BULLETIN OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

VOLUME 47 NUMBER 1

CATALOGUE NUMBER *for* 1938

PUBLISHED BY THE INSTITUTE, JANUARY, 1938

The California Institute of Technology Bulletin is
Published Quarterly

Entered as Second-Class Matter at the Post Office at Pasadena,
California, Under the Act of August 24, 1912

VOLUME 47 NUMBER 1

Bulletin of the

CALIFORNIA INSTITUTE OF TECHNOLOGY

A COLLEGE, GRADUATE SCHOOL, AND INSTITUTE OF RESEARCH IN SCIENCE, ENGINEERING AND THE HUMANITIES

CATALOGUE NUMBER

FOR

1938

PASADENA, CALIFORNIA

JANUARY, 1938

CONTENTS

	PAGE
ACADEMIC CALENDAR	5
BOARD OF TRUSTEES	6
OFFICERS:	
Board of Trustees	6
Administrative Officers of the Institute	7
Officers and Committees of the Faculty	8
STAFF OF INSTRUCTION AND RESEARCH	9
STAFF OF INSTRUCTION AND RESEARCH SUMMARY	44
CALIFORNIA INSTITUTE ASSOCIATES	55
HISTORICAL SKETCH	57
EDUCATIONAL POLICIES	59
BUILDINGS AND FACILITIES	62
ATHENÆUM	66
STUDENT HOUSES	67
EXTRA-CURRICULAR OPPORTUNITIES	68
STUDENT HEALTH AND PHYSICAL EDUCATION	72
REQUIREMENTS FOR ADMISSION TO UNDERGRADUATE STANDING	75
EXPENSES	82
SCHOLARSHIPS, PRIZES, AND STUDENT AID	85
REGISTRATION AND GENERAL REGULATIONS	89
SCHOLASTIC GRADING AND REQUIREMENTS	90
STUDY AND RESEARCH AT THE CALIFORNIA INSTITUTE:	
Physics	95
Mathematics	97
Chemistry and Chemical Engineering	97
Engineering	99
Aeronautics	105
Geological Sciences	108
Biological Sciences	112
Astrophysics	113
The Humanities	116
PUBLICATIONS OF THE STAFF	120
INFORMATION AND REGULATIONS FOR THE GUIDANCE OF GRADUATE STUDENTS	136
DESCRIPTION OF THE UNDERGRADUATE AND FIFTH-YEAR COURSES	158
SCHEDULES OF THE UNDERGRADUATE COURSES	161
SCHEDULES OF COURSES FOR THE DEGREE OF MASTER OF SCIENCE	175
SUBJECTS OF INSTRUCTION	180
DEGREES AND HONORS, 1937	245
GRADUATE STUDENTS	251
UNDERGRADUATE STUDENTS	260
INDEX	275

CALENDAR

1938

JANUARY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

FEBRUARY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

MARCH

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

APRIL

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

JUNE

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

JULY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

AUGUST

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

SEPTEMBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

OCTOBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

NOVEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DECEMBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

