a Fellowship at Caius in 1970.

C.227 Nobbs, C.L. 1963-71

C.228 Parrish, R.G. and others 1951-56

Parrish was a Merck postdoctoral fellow at the laboratory 1952-54; correspondence is on funding and career, research programme and results.

C.229 Pauling, P.J. and others 1951-56

C.230 Pinkerton, M. 1955-61, 1969

C.231 Schoenborn, B.P. and others 1964-69, 1974

Research, publications.

C.232 Steinrauf, L.K. and others 1958-63, 1967

C.233 Stockell, A. 1958-59

Work on papain.

C.234 Strandberg, B.E. 1959-65

Correspondence July 1959 refers to crucial stage of 2-Å resolution work and pressure to complete before R.E. Dickerson and Strandberg finished their stay at laboratory (see also C.84).

C.235 Stryer, L. and others 1961-64

C.236 Watson, H.C. 1959, 1964-68

Watson had an MRC staff appointment at the laboratory December 1959 - June 1968.

C.237 Wheeler, J. 1959-62

Part time MRC staff member, working on EDSAC programming.

C.238 Wyckoff, H.W. and others 1954-57, 1963

Kendrew's letter of 17 July 1955 includes a very clear summary of the current state of the myoglobin programme. Wyckoff's reports on his research are also included.

Chronological files

Shorter correspondence relating to applications to vist or work at the laboratory. Similar material to C.210-C.238 above, but less extensive.

C.239 1951.

C.240 1952-54.

C.241 1955-56.

C.242 1957.

C.243 1958-59.

C.244 1960.

C.245 1961.

C.246 1962.

C.247 1964, 1965, 1966.

CORRESPONDENCE

Aspects of myoglobin

C.248-C.272 below are the contents of Kendrew's bulky folders, sub-divided for ease of reference, with his own descriptive titles. The material for each topic, which may extend over very many years, is presented in chronological order. The content may have some degree of overlap with correspondence elsewhere e.g. on methods of preparation, exchange of specimens and results, comments on publications, but Kendrew's arrangement has been respected.

Myoglobin - biochemistry 1947-81

C.248 1947.

C.249 1950-54.

C.250 1955-57.

C.251 1958-59.

C.252 1960-62.

C.253 1964.

C.254 1965.

C.255 1972, 1979, 1981.

Myoglobin - Theory 1949-68

C.256 1949-53.

C.257 1958, 1965, 1968.

Myoglobin - electrical - magnetic 1953-70

C.258 1953, 1958.

C.259 1959.

C.260 1960-63.

C.261 1964, 1968, 1970.

Myoglobin - electron microscopy 1954-63

C.262 1954, 1958, 1961, 1962-63.
Includes samples of micrographs.

Myoglobin - helix content 1955-62

C.263 1955, 1957-58, 1962.

Heavy atoms 1957-66

C.264 1957-60, 1965, 1966.

Myoglobin - physical chemistry general 1958-77

C.265 1958, 1961-63.

C.266 1964-65.

C.267 1968.

C.268 1970, 1973, 1977.

Myoglobin - oxygen reaction 1960-74

C.269 1960-62, 1966-67, 1970, 1972, 1974.

Myoglobin - 2-Å Fourier 1960-67

C.270 1960-62, 1965, 1967. Mainly on helical structure and position of haem group.

Porphyrin structure 1961-66

C.271 Correspondence and data 1961-66.

C.272 Shorter correspondence 1954-75; requests for information on supplies, specimens, preparation methods, equipment etc.

Atomic co-ordinates/amino-acid sequencing

C.273 Correspondence 1955-59 with US colleagues on collaborative work suggested by Kendrew 2 November 1955 for the chemical determination of the amino-acid sequence of myoglobin, to be undertaken by the Rockefeller Institute for Medical Research New York alongside the X-ray diffraction analysis in progress at the MRC Laboratory.

The correspondence is mainly with S. Moore and W.H. Stein at the Rockefeller Institute, and with A.B. Edmundson who was the first graduate student to work on the project, initially at the Rockefeller Institute, later at Brookhaven and eventually as a postdoctoral research fellow at the MRC Laboratory (C.219). Some correspondence with other colleagues is included.

The exchanges are of particular interest in chronicling the progress of the myoglobin project at a critical time.

C.274 Kendrew's and Watson's tables of co-ordinates circulated April 1967, August 1967, revised October 1967. With miscellaneous lists of requests for tables, and chart of those supplied 1967-74.

C.275 Correspondence from colleagues on sequencing research, some simple requests for Kendrew's results, others with more detailed exchanges on work in progress, publications, 1960-67.

Kendrew's letter to C. Levinthal of 15 February 1965 explains his reluctance to distribute the tables of co-ordinates prematurely.

C.276, C.277 Shorter correspondence distributing or requesting tables of co-ordinates compiled by Kendrew and Watson in 1967 (C.274). Includes letters of thanks, information on research or educational projects, myoglobin model-building, requests to use or quote material.

C.276 1967-69. C.277 1970-78.

Publications

General correspondence

General correspondence 1958-68 arising from publications on myoglobin by Kendrew and collaborators, received from colleagues, authors, editors and publishers. Includes letters of congratulation, requests for reprints and photographs, permission to quote or reproduce material, letters of thanks, and some scientific exchanges related to or arising from published results and continuing work on myoglobin.

C.278 1958.

C.279 1959.

C.280 1960 January-May.

C.281 1960 June-December.

C.282 1961.

C.283 1962 January-May.

C.284 1962 June-December.

C.285 1963 January-May.

C.286 1963 June-December.

C.287 1964, 1968.

Myoglobin papers

C.288 Correspondence August 1957 - January 1958 on the 6-Å resolution synthesis and its publication (with Bodo, Dintzis, Parrish, Wyckoff and Phillips) in *Nature*, **181**, 1958.

Kendrew's letter of 20 August, sent to Parrish, Bluhm, Dintzis, Bodo, Wyckoff and Kraut, is reproduced below for its historical interest, summary of the work and future plans:

CAVENDISH LABORATORY,
CAMBRIDGE

20 August, 1957

" Dear

To save repeating myself, this is a circular letter to tell you that we finally managed to do a 3-dimensional Fourier synthesis of myoglobin the other day, with a resolution of 6 A. The phases were determined using 5 different isomorphous derivatives - mercury diammine, gold, PCMBS, mercury diammine + PCMBS, and gold + PCMBS - with an accuracy which I should estimate as ± 20°; 400 terms in all, of which 100 were h01's and therefore real. The calculation was done on EDSAC in 76 minutes using a 2-dimensional program of David Green's modified for the purpose; and as a double check it has since been repeated on DEUCE, the big machine at the National Physical Laboratory.

The Fourier shows much more than I personally ever hoped it would. First of all the main parts of the polypeptide chains are quite clear; and so is the iron atom, which gives a peak 50% higher than the chains and is the most prominent feature in the pattern. Its position checks up exactly with that of the iodine peak in the 2-dimensional difference Fourier of p-iodo-phenylhydroxylamine. The general shape of the molecule corresponds pretty well with what we have said in earlier papers, and its position in the unit cell is precisely what was suggested by Howard Dintzis's salt-water difference-Fourier. All the main features of the 2-dimensional Fourier of the protein are now interpretable, and its highest peak, incidentally, turns out to be the iron atom. The arrangement of the chains is complicated and our old term "quasi-parallel" is an over-simplification! Unfortunately when they turn corners the average electron density of the chains drops to near average so that at this resolution they nearly fade out, or at least the turns are not distinguishable from salt bridges, etc.: the consequence is that it may not be possible at this stage to string together the various segments into a unique sequence. Several of the segments are essentially parallel (though not straight), but others run at right angles and so to speak tie the bundle together round the outside. The haem group is not inside the molecule - in one sense it is definitely on the

outside, though in another one might say that it was buried in a cleft, though there is clear access for oxygen and other molecules.

Our plan is to extend the resolution to 3 A. using the same techniques as hitherto, though the phase determination will not be so accurate. Maybe we can do this in 18 months or 2 years. (3,000 reflexions per derivative this time!). This should clear up a lot of the doubtful points. After that atomic resolution!

I thought you might like to have this advance information about the latest results which, it goes without saying, would not have been possible to achieve without the efforts you made when you were in the Unit. All good wishes from everyone here.

Why not come back for a while and help with the 3 A stage?

All the best - "

Folder also includes a generous letter of congratulation from W.L. Bragg dated 17 August ("I feel I must write to say what a thrill it was to see your structure yesterday ... I did deeply appreciate your coming over so quickly to show it to me"), which suggests that "the other day" of Kendrew's letter, when the synthesis was actually completed, was 16 August.

Also included are letters to and from colleagues, and brief correspondence with *Nature* about publication.

C.289 Correspondence January-February 1960 on the 2-Å resolution synthesis and its publication. Bragg again writes enthusiastically ("I have been reading your paper and Perutz' with a real thrill ... the paper describing these results is all so fascinating and meaty that it would be a pity to cut any of it out"). *Nature* published the papers very rapidly, receiving the manuscripts in early January and publishing in the 13 February issue. Also includes a little correspondence with collaborators and colleagues.

Included here is the abstract of the paper "Progress with the 1.4-Å resolution myoglobin structure determination" by Watson, Kendrew, Coulter, Brändén, Phillips and Blake, presented at Sixth International Congress and Symposia of the International Union of Crystallography, Rome, 9-18 September 1963 (photocopy of supplement to *Acta crystallogr.*, **16**, 1963, A 81, kindly provided by D.C. Phillips). C.L. Coulter also presented papers on the research in 1962 (see C.215) but there is no fully written-up record of the 1.4-Å work.

C.290 Series (a)-(h) and caption for Figure 18 pp.94-95 of "Crystal structure of myoglobin V", with Bodo, Dintzis and Wyckoff, *Proc. Roy. Soc.* **253**, 1959.

Miscellaneous captions for exhibits.

C.291 Circulation list for Kendrew's publications c.1954-58.

Note In July 1986 *Current Contents*, **29** no.29 featured the 2-Å paper (*Nature*, **185**) as "This Week's Citation Classic" by which date it had been cited in 475 publications. The 6-Å paper (*Nature*, **181**) had been cited 140 times and the amino-acid sequencing paper (*Nature*, **190**) had been cited 405 times at the same date.

MODELS

Skeletal model

These were originally designed by Kendrew and made up in the Cavendish workshops and later (from 1958) in the MRC Unit's own workshops. By 1960 they were manufactured by Cambridge Repetition Engineers Ltd., several being sold to other laboratories mainly in US. They were frequently, though unofficially, known as Kendrew models. Correspondence with MRC and others August 1963 - December 1965, provides historical information on the matter.

C.292 Correspondence with colleagues, Cambridge Repetition Engineers, MRC and others on supply of models 1960-70.

Ball-and-spoke model

Following many requests for models of the myoglobin molecule, Kendrew approached MRC in May 1965 with a view to commercial manufacture and sale. He suggested the services of A.A. Barker of Cambridge Engineering Laboratories who had a small private business of the kind. After various discussions with MRC and National Research Development Corporation (NRDC) it was agreed that Barker should be formally licensed by NRDC to produce the models. Letters to colleagues about the scheme were circulated in May 1966; orders were received and processed, and priorities established, by Kendrew and passed on to Barker.

C.293 Preliminary correspondence and negotiations with MRC and NRDC, circular letters to colleagues May 1965 - May 1966.

C.294-C.297 Correspondence and orders, periodical lists of orders and priorities 1966-71. 4 Folders.

Science Museum London

C.298 Correspondence with museum staff about loan or gift of various models, advice on captions etc. Various dates 1958-77.

Correspondence

Correspondence with colleagues and manufacturers on methods, costs etc. of atomic model-building and scientific illustration.

C.299 1953-58. With R.B. Corey, on "Pauling-Corey space-filling models", often referred to elsewhere in the correspondence.

C.300 1957. With manufacturers of expanded polystyrene/plastics.

C.301 1957-59.

C.302 1961-62.

C.303 1963.

C.304 1965. Includes catalogue of British Biophysical Society Winter Meeting Exhibition of Molecular Models, and an earlier (September 1960) report of the Conference of the committee on atomic and molecular models of the Biophysics and Biophysical Chemistry Study Section of the US National Institutes of Health.

C.305 1966-67.

C.306 1969.

C.307 Printed/duplicated information on model-building.

MISCELLANEOUS

Pantographs

C.308 Masks and "pantographs" of finback whale myoglobin (End on) taken 1952 with the so-called "fly's eye" optical diffractometer based on the work of H.S. Lipson. See C.203.

SECTION D MRC LABORATORY OF MOLECULAR BIOLOGY, CAMBRIDGE D.1-D.39

INTRODUCTION

D.1-D.5 BUILDINGS

D.6-D.12 APPARATUS AND EQUIPMENT

D.13-D.32 STAFF

D.33-D.38 RESEARCH AND ADMINISTRATION

D.39 HISTORICAL

INTRODUCTION

This is the last and current title of the famous institution where most of the brilliant early research was conducted which gave Britain its historical lead in protein crystallography and molecular biology. Under its original name of Unit for the Study of the Molecular Structure of Biological Systems it was set up in Cambridge by the Medical Research Council from 1 October 1947 with a staff of two, M.F. Perutz and J.C. Kendrew, housed in the old Cavendish Laboratory in Free School Lane. The Unit expanded rapidly - by 1950 F.H.C. Crick and H.E. Huxley were already working there and J.D. Watson arrived in Michaelmas 1951 - and was renamed the Molecular Biology Research Unit in 1956. Although plans were put forward by Perutz, and accepted by the MRC, in 1958 for its expansion into a Laboratory of Molecular Biology with its own building, the work continued at the Cavendish in increasingly cramped conditions until 1962, when new quarters were opened by the Queen in the University Postgraduate Medical School on the New Addenbrooke's Hospital site. A further major extension was agreed in 1964.

M.F. Perutz was Chairman of the Laboratory until he reached retirement age in 1979, his successors being S. Brenner (until 1986) and A. Klug. Kendrew was Deputy Chairman and Director of the Division of Structural Studies until 1974 when he was seconded to EMBL. The records of his own research in Cambridge constitute Section C.

The fortieth anniversary of the first MRC Unit was marked in 1987 by various celebrations, gatherings, articles and TV programmes; information about some of these is at D.39.

BUILDINGS

Plans

D.1 Architects' plans January, March 1960 for laboratory on Addenbrooke's site.

D.2 Architects' plans June 1966 for extension.

Correspondence

Correspondence, memoranda, negotiations on extension to laboratory, mainly conducted by Perutz 1963-64 with MRC, but including research notes and ideas from colleagues and also a little later material.

D.3 1963

D.4 1964

D.5 Miscellaneous later material 1965, 1967, memoranda and correspondence on possible accommodation for EMBL, or for European scientists, 1968.

APPARATUS AND EQUIPMENT

Much of the material deals with the laboratory's later needs for computer hard or software. Equipment for Kendrew's own research is documented in Section C.

Computers

D.6 MRC Conferences on computer needs and access to computing facilities for staff of MRC Units, 1958, 1962.

D.7 General correspondence, memoranda, estimates, notes of discussions, meetings and committees, in MRC laboratory and Cambridge University, with computer firms, colleagues and MRC officials, covering all aspects of computer policy and requirements, purchase, hire or collaborative use of machines 1961-69.

Includes memoranda and notes from other members of laboratory, in particular D.M. Blow, U.W. Arndt, and also information and reports received from colleagues working elsewhere.

D.8 Correspondence, memoranda, discussion notes etc. 1963-69 on Cambridge University Titan machine.

D.9 Correspondence, memoranda, notes of meetings and discussions 1963-66 on purchase by MRC of Ferranti Argus 304 Computer (to process data from X-ray diffractometer, see D.11) at a cost of £140,000. Includes copy of letter by Perutz November 1966 complaining of poor performance of machine.

D.10 Correspondence and papers 1963-67 on use of computer time at Atlas Computer Laboratory.

Other

D.11 Correspondence, memoranda, discussion notes, costings etc. 1959-66 on purchase of Hilger & Watts/Ferranti diffractometer apparatus. Includes copy of complaint by Perutz on poor performance of Ferranti apparatus. See also D.9.

D.12 Miscellaneous correspondence 1957-61 on Polaroid rapid processing camera for slide making.

STAFF

Computing Staff

D.13 Tabulated information by Kendrew and others on requirements for computing staff for various members of laboratory. A few notes on those engaged.

D.14 Correspondence with successful applicants for full or part time work as computing staff in laboratory 1957-62. Includes Kendrew's notes.

D.15 Not used.

Research Staff

Applications to work in laboratory, earliest date 1962 but mainly 1969-73. Material includes correspondence, curricula vitae, recommendations and a log of correspondence (compiled in laboratory).

D.16	A	D.24	J
D.17	B	D.25	K
D.18	C(1)	D.26	L
D.19	C(2)	D.27	M
D.20	F	D.28	R
D.21	G	D.29	S
D.22	H	D.30	T
D.23	I	D.31	W

D.32 Z

RESEARCH AND ADMINISTRATION

D.33 Miscellaneous administrative papers 1961, 1964-74. Includes agendas and minutes of laboratory Board meetings, requests for equipment, space allocation, lists of personnel and visitors, new proposals for research projects or sub-divisions in the laboratory, finance, a little correspondence.

D.34 Miscellaneous research reports and proposals by members of laboratory:

TMV	1964	K.C. Holmes, A. Klug
X-ray diffraction	n.d.	unsigned
Nucleic acid	1965	F. Sanger
Chymotrypsin	1967	D.M. Blow
Mass spectrometry	1968	F. Sanger
NMR	1968	A.D. McLachlan

D.35 Notices, applications etc. for symposia and study courses on the work of the laboratory 1967-73 and undated.

D.36 Arrangements for MRC Subcommittee visit to Division of Structural Studies 9 May 1973. Members of the Subcommittee were J.A.B. Gray (Chairman), A.S.V. Burgen, A.F. Huxley, D.C. Phillips, R.D. Preston and P.M.B. Walker. Includes programme, timetable, synopses of talks accompanying demonstrations and other background information supplied to Subcommittee, report on visit and comments.

D.37 Brief notes by Kendrew on various matters related to laboratory, including a breakdown of time spent in UK, at EMBL, on ICSU and other business trips for 1975.

D.38 Structural Studies Committee Meetings 1-118, 10 February 1969 - 3 March 1975.

Includes agendas, minutes and some background papers and correspondence, dealing with all aspects of staffing, space allocation, apparatus and equipment requirements, visitors, financial estimates and allocations relating to the work of the Structural Studies Division.

N.B. For meetings 1-7 only the agendas survive.

HISTORICAL

D.39 Miscellaneous items commemorating the fortieth anniversary of the laboratory in 1987.

SECTION E CAMBRIDGE : UNIVERSITY AND COLLEGE E.1-E.16

INTRODUCTION

CAMBRIDGE UNIVERSITY

E.1, E.2	Teaching and curriculum
E.3 -E.5	Committees
E.6	Electoral and Advisory Boards

PETERHOUSE

E.7 -E.10	Scholarship and entrance examinations
E.11-E.13	Supervision
E.14	Prizes
E.15, E.16	Mastership elections

INTRODUCTION

The material in this section deals with Kendrew's postwar career at Cambridge. Though by no means a complete record, it gives some picture of his involvement in university and college life.