1939

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

MARCH

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

APRIL

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

MAY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

JUNE

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

JULY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

AUGUST

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

SEPTEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

OCTOBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

NOVEMBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

DECEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

CALENDAR

1938

JANUARY 3 ..... Registration (9 A. M. to 3 P. M.)
JANUARY 15 ..... Examinations for Removal of Conditions
MARCH 1 ..... Last Day for Applications for Fellowships and Assistantships
MARCH 14-19 ..... Term Examinations
MARCH 19 ..... Notifications of Awards of Fellowships and Assistantships
MARCH 19 ..... End of Second Term (12 M.)
MARCH 20-27 ..... Recess
MARCH 25 ..... Meeting of Freshman Registration Committee
MARCH 26 ..... Meeting of Registration Committee
MARCH 26 and APRIL 2 ..... Examinations for Admission to Freshman Class and for Freshman Scholarships (see page 76)
MARCH 28 ..... Registration (9 A. M. to 3 P. M.)
APRIL 9 ..... Examinations for Removal of Conditions
APRIL 16 ..... List of Approved Candidates for Bachelor of Science Degree Posted
MAY 26 ..... Last Day for Examinations and Presenting Theses for the Degree of Doctor of Philosophy
MAY 30 ..... Memorial Day Recess
JUNE 4 ..... End of Examinations for Candidates for the Degrees of Bachelor of Science and Master of Science
JUNE 6-10 ..... Term Examinations for All Undergraduates Except Seniors
JUNE 7 ..... Meetings of Committees on Course in Engineering and Course in Science (10 A. M.)
JUNE 8 ..... Faculty Meeting (10 A.M.)
JUNE 9 ..... Class Day
JUNE 10 ..... Commencement
JUNE 10 ..... Annual Meeting of Alumni Association
JUNE 4, 10, 11 ..... Examinations for Admission to Upper Classes
JUNE 11 ..... End of College Year (12 M.)
JUNE 20 ..... Meeting of Freshman Registration Committee
JUNE 21 ..... Meeting of Registration Committee
SEPTEMBER 16 and 17 ..... Examinations for Admission to Upper Classes
SEPTEMBER 16 ..... Examinations for Removal of Conditions
SEPTEMBER 20 ..... Registration of Freshmen (1:30 P. M.)
SEPTEMBER 22-23 ..... Registration of Students Transferring From Other Colleges (9 A. M. to 3 P. M.)
SEPTEMBER 23 ..... General Registration (9 A. M. to 3 P. M.)
SEPTEMBER 26 ..... Beginning of Instruction
NOVEMBER 19 ..... Last Day for Announcing Candidacy for Bachelor's Degree
NOVEMBER 24-26 ..... Thanksgiving Recess
DECEMBER 12-17 ..... Term Examinations
DECEMBER 17 ..... Last Day for Applications for Candidacy for the Degree of Doctor of Philosophy in June, 1939
DECEMBER 17 ..... End of First Term (12 M.)
DECEMBER 28 ..... Meeting of Freshman Registration Committee
DECEMBER 29 ..... Meeting of Registration Committee
JANUARY 3, 1939 ..... Registration (9 A. M. to 3 P. M.)

THE BOARD OF TRUSTEES

(Arranged in the order of seniority of service)

		Term Expires
Hiram W. Wadsworth	Pasadena	1942
George E. Hale	Pasadena	1942
Harry Chandler	Los Angeles	1939
Henry W. O'Melveny	Los Angeles	1940
Allan C. Balch	Los Angeles	1938
Louis D. Ricketts	Pasadena	1940
William L. Honnold	Los Angeles	1941
Harry J. Bauer	San Marino	1939
Ben R. Meyer	Los Angeles	1938
Harvey S. Mudd	Beverly Hills	1939
James R. Page	Los Angeles	1940
George E. Farrand	Los Angeles	1941
William C. McDuffie	San Marino	1942
Max Farrand	San Marino	1941
John S. Cravens	Pasadena	1942
J. Hudson Poole	Pasadena	1939
A. B. Macbeth	Pasadena	1938

OFFICERS

Arthur H. Fleming	President Emeritus
Allan C. Balch	President
Louis D. Ricketts	First Vice-President
Henry W. O'Melveny	Second Vice-President
Hiram W. Wadsworth	Third Vice-President
J. Hudson Poole	Treasurer
Edward C. Barrett	Comptroller and Secretary

FINANCE COMMITTEE

Allan C. Balch, *Chairman*

Ben R. Meyer Harvey S. Mudd James R. Page Louis D. Ricketts

ADMINISTRATIVE OFFICERS OF THE INSTITUTE

EXECUTIVE COUNCIL

ROBERT A. MILLIKAN, *Chairman*

ALLAN C. BALCH	WILLIAM B. MUNRO
MAX MASON	JAMES R. PAGE
THOMAS H. MORGAN	LOUIS D. RICKETTS
HARVEY S. MUDD	RICHARD C. TOLMAN

EDWARD C. BARRETT, *Secretary*

CHAIRMEN OF DIVISIONS

ROBERT A. MILLIKAN ..... Physics, Mathematics, and Electrical Engineering
LINUS PAULING ..... Chemistry and Chemical Engineering
FRANKLIN THOMAS ..... Civil and Mechanical Engineering
JOHN P. BUWALDA ..... Geological Sciences
THOMAS H. MORGAN ..... Biology
CLINTON K. JUDY ..... Humanities
ROYAL W. SORENSEN ..... Physical Education

OTHER OFFICERS

EDWARD C. BARRETT ..... Comptroller
RICHARD C. TOLMAN ..... Dean of the Graduate School
FREDERIC W. HINRICHS, JR. ..... Dean of Upper Classmen
RAY E. UNTEREINER ..... Dean of Freshmen
PHILIP S. FOGG ..... Registrar
W. NOEL BIRCHBY ..... Assistant Registrar

ADVISORY COUNCIL

GANO DUNN, President, J. G. White Corporation.

FRANK B. JEWETT, President, Bell Telephone Laboratories, Inc., and Vice-President, American Telephone and Telegraph Company.