For virtually the whole of this period, that is from the start of the MRC Unit on 1 October 1947, Kendrew was a full-time salaried member of the staff of the Medical Research Council and indeed remained so until his retirement from EMBL in 1982. His own position, like that of the MRC Unit itself, was thus somewhat ambivalent vis-à-vis the organisation of the university and its collegiate life, but like many of his colleagues he made a full contribution to the requirements of research, teaching and administration at university level, while his connection with Peterhouse gave him a valued link with college life.

Kendrew was elected to a Research Fellowship at Peterhouse from 1 July 1947 to 1953, and to a Supernumerary Fellowship from 1953 until he resigned in July 1975 on his secondment to Heidelberg; he was elected an Honorary Fellow in November 1975. Despite the intense pressure of his own research during the 1950s, together with his responsibilities for the protein crystallography section of the MRC Unit, he continued to be actively involved with many aspects of life at Peterhouse. He was Director of Studies in Natural Sciences 1950-56 and a College Lecturer in Natural Sciences 1956-67 and organised the selection and tuition of scholars and undergraduates with his accustomed efficiency; he was Steward from 1955 to 1959 and as a member of the Governing Body served on various committees. Official material relating to the latter is held in the College Archives.

Kendrew's annual reports to the Master of Peterhouse during the tenure of his Research Fellowship 1947-53 give succinct and interesting accounts of his developing research and of the early growth of the MRC Unit. They are included at C.27.

Information about Kendrew's appointments at Peterhouse is at R.8, R.9.

CAMBRIDGE UNIVERSITY

Teaching and curriculum

E.1 Notes of graduate supervision fees paid to Kendrew 1950-68, kept as record. Names include H.E. Huxley, J.D. Watson, R.G. Parrish, P.J. Pauling, C.L. Nobbs, R.A. Crowther, P.A. Bretscher.

E.2 Brief correspondence and papers 1959-60 on proposed "Half subject cell biology" in Part I of Natural Sciences Tripos, suggested by J.W.S. Pringle and J.A. Ramsay.

Committees

E.3 Committee of the General Board on the long-term needs of scientific departments; the Chairman was W.A. Deer and the members were E.C. Bullard, J.B. Hutchinson and J.C. Kendrew. The report was submitted in October and published in December 1965 as no.4485 of the Cambridge University Reporter.

Copy of published report.

E.4 Papers and brief correspondence 1968-70 on Committee of Management for Biophysical Chemistry and Colloid Science, set up after the discontinuation of the Department of Colloid Science in July 1968, to administer the funding, staff and research of the Department. The Chairman of the Committee was G.B.B.M. Sutherland.

E.5 Visit of U.G.C. Biological Sciences Sub-Committee, 21 January 1970 "to learn as much as possible about the activities of the departments of biology and to discuss problems that may exist at Cambridge."

Correspondence and material prepared by the "Professorial Group" (Chairman A.S.V. Burgen, Secretary D.F. Barton) for discussion with Sub-Committee. M.F. Perutz was asked to join the group, but nominated Kendrew.

Electoral and Advisory Boards

E.6 Material relating to the following, on which Kendrew served, has been passed to Cambridge University Archives, University Library Cambridge (Ref: KEN. A-F):

1969	Advisory Committee on the Plummer Professorship of Biophysics
1970	Elector to the Directorship of the University Computing Service
1974	Elector to the Sir William Dunn Professorship of Biochemistry
1976	Elector to the Arthur Balfour Professorship of Genetics
1986	Advisory Committee on the Plummer Professorship of Physics

PETERHOUSE

Scholarship and Entrance Examinations

These were held separately at the time in question. Examinations for candidates aiming at a scholarship or exhibition were held in December; examinations for those aiming for entrance as a commoner were held in March. Colleges held their scholarship examinations in small groups with papers set and marked in common; the relevant group here was known as the "King's group" and consisted of King's College, Peterhouse, Pembroke, Gonville and Caius, and Corpus Christi Colleges. Entrance examinations were usually organised by the individual colleges.

E.7 Entrance scholarship and exhibition papers for King's group 1951, 1953-57, 1959, most with comments by Kendrew on the standard of questions set and analyses of performance, some with preliminary correspondence and drafts.

E.8 Full performance tables of all candidates in King's group 1954-57, 1959.

E.9 Peterhouse entrance examination papers, with notes and analyses of performance, 1950-59, 1962, 1963.

E.10 Kendrew's notes on interviews with Scholarship candidates 1952, 1953, 1956, 1958, 1959.

Supervision

E.11 Kendrew's notes on undergraduates supervised 1947-50.

E.12 Miscellaneous reading lists, correspondence with or about Peterhouse undergraduates 1962-67.

E.13 Correspondence on the supervision system at Cambridge, with W.B. Harland 1964, H. Butterfield (then Master of Peterhouse) 1965.

Prizes

E.14 Correspondence, suggestions for titles etc. for college prizes, (Tait Prize 1949, Sohan Lal Bhatia Prize in Physiology 1963-66).

Mastership

E.15 Correspondence and papers 1967-68.

E.16 Correspondence and papers 1972-73.

EUROPEAN MOLECULAR BIOLOGY

INTRODUCTION TO SECTIONS F, G AND H

European collaboration in research and teaching in molecular biology was a cause to which many scientists devoted themselves from the early 1960s. Kendrew was closely involved with the movement from its first inception, holding major offices in committees, advisory boards and working groups, and, through his participation in many of the similar bodies of the UK scientific consultative establishment, playing some part in the direction of official opinion.

Though the detailed history of the movement is exceedingly complex, its outline is simple. It began with the formation of the European Molecular Biology Organisation (EMBO), set up after various preliminaries in February 1964. This was, and remains, a private organisation of scientists working in the field, with Statutes, a Council and an elected membership, aiming to promote research and teaching in Europe by long- and short-term fellowships, courses, summer schools, and collaborative research. Funds for these purposes were provided by small grants, and, from December 1965, by a major pump-priming grant from the Volkswagen Foundation for the three years 1966-68. The proven success of the EMBO programme over this period, and the helpful initiative shown from the earliest days by the Swiss Government, led to a series of intergovernmental meetings and eventually to an agreement to establish a European Molecular Biology Conference (EMBC); the agreement was reached in 1969 by thirteen West European states, their number increased by later admissions to seventeen. The members of the Conference are representatives of governments, not individual scientists, and its principal role is to agree a budget for the scientific programme drawn up by EMBO which is then entrusted with the administration and implementation thereof. In this way the primacy of EMBO's scientific aims is achieved relatively free from international bureaucracy.

While the fostering of European excellence in molecular biology by comparatively simple low-cost means such as fellowships and courses had not met with really serious opposition, it is clear from the very earliest documents that the establishment of a major research institute or laboratory had always

been part of the plan and that this project was especially dear to Kendrew himself. It was written into all the manifestos and proposals, a Laboratory Committee with Kendrew as chairman was in being from 1964, a proportion of the Volkswagen grant was earmarked for feasibility studies and the EMBC budget included from the first a provison for laboratory working-groups. It is equally clear that the laboratory project was regarded as highly controversial, by governments because of its high and continuing costs (especially as presented in its first and grandiose form), and by many scientists and members of EMBO itself who disliked and saw no necessity for the concept of a large international institution which might cream off gifted researchers from national centres of excellence. The Laboratory proposal had to be soft-pedalled at the intergovernmental meetings, the plans themselves were scaled down, in Britain many high-level debates continued to show reluctance to admit the necessity for such an institution, and not all the members of EMBC were able to afford a contribution to the cost. Nevertheless the tenacity of the proponents of the laboratory scheme was rewarded when in May 1973 the Agreement was signed by ten of the thirteen EMBC states establishing the European Molecular Biology Laboratory (EMBL). By that date a site had been agreed at Heidelberg, with temporary accommodation at other institutes in the town, plans for collaboration with the "outstations" at Hamburg and Grenoble which offered special facilities were well advanced and a Provisional Scientific Advisory Committee had been set up in October 1971 to establish a programme of research. In 1974 the Secretariat of EMBO as well as of EMBL moved to Heidelberg where they maintain separate offices under the same roof. The laboratory was formally opened in 1978.

The material relating to all these organisations which is preserved here is of historical interest for its content and also for its provenance. It consists of letters, memoranda, reports and drafts covering twenty years from the earliest informal discussions by groups of molecular biologists to 1982 when Kendrew's service as the first Director-General of the EMBL came to an end. The staple is Kendrew's own carefully-preserved accumulation of files: he was a founder member of EMBO, served on its Council 1963-71 and 1975-77 and as its Secretary-General 1969-74; he was Secretary-General of the EMBC 1970-74 and Project-Leader 1971-74 then Director-General of the EMBL. He was thus uniquely placed at or near the centre of the developing project. In addition, Professor Jeffries Wyman, also a founder member of EMBO, its Deputy Chairman and first Secretary-General 1963-69, has made over his own papers and correspondence on the subject for incorporation. There is also a considerable

amount of material of Max Perutz, the first Chairman of EMBO and a prime mover in the early meetings and the negotiations for the vital Volkswagen grant and the intergovernmental meetings; and there are letters, carbons or photocopies exchanged between most of the founder members of EMBO who were all leading scientists working for the encouragement of European collaborative research in the intervals of active laboratory life.

The early history of EMBO and of the "Swiss Initiative" leading eventually to EMBC are thus very well documented in almost every aspect by original material. The records of the early history of EMBL are unique because of Kendrew's special commitment to the project; they include the preparatory studies carried out under EMBO and EMBC and also the building, research programmes and administration of the laboratory itself. Some of the political dimension of the project as it affected Britain can be traced in the papers of the Royal Society's International Relations Committee, the Council for Scientific Policy and less extensively of the Medical Research Council. Developments in other European member states can only be glimpsed in correspondence with colleagues and there is no official intergovernmental material as such.

The abundance of material has made it expedient to present it in separate sections for the Organisation EMBO (Section F), the Conference EMBC (Section G) and the Laboratory EMBL (Section H), each of which has its own introduction and list of contents. It is of course acknowledged that this is in some ways an artificial distinction and that - especially with the earliest material - there is some overlap when correspondence may range over several topics and when meetings and membership of committees were arranged to coincide and remain interlinked in a careful system of checks and balances. Nevertheless it has a justification both in chronology and, later, in separate legal identities. The EMBO material remains primarily the continuing story of a private scientific organisation traceable from 1963; there is some overlap through scientists and scientific administrators in Switzerland leading to the political decision to establish EMBC: the first surviving document here is of July 1964. Both these organisations were obviously continuously involved with the laboratory project and it is much more difficult to assign a "starting date" for EMBL when scientific, political and administrative considerations were, sometimes uneasily, combined. The choice has been made of 1971, when Kendrew was appointed Project Leader, a Provisional Scientific Advisory Committee was set up to decide a research programme and a Building Committee

was established to determine site, specifications and choice of architect.

Every effort has been made throughout to avoid or minimise overlap and cross-references have been provided whenever they seemed useful.

The success of EMBO in weathering financial storms, bureaucratic takeovers and political indifference over so long a period, maintaining its own entity and developing to play a significant role in an intergovernmental institution such as EMBC and a major international facility such as EMBL is generally agreed to be largely due to the close network of distinguished scientists who knew and trusted each other as colleagues and friends. On a practical level this means that many of the early documents in all three sections are letters exchanged with varying degrees of informality. Many are in longhand, or have manuscript additions and afterthoughts. Not all are dated, including many from J. Wyman; not all are signed, including many of the carbon copies from M.F. Perutz; these have been assigned a place and provenance from their content. It should also be remembered that the MRC Unit at Cambridge was Kendrew's base until 1974 and that much of the work of EMBO, EMBC and EMBL emanated from there, as well as letters on the unmistakable pink copy paper apparently favoured there during the 1960s from the leading members of its staff (S. Brenner, H.E. Huxley, F.H.C. Crick, A. Klug in addition to Perutz and Kendrew) who were founder or very early members of EMBO and its committees.

SECTION F EUROPEAN MOLECULAR BIOLOGY ORGANIZATION (EMBO) F.1-F.232

INTRODUCTION

EARLY HISTORY

F.1 -F.9	Preliminary meetings and correspondence 1963	
F.10-F.15	Formal constitution and statutes	
F.16-F.33	Relations with other organisations	
F.34-F.42	Policy document	
F.43-F.56	Funding	
F.57-F.60	Miscellaneous correspondence	

MEMBERSHIP

F.61-F.77	Nominations and elections	1963-82
F.78,F.79	Circulars and lists	1964-75

COUNCIL

F.80 -F.118A	Correspondence and meetings	1964-80
F.119-F.127	Membership and elections	1963-74
F.128,F.129	Minutes and circulars	1963-81

FUND COMMITTEE

F.130-F.132	Membership	1965-74
F.133-F.140	Correspondence and papers	1964-74
F.141-F.149	Fellowship applications	1964-74
F.150	Minutes	1965-73

COURSE COMMITTEE

F.151-F.153	Membership	1965-74
F.154-F.167	Correspondence and papers	1965-74
F.168	Minutes and circulars	1966-69

LABORATORY COMMITTEE

F.169-F.208	Meetings, correspondence and papers	1963-73

ADMINISTRATION

F.209,F.210	Appointments
F.211-F.215	Finance and accounts
F.216-F.220	General administrative correspondence

SYMPOSIUM COMMITTEE

F.221-F.228	Correspondence and papers	1974-81
F.229	Minutes	1974-80

MISCELLANEOUS

F.230,F.231	Press releases, articles, comments	1963-71
F.232	Annual reports	1966-81

INTRODUCTION

The earliest surviving documents (F.1) are dated January 1963. References in the correspondence, and Kendrew's later letter of 1971 included in the same folder, mention informal discussions in Geneva and Washington at the end of 1962 in which Kendrew, J.D. Watson, and V.F. Weisskopf took part and L. Szilard played a leading role. (Szilard's early involvement and strong encouragement of the project were subsequently commemorated in the Szilard Library at EMBL. See F.47, H.48, H.54, H.312). At this early stage, throughout and indeed considerably later than 1963, the possible establishment of a central organisation and institute in Switzerland on the model of CERN was envisaged. The project was often referred to as CERB (the biological equivalent of CERN); other names and acronyms were European Fundamental Biology Organisation (EFBO) and European Biological Organisation (EBO).

The crucial preliminary meeting, and the first attended by Perutz (later first Chairman of EMBO) was at Ravello in August 1963 (F.4-F.7). Here much of the future shape of the organisation was determined, notably the two purposes of funding research fellowships and courses and the establishment of a research institute. A provisional executive committee was appointed and met (F.8, F.9), suggestions for membership were requested (F.60, F.61) and the constituent Council meeting was held in February 1964 (F.80). This, like most of the early meetings, was held at CERN; links with Switzerland continued close through personal relationships with scientists (Weisskopf, E. Kellenberger and others) and the encouragement of the Swiss government.

The first Council meeting ushered in a period of great activity, all well documented: the drafting of a constitution (F.10-F.15), the formalisation of EMBO's aims (F.34-F.42) and the assuring of funds - EMBO is elective and there is no subscription or entrance fee. The funding problem was closely bound up with the problem of EMBO's relations with, or independence of, other organisations, some of which, it was thought, were too narrowly confined by national boundaries or limited scientific aims, while others such as the Council of Europe or UNESCO entailed the slower pace and political ramifications of international bureaucracy. Some of these negotiations are documented (F.16-F.33) through correspondence and reports and also through aide-memoires and notes of meetings or discussions for private circulation. In

the event EMBO kept its independence and launched its scientific programme thanks to a three-year grant from the Volkswagen Foundation (F.43-F.49) which, together with the diplomatic efforts of the Swiss government, saw it through to the signing of the intergovernmental agreement to provide financial support.

All these administrative and financial matters, and the continuing negotiations with the Swiss government, necessitated relatively frequent meetings of Council in 1964 and 1965 as well as private discussions or attendance at meetings which were reported to Council members by postal circular. The papers and correspondence for these early meetings are of considerable interest in tracing the growth of EMBO through the efforts and personal connections of its founder members.

Although the rules of EMBO prescribe that the Council should meet "not less than once a year, normally in January or February", this steady state was rarely achieved. The movement towards the establishment of the Conference and the protracted negotiations for the existence, scope, site and funding of the Laboratory all required special meetings, the setting-up of working groups and the preparation of reports and position papers. From 1966 the Council papers should be consulted in conjunction with those relating to the EMBC material in Section G.

EMBO's scientific programme was implemented through the Fund Committee which received and evaluated applications for short- and long-term fellowships and which met for the first time in November 1965; the Course Committee which first met formally in July 1966; and the Laboratory Committee which had its first meeting jointly with the World Health Organisation in May 1964. Full records of all these committees are preserved here from their founding documents up to 1974.

The records of the Laboratory Committee are of particular interest because of Kendrew's special involvement with it (he was its chairman from its inception until 1969) and because of the lukewarm and even hostile reception which the project encountered from scientists and politicians. It met less regularly than the other EMBO committees and its main task was to prepare proposals and costs for submission to EMBO members, to the Volkswagen Foundation, to the intergovernmental meetings and to the European Molecular Biology Conference. A major proposal devised in 1967 (F.171-F.182) was submitted to the second intergovernmental meeting of January 1968 where the

agreement was reached to provide, initially for five years, resources for the EMBO programme. The cost of this first laboratory scheme was considered excessive and an important meeting of EMBO members and other scientists was held in November 1969 at Konstanz; here the scientific programme was revised and working parties were set up for each of the specific activities agreed as most appropriate for an international laboratory (F.190-F.194). The revised proposal (F.195, F.196) was published in February 1970 and discussed at the first plenary session of EMBC in April 1970. It was accepted in principle and the Conference set up its own working parties in November 1970 to consider specific aspects of the laboratory; these are documented in Section G.

In addition to these three original committees, special EMBO committees were set up from time to time. Of these, the Symposium Committee is documented (F.221-F.229) from its inception in 1974 until its absorption in the Course Committee in 1980. The ad hoc Committee on rDNA which was set up by Council in January 1975 was established as a Standing Advisory Committee in January 1976. Its recommendation at its first meeting in February 1976 that a containment laboratory be set up within the framework of EMBL led to the development of the "P4" facility. All the material relating to the containment laboratory, including papers preceding and relative to the EMBO Committee, are in Section H.

EARLY HISTORY

PRELIMINARY MEETINGS AND CORRESPONDENCE 1963

F.1 Geneva 28 March

Correspondence and papers, January - March, on plans for proposed international laboratory and meeting held at CERN chaired by Weisskopf. Includes Kendrew's notes of costings, scientists to be approached. No agenda or note of discussions are included; those invited included J. Monod, C.H. Waddington, A. Engström, H. Friedrich-Freksa, M. Delbruck, E. Amaldi, A.A. Buzzati-Traverso, L. Cavalli-Sforza.