JOHN C. MERRIAM, President, Carnegie Institution of Washington.

CHARLES L. REESE, Chemical Director, E. I. du Pont de Nemours and Company.

OFFICERS AND COMMITTEES OF THE FACULTY

OFFICERS

CHAIRMAN, R. W. Sorensen
SECRETARY, H. C. Van Buskirk

FACULTY BOARD

CHAIRMAN, Earnest C. Watson; SECRETARY, H. C. Van Buskirk; E. C. Barrett, S. J. Bates, J. E. Bell, H. Borsook, J. P. Buwalda, R. L. Daugherty, P. S. Fogg, F. W. Hinrichs, Jr., C. K. Judy, William N. Lacey, Max Mason, W. W. Michael, R. A. Millikan, T. H. Morgan, W. B. Munro, L. Pauling, W. R. Smythe, R. W. Sorensen, F. Thomas, R C. Tolman, R. E. Untereiner, Morgan Ward.

FACULTY COMMITTEES

ADMISSION TO UPPER CLASSES ..... Chairman, S. J. Bates
ASSEMBLY ..... Chairman, C. K. Judy
COMMENCEMENT EXERCISES ..... Chairman, L. W. Jones
COURSE IN ENGINEERING ..... Chairman, W. W. Michael
COURSE IN SCIENCE ..... Chairman, W. R. Smythe
FRESHMAN ADMISSION ..... Chairman, P. S. Fogg
FRESHMAN REGISTRATION ..... Chairman, J. E. Bell
GRADUATE COURSES OF STUDY ..... Chairman, R. C. Tolman
HONOR STUDENTS ..... Chairman, Morgan Ward
LECTURES AND VISITS FOR OUTSIDE ORGANIZATIONS ..... Chairman, H. N. Gilbert
MUSICAL ACTIVITIES ..... Chairman, F. Thomas
PHYSICAL EDUCATION ..... Chairman, R. W. Sorensen
PUBLICATIONS AND PUBLICITY ..... Chairman, William Huse
REGISTRATION ..... Chairman, P. S. Fogg
RELATIONS TO HIGH SCHOOLS ..... Chairman, J. E. Bell
STUDENT AID ..... Chairman, F. W. Hinrichs, Jr.
STUDENT BODY FINANCE ..... Chairman, H. N. Gilbert
STUDENT HEALTH ..... Chairman, H. Borsook
STUDENT RELATIONS ..... Chairman, F. Thomas
STUDENT SOCIAL FUNCTIONS ..... Chairman, L. W. Jones

STAFF OF INSTRUCTION AND RESEARCH

ROBERT ANDREWS MILLIKAN, PH.D., LL.D., Sc.D., Nobel Laureate

Professor of Physics
Director of the Norman Bridge Laboratory of Physics
Chairman of the Executive Council

A.B., Oberlin College, 1891; A.M., 1893; Ph.D., Columbia University, 1895. Assistant in Physics, University of Chicago, 1896-1897; Associate, 1897-1899; Instructor, 1899-1902; Assistant Professor, 1902-1907; Associate Professor, 1907-1910; Professor, 1910-1921. Recipient of Comstock Prize, National Academy of Sciences, 1913; of Edison Medal of the American Institute of Electrical Engineers, 1922; of the Nobel Prize in Physics of the Swedish Royal Academy of Science, 1923; of the Hughes Medal of the Royal Society of Great Britain, 1923; of the Faraday Medal of the London Chemical Society, 1924; of the Matteucci Medal of the Societa Italiana della Scienze, 1925; of the Gold Medal of the American Society of Mechanical Engineers, 1926; of the Messel Medal of the Society of Chemical Industry of England, 1928; of the Gold Medal of the Society of Arts and Sciences, 1929; of the Gold Medal of the Radiological Society of North America, 1930; Gold Medal of the Holland Society, 1930; and of the Gold Medal of Honor, Roosevelt Memorial Foundation, 1932; Member, Pontificia Accademia delle Scienze, 1936; Commandeur de l'Ordre National de la Légion d' Honneur, 1936. California Institute, 1916-

1640 Oak Grove Avenue

MAX MASON, PH.D., LL.D., Sc.D.