C.H. Waddington's letter of 11 March outlines many of the objections to the idea of a centralised laboratory which continued to be made throughout the ensuing decade.

Also included here is correspondence 1971 with a biographer of Szilard in which Kendrew outlines the early discussions and Szilard's part in them.

F.2, F.3 Geneva 28 June

F.2 Correspondence April - June on arrangements for meeting, choice of participants, matters for discussion.

F.3 Draft and final "Record of Discussion on Molecular Biology ... ", papers presented at meeting (Kendrew's "Proposal for an international laboratory of molecular biology in Europe" CERB, Waddington's non-centralised "European Biological Organisation" EBO), comments by M. Delbruck.

F.4-F.7 Ravello 16-17 September

The meeting was held at the invitation of the Italian Physical Society during its summer course. The Kendrew and Waddington papers were further discussed and the EMBO was set up, together with a provisional executive committee (Chairman: Perutz), a Laboratory subcommittee (Chairman: Kendrew) and a "Federal Organization Subcommittee" (Chairman: Buzzati-Traverso).

F.4 Correspondence February - August with organisers of meeting and colleagues; includes invitation, proposed participants, discussions of proposals.

F.5 Correspondence July - August with Szilard and Waddington *re* draft proposals, and French representation at meeting.

F.6 Correspondence October on Kendrew's draft summary of the meeting.

F.7 Summary of proceedings of meeting, by Kendrew, 29 October, annotated agenda of meeting, lists of participants, comments on proposals, ms. notes by Kendrew.

F.8, F.9 Provisional Executive Committee, Brussels 12 December

This meeting was organised by Buzzati-Traverso who acted as chairman in the absence of Perutz. The expenses were defrayed by EURATOM.

F.8 Correspondence October - December. Participation in EMBO of J. Wyman, French cancer research proposal, WHO proposal, invitations and nominations.

F.9 Agenda of meeting, Wyman's account of meeting (there were no formal minutes), continuing correspondence December 1963 - January 1964.

In February 1964 the EMBO Council had its first meeting. See F.80-F.118 for papers and correspondence for that and subsequent meetings 1964-80.

FORMAL CONSTITUTION AND STATUTES

Drafts for a constitution and regulations were prepared by Kendrew, Perutz, Kellenberger and Wyman, and presented to the first EMBO Council in February 1964. Firms of international lawyers in Belgium and Switzerland were approached and further drafts drawn up. The Swiss firm was chosen at the Council meeting in July 1964.

F.10 Correspondence on choice of lawyer.

F.11 Manuscript notes and drafts, some dated January 1964, by Kendrew and others.

F.12 Draft submitted by Belgian lawyers, with a little correspondence and comments, April - June 1964.

F.13 Drafts drawn up by Swiss lawyers, with annotations and comments by Kendrew and Perutz, June - September 1964.

F.14 Final versions of Rules and Statutes (English and French).

F.15 Correspondence with members of EMBO and with Swiss lawyers *re* registration of EMBO in Switzerland (12 July 1964), drafts and amendments of constitution, February 1964 - September 1965.

RELATIONS WITH OTHER ORGANISATIONS

The movement towards scientific co-operation in the 1960s produced numerous initiatives, some private or semi-private, some national and some international. EMBO was involved with several of these which are documented in varying degrees of detail. They are presented, for convenience, in chronological order though in fact meetings and negotiations were often going forward concurrently, making the story a complex one.

Attention is also drawn (F.169, K.118 and K.119), to a similar initiative by the World Health Organisation to set up an international health research centre, to which reference is made in the correspondence.

F.16-F.26 UNESCO, ICRO, ILSI 1963-68

ICRO, the International Cell Research Organization, was founded in 1962 to serve as consultant to UNESCO's Cell Biology programme and was supported by UNESCO funds. Kendrew was proposed as "convenor" on its "Panel 1, Molecular Biology and Control Processes" (F.16).

ILSI, the International Life Sciences Institute, was set up by a group of Belgian and foreign scientists under the auspices of the Princesse Liliane Foundation. J. Brachet and P.B. Medawar were among those closely involved in the plan, whose scope and aims were very similar to those of EMBO. Its first meeting was in November 1963 (F.17).

The similarity in many respects between EMBO and ILSI led to consideration of a merger of interests via UNESCO which provided some administrative and financial assistance. Several meetings were held, and an "Expert Committee" was set up to prepare a "Study on the present needs for international cooperation in the basic biological sciences" (F.25). EMBO however preferred not to become absorbed into a global institution of such scale and to maintain its "European" links in the search for intergovernmental support.

F.16 May, September - December 1963.

F.17 Information about ILSI, constitution, governing board, programme, budget etc.

F.18 December 1963 - February 1964.

F.19 March - April 1964

Includes aproach to UNESCO, notes of discussions in Belgium and London (April).

F.20 May - June 1964

Arrangements and notes of meetings Brussels 3 May, London 28 May, draft document by UNESCO, meeting of working group of "UNESCO Experts" in London 5 June.

F.21 July - September 1964

Includes extract from EMBO Council meeting (financed by UNESCO) affirming Council's "intention to maintain complete independence of UNESCO and other similar organisations in matters both of policy and of administration", meeting with EMBO (Perutz, Kendrew) and ILSI (Medawar, Theorell, de Duve) London 22 July at which Medawar reported readiness of ILSI to negotiate agreement with EMBO, and UNESCO Expert Committee was set up; correspondence, minutes etc.

F.22 November 1964 - January 1965

Meeting of UNESCO Expert Committee 19 October (official Minute and two separate private accounts by Wyman) and correspondence arising.

F.23 March 1965

Correspondence of Perutz with Brachet and with MRC; letter to Brachet sets out clearly the objections both to a clinically oriented scheme and to a broad international scheme; the letter to MRC on general aims of EMBO was written for MRC Sub-committee meeting. Also included is Perutz's report on the meeting (hostile to the laboratory) for EMBO Council members.

F.24 April - October 1965

Meeting of UNESCO Expert Committee 17 September and its report.

F.25 1966

Final copy of report, correspondence and comments from colleagues.

F.26 1968

F.27 CERN 1964

Miscellaneous correspondence with F. Jacob, V.F. Weisskopf.

F.28 French Cancer Research Proposal 1964

Miscellaneous correspondence with F. Jacob, A. Haddow. See also F.8.

F.29-F.32 COUNCIL OF EUROPE 1964-66

The Council's Committee for Higher Education and Research had been concerned since 1963 with projects for combined research. Its Study Group included molecular biology for discussion at its meetings at The Hague June and Aarhus October 1964, Strasbourg March 1965 and March 1966. Further action was deemed unnecessary in view of the negotiations by the Swiss Government to convene an intergovernmental conference. See memo. at F.32.

F.29 April - November 1964, correspondence and papers, meetings and discussions at The Hague and Aarhus.

F.30 January 1965 - January 1966

F.31 Correspondence January - June 1965 between Perutz and A. Frank on Interim Committee on Science to discuss "International Cooperation in Biology", including comments on meetings and EMBO affairs.

F.32 Council of Europe "Note on Council of Europe action in the field of molecular biology" summarising negotiations.

Reports of Interim Committee on "International Cooperation in Biology".

F.33 EUROPEAN CELL BIOLOGY ORGANIZATION (ECBO) 1968-72

Correspondence and papers *re* setting-up of ECBO, nominations of EMBO representatives at meetings (J. Brachet, M.G.P. Stoker), foundation meeting, statutes, comments by ECBO on Laboratory plans.

See G.113 for later discussions on relations between EMBO and ECBO.

POLICY DOCUMENT

The "Document", made available in English, French and German, was published in April 1966 as a 36pp. booklet. It set out EMBO's history, philosophy and scientific programme of fellowships, advanced courses and study sessions, research grants, the case for a European laboratory of molecular biology, and financial estimates; the EMBO Statutes and Rules were also included. Drafts of the material had been prepared and agreed by June 1965 but publication of the booklet was timed to coincide with the formal announcement of the three-year grant (made in December 1965) from the Volkswagen Foundation which enabled the fellowship and teaching programme, and further studies of the laboratory project, to go ahead.

The booklet was an important element - hence the name "Policy Document" generally applied to it - in the Swiss Government's initiative to launch an intergovernmental meeting leading to the establishment of the European Molecular Biology Conference.

The document, a corporate version agreed by members of the EMBO Council, drew very largely on the early "Proposal for a European Organisation of Fundamental Biology" by Kendrew and C.H. Waddington of August 1963; other source materials were the "Draft Proposal for Operation and Activities of EMBO Fund" of March 1965 by A.A. Buzzati-Traverso (F.34) and "Policy for EMBO Research Grants" of May 1965 by J. Monod (F.35). The drafts were assembled and circulated by J. Wyman and the final version sent to Kendrew who supervised arrangements for translation and printing.

F.34 Kendrew's and Waddington's paper, August 1963; Buzzati-Traverso's paper March 1965 (Perutz's copy with ms. corrections and comments); revised version by Wyman; Kendrew's copy, very heavily rewritten by him.

F.35 Manuscript and typescript drafts for sections of the document, mainly by Wyman and Kendrew, but including J. Monod's draft contribution on policy on research grants.

F.36 Later heavily corrected manuscript and typescript draft.

F.37 Two duplicated typescript drafts with manuscript corrections (one in Perutz's hand).

F.38 Papers and correspondence May - July 1965 on circulation of draft by Wyman to EMBO Council members 20 May, their comments and correspondence arising.

F.39 Final draft with manuscript note by Wyman "Final document as sent to JCK end of June for printing. This (with version C. of Ch.4) was translated by Jacob and is to be printed". With a covering letter by Wyman, June 1965.