Vice-Chairman of the Observatory Council
Member of the Executive Council

B.L., University of Wisconsin, 1898; Ph.D., University of Göttingen, 1903. Instructor in Mathematics, Massachusetts Institute of Technology, 1903-1904; Assistant Professor of Mathematics, Yale University, 1904-1908; Associate Professor of Mathematics, University of Wisconsin, 1908; Professor of Mathematical Physics, 1910-1925; President, University of Chicago, 1925-1928; President of the Rockefeller Foundation, 1928-1936. LL.D., University of Wisconsin, 1926; Yale University, 1926; Dartmouth College, 1927; Pomona College, 1937; Sc.D. (hon.), Columbia University, 1926. Colloquium Lecturer, American Mathematical Society, 1906; Visiting Lecturer, Mathematical Physics, Harvard University, 1911-1912; Member of Research Staff, Naval Experiment Station, New London, Connecticut, 1917-1919. Member, National Academy of Sciences. California Institute, 1936-

1505 Circle Drive

THOMAS HUNT MORGAN, PH.D., LL.D., Sc.D., Nobel Laureate

Professor of Biology
Member of the Executive Council

B.S., University of Kentucky, 1886; M.S., 1888; Ph.D., Johns Hopkins University, 1890. Professor of Biology, Bryn Mawr College, 1891-1904; Professor of Experimental Zoology, Columbia University, 1904-1928. LL.D., Johns Hopkins University, 1915; University of Kentucky, 1916; McGill University, 1921; University of Edinburgh, 1922; University of California, 1930; Sc.D. (hon.), University of Michigan, 1924; Docteur Honoris Causa, University of Paris, 1935; Ph.D. (Dr. of Nat. Phil.), Heidelberg University, 1931. M.D. (hon.), University of Zurich, 1933. Fellow of the American Association for the Advancement of Science (President, 1930); Member, American Philosophical Society; President, National Academy of Sciences, 1927-1931; Member, Linnean Society of London; Royal Society of Sciences of Denmark; Foreign Member, Royal Society of London; Finnish Society of Sciences; Associate Member, Société Royale des Sciences Médicales et Naturelles de Bruxelles; Society Belge de Biologie, Bruxelles; Société de Biologie de France; Corresponding Member, Zoological Society of London; Académie des Sciences de Russie; Bavarian Academy of Sciences; Honorary Member, Royal Irish Academy, Ordinary Member, Royal Society of Sciences of Upsala; Foreign Associate, Royal Accademia Nazionale dei Lincei, Rome; Correspondent, Académie des Sciences, Institut de France; Member, Academia Scientiarium Instituti, Bononiensis (Bologna); Member, Pontificia Accademia delle Scienze, 1936; Honorary Foreign Member, Académie Royale de Medicine de Belgique, 1936; Recipient of the Nobel Prize in Medicine of the Swedish Royal Academy of Science, 1933. California Institute, 1928-

1149 San Pasqual Street

WILLIAM BENNETT MUNRO, PH.D., LL.D., LITT.D.

Professor of History and Government
Member of the Executive Council

B.A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard University, 1899; Ph.D., 1900; M.A. (hon.), Williams College, 1904; LL.D., Queens University, 1912; Litt.D., University of Southern California, 1930; LL.D., Mills College, 1931; Parker Traveling Fellow, Harvard University, 1900-1901; Instructor in History and Political Science, Williams College, 1901-1904; Instructor in Government, Harvard University, 1904-1906; Assistant Professor of Government, 1906-1912; Professor of Municipal Government, 1912-1925; Jonathan Trumbull Professor of American History and Government, 1925-1930; Chairman of the Division of History, Economics and Government, Harvard University, 1920-1928; Weil Foundation Lecturer, University of North Carolina, 1921; McBride Foundation Lecturer, Western Reserve University, 1925; Jacob H. Schiff Foundation Lecturer, Cornell University, 1926; Marfleet Lecturer, University of Toronto, 1929; Acting Director, Harvard Graduate School of Public Administration, 1936-1937; President of the American Association of University Professors, 1930-1931; President of the American Political Science Association, 1927; Vice-President and Chairman of the Section on Historical and Philological Sciences, American Association for the Advancement of Science, 1931. Fellow of the American Academy of Arts and Sciences. California Institute, 1925-

268 Bellefontaine Street

RICHARD CHACE TOLMAN, PH.D.

Professor of Physical Chemistry and Mathematical Physics
Dean of the Graduate School
Member of the Executive Council

S.B., in Chemical Engineering, Massachusetts Institute of Technology, 1903; Ph.D., 1910; Student, Berlin and Crefeld, 1903-1904. Dalton Fellow, Instructor in Theoretical Chemistry, and Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1905-1910; Instructor in Physical Chemistry, University of Michigan, 1910-1911; Assistant Professor of Physical Chemistry, University of Cincinnati, 1911-1912; Assistant Professor of Chemistry, University of California, 1912-1916; Professor of Physical Chemistry, University of Illinois, 1916-1918; Chief, Dispersoid Section, Chemical Warfare Service, 1918; Associate Director and Director, Fixed Nitrogen Research Laboratory, Department of Agriculture, 1919-1921. Member of National Academy of Sciences, American Philosophical Society, and of American Academy of Arts and Sciences. California Institute, 1921-

345 South Michigan Avenue

EDWARD CECIL BARRETT, B.A.