F.40 Correspondence July 1965 - May 1966 on French translation, circulation of printed version etc. Kendrew's letter to Jacob of 10 August refers to the delay in publication at the request of the Volkswagen Foundation; his letter to Wyman 4 May 1966 mentions a possible site at Nice for the EMBO laboratory.

F.41 Correspondence June 1965 - July 1966 *re* design and printing of booklet.

F.42 Copy of booklet.

FUNDING

Several initiatives in the search for funding were made in 1964 after the first formal EMBO Council meeting. The most successful of these approaches in quantitative terms was to the Volkswagen Foundation which agreed a grant of DM.2,748,000 in December 1965 for three years 1966-68. This enabled the EMBO programme for fellowships and courses to prove its value. The negotiations and terms of the grant are well documented in the papers at F.43-F.49.

Although the VW grant was crucial, there were other smaller sums which came in betimes in 1964 and helped the infant EMBO to survive administratively and start its fellowship programme on a small scale. These usually resulted from the good offices of individual members of EMBO and are presented at F.50-F.54.

F.43-F.49 Volkswagen Foundation

F.43 February - March 1964

Mainly replies by EMBO Council to Perutz's circular giving estimates to put to VW Foundation; includes letter (photocopy) from H. Friedrich-Freksa with first suggestion of approach to VW.

F.44 March - September 1964

Includes note of meeting 22 March with VW representatives.

F.45 March - September 1965

Includes copy of original grant application sent to VW June 1965.

F.46 October - November 1965

Continuing negotiations, amended application.

F.47 November - December 1965

Papers and correspondence for special meeting with VW to discuss terms of application, 3 December. Includes Wyman's memorandum on meeting and his annotated papers and copy of letter from VW 10 December confirming grant. This covered four heads of expenditure: 1. Administrative costs; 2. Fellowships; 3. Courses and workshops; 4. Costs relating to studies and planning work as a basis for a decision in principle on the setting-up of a central laboratory.

N.B. Wyman's memorandum refers to information from R. Kerschner of VW that "Volkswagen's interest in EMBO was originally aroused by a telephone call from Szilard just after the Ravello meeting. It was this which led to the original Volkswagen approach to us."

F.48 1966

Mainly arrangements for administering grant.

F.49 1969-72

Later correspondence on final spending of VW grant. Included here is a copy of "EMBO Activities 1966-68. A report to the Volkswagen Foundation on the utilisation of the grant."

F.50 Research Council of Israel 1964-66

Various donations were made to the fellowship fund at the request of E. Katchalski.

F.51 Interpharma 1964

A donation of S.Fr.42,000 was made through the good offices of E. Kellenberger.

F.52 Amis de l'Université de Strasbourg 1964

A donation of $1000 was made through the good offices of C. Sadron.

F.53 International Laboratory of Genetics and Biophysics 1964

Support for two fellowships, arranged by A.A. Buzzati-Traverso.

F.54 Sweden 1965

Support for two EMBO fellowships (for 1966) arranged by A. Engström.

F.55, F.56 Other miscellaneous approaches

F.55 Ford Foundation 1966

F.56 National Institutes of Health, Bethesda 1966-69

MISCELLANEOUS CORRESPONDENCE

F.57, F.58 While every effort has been made to assign a specific place to correspondence and papers, a few escape classification usually because they deal with several topics in the affairs of EMBO, occasionally because they are peripheral to its main concerns. They are retained here in chronological order.

F.57 1964

F.58 1965

F.59, F.60 Requests for information about EMBO, from scientists, science journalists and editors, some with suggestions for collaborative research or for projects to be undertaken by EMBO.

F.59 1964. Mainly arising from press release and articles in *Nature*, *Science* etc. following Council meeting of February 1964.

F.60 1965-73. Similar material, but referring to EMBL as well as EMBO.

MEMBERSHIP

NOMINATIONS AND ELECTIONS 1963-82

After the Ravello meeting it was decided to invite some 100-200 European biologists to become members of EMBO. Perutz as Chairman of the Provisional Executive Committee asked for suggestions for membership from the founder members and leading scientists (F.61). These were presented for consideration at the Council meeting in February 1964 and invitations issued (F.62-F.68). With the formalisation of EMBO and the drawing-up of Statutes and Rules, the procedures for election of ordinary, associate and Council members were more closely established. The membership has powers of nomination and election and constitutes the General Assembly and supreme organ of EMBO. Should the General Assembly not be convened, members are consulted by post by Council; hence the importance especially in the early years of the circulars preserved at F.78.

F.61 Perutz's circular letter 1 November 1963 requesting suggestions for membership, with replies from C.H. Waddington, E. Katchalski, L.L. Cavalli-Sforza, A. Engström, F. Jacob, C. Sadron, E. Kellenberger, F. Lipmann, A.A. Buzzati-Traverso, O. Maaloe, H. Friedrich-Freksa, A.M. Liquori, G.N. Cohen, H. Chantrenne and others.

F.62 Final lists of original membership compiled by Kendrew; copy of Perutz's letter of invitation to members, sent after first Council meeting.

F.63-F.67 Letters of acceptance of membership, some with comments on EMBO programme (several hostile to laboratory) or including personal or scientific news.

F.63 A-C

F.64 D-J

F.65 K-O

F.66 P-S

F.67 T-Z

F.68 Letters 1964 declining membership.

F.69 Election of Associate Members 1965-74.

F.70-F.72 General correspondence on nominations, recommendations, ballots and elections for membership 1964-82.

F.70 1964, 1966-68

F.71 1969-70

F.72 1971-75, 1981-82

F.73 Letters of acceptance of membership, 1969-74.

F.74-F.77 Papers and correspondence 1972-74 *re* new procedure for election aimed at enlarging membership of EMBO to include younger scientists working in new fields.

F.74 Correspondence and drafts on new procedure prepared for discussion at Council meeting November 1972, circular to members and selected comments by them.

F.75 Election of Nominating Committee 1972-73. The final membership was S. Brenner, M. Eigen, F. Jacob, G. Klein, M. Sela and the Chairman was N.K. Jerne.

F.76 Correspondence with scientists requesting their consent to be nominated 1974, 1975.

F.77 Correspondence 1974 with N.K. Jerne on work of Nominating Committee and other EMBO affairs.

CIRCULARS AND LISTS

F.78 Miscellaneous circulars to EMBO members 1964-75.

F.79 Membership lists.

COUNCIL

CORRESPONDENCE AND MEETINGS 1964-80

F.80 2 February 1964, Geneva

This was the first formal meeting of Council. Matters discussed included elections to membership, constitution, funding, relations with other organisations, registration.

Folder includes correspondence preceding and following meeting, press releases, minutes. Perutz's circular letter of 28 January discusses proposed name of organisation and feels that " 'Fundamental Biology' is presumptuous" and " 'Molecular Biology' might be better from that point of view".

F.81-F.83 12 July 1964

F.81 Comment by Council members April-May on proposal transmitted by F. Jacob that part of French Government's Cancer Fund might be channelled via EMBO to support research in French laboratories.

F.82 Agenda, circulars, arrangements, memoranda, minutes.

F.83 Correspondence with members June-July.

F.84, F.85 2 February 1965

F.84 Agenda, circulars, memoranda, minutes.

F.85 Correspondence, discussion notes, correspondence with members September 1964 - February 1965.

F.86-F.88 8-10 May 1965

F.86 Reports by Council members on developments in molecular biology, and attitudes to EMBO, in their countries.

F.87 Circulars, memoranda, minutes, heavily-corrected draft minutes, draft note on "Further developments" (meeting with Swiss minister Burckhardt).

F.88 Correspondence with members March-April.

F.89, F.90 15 January 1966

F.89 Agenda, memoranda, circulars, minutes.

F.90 Correspondence with members and others July 1965 - January 1966.

F.91, F.92 14 January 1967

F.91 Agenda, arrangements, Perutz's notes, Wyman's notes of meeting, minutes.

F.92 Correspondence June 1966 - May 1967 (elections to Council, Laboratory project, intergovernmental meeting).

F.93-F.96 21 January 1968

F.93 Agenda, memoranda, circulars, minutes.

F.94 Perutz's circular on Draft Arrangements for Conference, and Council members' replies.

F.95 Correspondence December 1967 - March 1968.

F.96 Invitations, acceptances and arrangements.

F.97-F.99 12 January 1969

F.97 Agenda, circulars, minutes and correspondence *re* minutes.

F.98 Correspondence October 1968 - February 1969.

F.99 Invitations, travel arrangements.

At this meeting Perutz and Wyman resigned as President and Secretary-General, being replaced by M. Eigen and Kendrew respectively.

F.100 1 June 1969

Meeting held in preparation for the Interim Conference of European Molecular Biology at CERN on 2 and 3 June.

Agenda, papers, minutes, correspondence, travel arrangements.

F.101 26 November 1969

Meeting held at Konstanz immediately preceding discussion meeting on laboratory plans. (See also F.190-F.194.)

Agenda, papers, minutes, correspondence, Israel membership.

F.102, F.103 17 January 1970

F.102 Agenda, papers (revised laboratory proposal, indicative scheme).

F.103 Correspondence, travel arrangements.

F.104 5 April 1970

Meeting held at CERN preceding meeting of EMBC 6-8 April.

Agenda, minutes, correspondence.

F.105 28 September 1970

Joint meeting with Laboratory Committee.

Agenda, circulars, minutes, travel arrangements. (See also F.197.)

F.106 25 & 28 November 1970

Agenda, circulars, minutes, travel arrangements, correspondence on setting up of Laboratory Working Groups. (See also G.65 *et seq.*)

F.107 26 April 1971

Emergency meeting of Council and Laboratory Committee to discuss choice of site.

Agenda, circulars, memoranda, minutes, correspondence, travel arrangements.

F.108 11 October 1971

Agenda, circular *re* setting-up of Scientific Advisory Committee for laboratory, papers and proposals, correspondence.

F.109 3 December 1971

Agenda, circular, correspondence, travel arrangements.

F.110 19-20 April 1972

A joint meeting with the Provisional Scientific Advisory Committee, to discuss reductions in budget estimates for laboratory.

Agenda, circulars, memoranda, papers, correspondence, minutes of meeting and of informal meeting 28 April 1972.

F.111-F.113 4 November 1972

Meeting preceding "Haarlass meeting" on research programme of laboratory. (See F.205-F.207.)

F.111 Agenda, circulars, papers and proposals (A. Tiselius, A. Katchalski memorials), correspondence, minutes.

F.112 Working party on programme and activities of EMBO after 1974 set up at November meeting; the members were N.K. Jerne, A. Engström, J. Wyman, R.K. Appleyard.

Drafts November 1972 - May 1973 by several working party members (includes version heavily-corrected by Kendrew which became final text), correspondence *re* meetings and drafts.

F.113 Kendrew's circular to EMBO members on draft report of working party, and replies April 1973

F.114 12 January 1973

Agenda, minutes, correspondence, travel arrangements.

F.115 4 May 1973

Agenda, papers and proposals, correspondence, minutes, travel arrangements.

F.116, F.117 12 February 1974

F.116 Agenda, memoranda, minutes of meeting and of informal meeting 20 October 1973, correspondence.

F.117 Travel arrangements and correspondence.

F.118 10 January 1975

This was the last meeting which Kendrew attended as Secretary-General, his successor being N.O. Kjeldgaard. Material includes set of papers (some annotated), correspondence on agenda items and on elections as officers of EMBO, Kendrew's letters to new and to retiring members of EMBO Committees.

N.B. At this meeting the Council discussed under Item 14 the matter of biohazards, the possible modifications to the Laboratory design to permit hybrid DNA research, and the setting-up of an *ad hoc* Committee on biohazards. See H.100-H.102, H.156-H.177.

F.118A Miscellaneous later correspondence and notes on EMBO Council matters 1975-80.

MEMBERSHIP AND ELECTIONS

F.119 Lists and charts of Council membership compiled by Kendrew, indicating duration of service on Council and type of membership (original member; elected; co-opted; invited) and extending 1963-90.

Early lists compiled by Wyman of "EFBO Executive Committee" (1963) and original Council.

F.120-F.127 Nominations, recommendations and general correspondence on membership of Council.

F.120	1966	F.124	1970
F.121	1967	F.125	1971
F.122	1968	F.126	1973
F.123	1969	F.127	1974

MINUTES AND CIRCULARS

F.128 Circulars sent to Council members July 1964 - July 1974.

F.129 Minutes of Council 1963-81.

FUND COMMITTEE

MEMBERSHIP 1965-74

F.130 Correspondence 1965-66 on orignal membership of Fund Committee: H. Chantrenne (Chairman), A.A. Buzzati-Traverso, J.A. Cohen, W. Hayes, H.T. Witt, A. Engström. C.H. Waddington was a co-opted member.

F.131 Membership 1969-70.

F.132 Membership 1971-74.

CORRESPONDENCE AND PAPERS 1964-74

The material consists of correspondence between members of the Fund Committee and the EMBO Secretariat, draft reports, budgets and financial estimates, memoranda and papers on meetings of the Committee, policy on fellowships, salary scales, press notifications.

F.133 December 1964 - June 1965

Correspondence mainly with A.A. Buzzati-Traverso *re* support for EMBO fellowships at his laboratory (Naples) and his "Draft proposal for operation and activities of EMBO fund".

Correspondence *re* appropriate salary scales.

F.134 August and December 1965

Papers and correspondence for and arising from first meeting held in Cambridge 8 November 1965. Includes policy paper, draft minutes and memoranda, notes on salary scales.

F.135 1966

F.136 1967

F.137 1968

F.138 1969-70

F.139 1971

F.140 1972-74

FELLOWSHIP APPLICATIONS 1964-74

Includes letters of application and enquiry, supporting documents, interview reports, recommendations.

F.141	1964-65	F.146	1970
F.142	1966	F.147	1971
F.143	1967	F.148	1972
F.144	1968	F.149	1973-74
F.145	1969		

MINUTES

F.150 Minutes 1965-73.

COURSE COMMITTEE

The committee was sometimes known in early correspondence as the "Summer Schools Committee" or the "Committee on Courses". The EMBO "Policy Document" published in April 1966 referred to it as "Committee on Courses" and "Course Committee", the latter form being preferred as from the first formal meeting in July 1966.

MEMBERSHIP 1965-74

F.151 Correspondence 1965-66 on original membership of Course Committee. Included here is Kendrew's chart of membership and period of service 1964-71

F.152 Membership 1969-71.

F.153 Membership 1972-74. Includes co-operation with Course Committee of FEBS.

CORRESPONDENCE AND PAPERS 1965-74

The material deals with the organisation of EMBO summer schools and courses, applications for support, policy notes, collaboration with other organisations (ICRO, FEBS, NATO), information on international courses organised by EMBO and others.

F.154 March - December 1965

Arrangements for "*ad hoc* Meeting on Courses" held by EMBO Council 15 January 1966; includes draft proposals on policy drawn up by A. Tiselius (2 copies respectively annotated by M.F. Perutz and Kendrew), and note of meeting.

F.155 July - December 1965

EMBO support for "Course on Genetics and Physiology of Bacterial Viruses", Naples (Director: A.A. Buzzati-Traverso) met from Interpharma grant. Includes information on course.

F.156 January - September 1966

Relations and co-operation with International Cell Research Organisation (ICRO), Federation of European Biochemical Societies (FEBS), Experimental Biology and Medicine.

F.157 March - December 1966

Policy, meetings, course proposals. Includes R.K. Appleyard's paper on "The problem of EMBO courses".

F.158 June - September 1966

Proposed conference on spores.

F.159 March 1966 - January 1967

EMBO support for Oxford University Summer School on Molecular Biology and Biophysics.

F.160 January - October 1967

F.161 May 1968 - January 1969

Immunology workshop by J. Oudin (cancelled).

F.162 June 1968 - June 1969

Course held in Greece (some political objections were raised).

F.163 November 1968 - July 1969

EMBO Lecturers scheme, proposed by W. Hayes and agreed by Council January 1969.

F.164 1970-71

F.165 December 1971 - October 1972

Includes letter from J. Wyman on future policy for EMBO courses from 1975 and renewal of EMBC Agreement.

F.166 October - November 1972

EMBO support for Aharon Katzir-Katchalsky Memorial Conference.

F.167 1974

EEC Sponsored Courses.

MINUTES

F.168 Minutes and circulars 1966-69.

LABORATORY COMMITTEE

MEETINGS, CORRESPONDENCE AND PAPERS 1963-73

F.169 1963-64

Correspondence and papers. Includes Kendrew's "Notes for the meeting on an International Laboratory of Molecular Biology to be held in Geneva under the sponsorship of WHO 1-2 May 1964" and his minutes of the meeting. The EMBO Laboratory Committee membership was L.L. Cavalli-Sforza, H. Chantrenne, A. Tissières and Kendrew (Chairman). See also K.118, K.119.

F.170 1965

"The case for a European Laboratory of Molecular Biology". Kendrew's draft 29 April 1965 prepared for committee and Council at request of Swiss government, with a few manuscript revisions by M.F. Perutz and J. Wyman.

F.171-F.182 Laboratory Proposal Document 1967

The document was prepared, after consultation with members of EMBO, for discussion at a meeting of the Laboratory Committee at Nice on 23 September. The material includes correspondence on the role of the laboratory, drafts and memoranda, notes of the meeting and of the preparation of the final version, which was submitted to the EMBC meeting in January 1968.

Several of the notes and documents are by M. Delauche who was seconded from EURATOM as an assistant on the laboratory project in 1967.

F.171-F.173 Correspondence with colleagues on research projects appropriate to a central laboratory, analysis of replies, notes of discussions and meetings, early drafts and comments preceding committee meeting.

F.171 April, May. Research proposals.

F.172 June. Includes notes of meetings and discussions, suggested draft prepared by R.K. Appleyard.

F.173 July, August. Continuing correspondence, drafts and comments.

F.174 Draft drawn up by Wyman and Kendrew for discussion at meeting. The draft quoted extensively from the original EMBO "Policy document" and envisaged a series of appendices to be written by individual scientists in support of the case for the laboratory. Three of these appendices, by J.A. Cohen, F.H.C. Crick and J. Monod are included in the folder. See also F.177, F.178, F.184.

F.175 "Summary" of Nice meeting, J. Wyman's notes on meeting, notes, drafts, comments, September.

F.176 Information on research programmes, laboratory costings and budgets for various European laboratories sent to Kendrew by colleagues in preparation for final draft proposal.

F.177, F.178 Correspondence *re* appendices for document, some of which are included. October 1967 - January 1968.

F.177 M. Delbruck, M. Eigen and N.K. Jerne (Appendix on "The complete solution to the Antibody Problem"), B. Hartley, F. Jacob (Appendix on "Control Systems").

F.178 C. Levinthal, H.C. Longuet-Higgins (Appendix on "Organisms as self-organising systems"), V.F. Weisskopf ("The experience of CERN and the proposal for a European biology laboratory").

F.179 Notes of conversations at Cambridge on research space and costings, November.

F.180 Amended draft proposal for laboratory, 69pp, November.

F.181 Correspondence November - December, mainly comments on draft.

F.182 Version submitted to EMBC. (N.B. 10 "Annexes" are listed, but only 6-10 are present and there is a further unlisted Annex 11 by A. Katchalsky.)

F.183 1968

General correspondence on laboratory matters; includes letter from J. Wyman to O. Maaløe inviting him to become Chairman of committee in view of Kendrew's move to office of Secretary-General.

F.184-F.188 Committee meeting at Linton, Cambridge (Kendrew's home), 16 March 1969

F.184 Correspondence January - March. Includes note on "Teaching at the EMBO Laboratory" by A.A. Buzzati-Traverso intended as Appendix to proposal document.

F.185 Papers circulated for meeting, by Buzzati-Traverso, R.K. Appleyard, O. Maaløe and Kendrew, on revised laboratory proposal.

F.186 Memorandum and minutes of meeting, drafts and circulars March - June, including copy of U.K. delegation note on the proposed laboratory presented at Interim Conference, June.

F.187 Information on present and future plans for molecular biology in various European countries, assembled as a result of March meeting.

F.188 Arrangements for meetings in March and June.

F.189 Royal Society Discussion meeting, 21 October 1969

This was a special meeting to discuss "greater participation by U.K. in the European Molecular Biology Organisation and particularly in its proposed laboratory or laboratories". The material is included in this sequence because it signals the concern in the scientific world at the laboratory proposal, and immediately precedes the "Konstanz meeting" at which the scientific programme was debated and which is referred to in some of the papers.

Folder includes invitation, list of participants, papers by Kendrew, M.G.P. Stoker, S. Brenner, draft contribution by Kendrew, note by C.H. Waddington, Kendrew's note of speakers and their opinions, report (apparently pirated) of meeting published in *Nature*, **224**.

F.190-F.194 The "Konstanz" meeting

This symposium "to discuss the present and future development of molecular biology with special reference to a European laboratory", was held at Konstanz 27-30 November 1969. Attendance was by invitation and was not confined to EMBO members. The Laboratory Committee met twice during the meeting, on 27 and 30 November and at the second meeting working groups were appointed (on subcellular structures, cell genetics, instrumentation and computation) to prepare a more specific scientific programme for a revised laboratory proposal document. At the same meeting Kendrew agreed "to take on the directorship, if the project proved to be good".

The success of the "Konstanz" meeting was such that it became a generic term for intensive research meetings of this kind; the similar occasion at Haarlass near Heidelberg in 1971 was referred to as "Konstanz II" (F.205-F.207) and there were plans for a "Konstanz III" (H.147).

See C.128, H.345 for Kendrew's notes on the meeting.

F.190 Circulars, invitations, lists of participants, agenda, papers circulated to participants, photograph taken at meeting.

F.191 Kendrew's notes for his opening remarks; "Notes on Embo meeting . . . " including the two meetings of the Laboratory committee, unsigned but by J. Wyman.

F.192 Working group on cell genetics.

Correspondence and notes, including comments on working group's report sent to S. Brenner (Convenor).

F.193 Working group on subcellular structures.

Circulars only.

F.194 Working group on instrumentation.

Correspondence, notes, draft report by H.E. Huxley (Convenor).

F.195, F.196 Revised Laboratory Proposal

F.195 Correspondence and circulars on meetings, preparation and circulation of document December 1969 - May 1970.

F.196 Copy of revised proposal 16 February 1970, submitted to Conference as CEBM 70/12E, 76pp., and also of Kendrew's "Summary of EMBO's new proposals for an international laboratory", 1 January 1970.

F.197 Correspondence and circulars June - September 1970 *re* meeting of Laboratory Committee as part of joint EMBO/EMBC meeting at The Hague, 28 September - 1 October. (See also F.105.) At this meeting the Sites Subcommittee of the Laboratory Committee was set up.

F.198-F.204 Sites Subcommittee

At its meeting at The Hague in September 1970 the EMBO Council appointed a sites subcommittee of the Laboratory Committee with O. Maaløe as Chairman; the members were H.E. Huxley, K.C. Holmes and C. Weissmann, with D.C. Phillips, A. Tissières and H. Zachau as consultants and M. Delauche as secretary. The subcommittee met and visited possible sites at Munich (October), CERN (November) and additional sites at Heidelberg, Karlsruhe and Hamburg (January - February 1971). Its "Report on a Selection of Sites in Germany", dated 22 February 1971, considered "that the case for the Heidelberg site is by far the strongest". Meanwhile the official Sites Committee of EMBC, set up by the Conference in November 1970, conducted its own programme of visits January - July 1971, and in its report of July 1971 also recommended the Heidelberg site. (See G.74-G.87.)

Also included is correspondence on various other possible sites for the laboratory which had been mooted, often for a considerable time. In particular, the idea of a site near Geneva like that of CERN had been an early favourite and was not easily abandoned. No records survive here of offers made by Italy and Austria, nor of a possible French site at Nice (though see F. Jacob's letter at F.202 and also F.40).

See G.87 for other, later suggestions.

F.198 Sites subcommittee: appointment, membership, correspondence, arrangements for meetings, notes and memoranda on sites visited, report. September 1970 - March 1971. See also G.78.

F.199-F.204 Other possible sites for laboratory

Greece 1966-70, 1976.

Offer made in 1966 and renewed in 1970 of accommodation in part of the "Greek Institute of Basic Biological Research - Alexander Fleming" founded by Amalia Fleming. Includes correspondence with members of EMBO Council, Greek colleagues and Lady Fleming (also a later letter 1976).

F.199 1966 F.200 1970, 1976

F.201 Cambridge, 1967-68.

Correspondence and memoranda.

F.202 Geneva/CERN, 1969-70.

Correspondence and memorandum.

F.203 Edinburgh, 1970.

F.204 Culham, 1970-71

F.205-F.207 "Second Konstanz meeting", 4-7 November 1972.

This was another meeting to discuss the scientific programme of the Laboratory; it was held at the Hotel Haarlass, Heidelberg, but was generally referred to as "Second Konstanz" because of the very successful first meeting (see F.190-F.194). The meeting was financed from $15,000 remaining from the Volkswagen Foundation grant. It was larger than the previous meeting, and like it included invited guests as well as EMBO members.

F.205 Correspondence, circulars, suggestions for participants, draft and final lists. December 1971 - November 1972.

F.206 Programme, circulars, correspondence with speakers, Kendrew's notes on scientific sessions (18pp. ms.), manuscript notes on meeting in unidentified hand.

F.207 Arrangements, travel claims, accounts for meeting.

F.208 Membership of Laboratory Committee

Miscellaneous brief correspondence, lists of members etc., 1967-73.

ADMINISTRATION

APPOINTMENTS - EXECUTIVE SECRETARY

F.209 Appointment of R.K. Appleyard (seconded part-time from EURATOM) with effect from 1 August 1965.

Correspondence and negotiations July 1964 - August 1965.

F.210 Appointment of J. Tooze with effect from 1 June 1973.

Correspondence and negotiations, Kendrew's notes November 1972 - June 1973.

FINANCE AND ACCOUNTS

F.211 Bank accounts in Brussels and Geneva 1964-68.

F.212 Financial estimates for EMBO activities 1969-71, prepared at request of first EMBC meeting (April 1967) by R.K. Appleyard, with correspondence arising with M.F. Perutz April-May 1967.

F.213 Revised draft as submitted to EMBO Council, with comments and replies, June-July 1967.

F.214 Miscellaneous material on financial situation of EMBO, September 1967 - October 1968.

F.215 EMBO Accounts 1964, 1966-70, 1973-80.

GENERAL ADMINISTRATIVE CORRESPONDENCE

The correspondence consists mainly of exchanges 1965-73 between R.K. Appleyard and J. Wyman, M.F. Perutz and Kendrew.

F.216 1965. Setting-up of EMBO office at Brussels, appointment of Price, Waterhouse as accountants.

F.217 1966

F.218 1967-68

F.219 1969-70

F.220 1971-73. Includes brief correspondence on Appleyard's resignation as Executive Secretary.

SYMPOSIUM COMMITTEE

This was set up by Council in February 1974 to organise a series of EMBO Symposia to be held annually in Heidelberg. One of the aims was to help to establish the reputation of the laboratory at Heidelberg as a major centre for research and the dissemination of leading research ideas. The symposia were at first organised privately by EMBO outside its general scientific programme under EMBC and therefore relied on independent finance and on fees. The first symposium was held in 1975, and the first in the laboratory itself, in May 1978, coincided with its formal opening.

At its meeting in January 1980 the EMBO Council agreed that the Symposium Standing Committee should be dissolved and its responsibilities assumed by the Course Committee; the symposia were thus incorporated in the general programme and supported through EMBC.

CORRESPONDENCE AND PAPERS 1974-81

F.221 Setting-up and membership of Committee 1974.

F.222-F.228 Organisation of symposia, fund-raising, Organising Committee meetings, lists of participants, programmes, notes and correspondence, press releases or articles.

F.222	1975	Developmental Genetics
F.223	1976	The Structure and Function of Biological Membranes
F.224	1977	Molecular Aspects of Gene Function
F.225	1978	Molecular Neurobiology
F.226	1979	Nucleic Acid - Protein Interactions
F.227	1980	Molecular Biologists Look at Green Plants
F.228	1981	Ribosome Structure and Function

MINUTES

F.229 Minutes of Standing Symposium Committee 1974-80.

MISCELLANEOUS

F.230 Correspondence mainly with press 1963-71 on articles and information about EMBO, EMBC and EMBL. Includes some transcripts and manuscripts.

F.231 Press cuttings, releases, comments 1964-71.

F.232 EMBO Annual Reports 1966-81.