Comptroller

B.A., State University of Iowa, 1906. Assistant Secretary, Board of Regents, 1906-1907; Registrar and Secretary to the President, State University of Iowa, 1907-1911. California Institute, 1911-

942 North Chester Avenue

HARRY BATEMAN, PH.D.

Professor of Mathematics, Theoretical Physics, and Aeronautics

B.A., Cambridge University, 1903; Smith Prize, 1905; Fellowship, Trinity College, Cambridge, 1905-1911; Ph.D., Johns Hopkins University, 1913. Lecturer in Mathematics, University of Liverpool, 1906-1907; Reader in Mathematical Physics, University of Manchester, 1907-1910; Lecturer in Mathematics, Bryn Mawr College, 1910-1912; Lecturer in Applied Mathematics, Johns Hopkins University, 1915-1917. Fellow of the Royal Society of London, 1928. Member, American Philosophical Society, National Academy of Sciences. California Institute, 1917-

1107 San Pasqual Street

STUART JEFFERY BATES, PH.D.

Professor of Physical Chemistry

B.A., McMaster University, Toronto, 1907; M.A., 1909; Ph.D., University of Illinois, 1912. Research Assistant, McMaster University, 1909-1910; Fellow in Chemistry, University of Illinois, 1910-1912; Research Associate in Physical Chemistry, 1912-1913. Instructor in Analytical Chemistry, University of Illinois, 1913-1914; Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1922-1923 (on leave from California Institute of Technology). California Institute, 1914-

2011 Rose Villa Street

ERIC TEMPLE BELL, PH.D.

Professor of Mathematics

A.B., Stanford University, 1904; A.M., University of Washington, 1908; Ph.D., Columbia University, 1912. Instructor, Assistant Professor, Associate Professor, University of Washington, 1912-1922; Professor, 1922-1926. Professor, summer quarters, University of Chicago, 1924-1928; Visiting Lecturer, Harvard University, first half 1926. Member of National Academy of Sciences and American Philosophical Society. California Institute, 1926-

434 South Michigan Avenue

JAMES EDGAR BELL, PH.D.

Professor of Chemistry

S.B., University of Chicago, 1905; Ph.D., University of Illinois, 1913. Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916. Associate Professor, California Institute, 1916-1918; Professor, 1918-

R. D. 1, Box 639, Pasadena

HENRY BORSOOK, PH.D., M.B.

Professor of Biochemistry

B.A., University of Toronto, 1921; M.A., 1922; Ph.D., 1924; M.B., 1927. Fellow, Research Fellow, and Lecturer in Biochemistry, University of Toronto, 1920-1929. Assistant Professor, California Institute, 1929-1935; Professor, 1935-

1121 Constance Street

IRA SPRAGUE BOWEN, PH.D.

Professor of Physics

A.B., Oberlin College, 1919; Ph.D., California Institute of Technology, 1926. Assistant in Physics, University of Chicago, 1920-1921. Member, National Academy of Sciences. Instructor, California Institute, 1921-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-1931; Professor, 1931-

380 Bonita Avenue

JOHN PETER BUWALDA, PH.D.

Professor of Geology

B.S., University of California, 1912; Ph.D., 1915. Instructor, University of California, 1915-1917; Assistant Professor of Geology, Yale University, 1917-1921; Associate Professor of Geology, University of California, 1921-1925; Professor of Geology, 1925; Dean of the Summer Sessions, 1923-1925. Associate Geologist, U. S. Geological Survey. Member, Federal Advisory Board for Yosemite National Park, 1928-. California Institute, 1925-

2103 San Pasqual Street

W. HOWARD CLAPP, E.M.

Professor of Mechanism and Machine Design

E.M., University of Minnesota, 1901. Instructor in Mathematics, Macalester College, 1897-1898. Superintendent and Designing Engineer, Sherman Engineering Company, Salt Lake City, 1905-1909; Superintendent, Nevada-Goldfield Reduction Company, Goldfield, Nevada, 1909-1910. Instructor, California Institute, 1911-1913; Assistant Professor, 1913-1914; Associate Professor, 1914-1918; Professor, 1918-

95 South Mentor Avenue

ROBERT L. DAUGHERTY, M.E.

Professor of Mechanical and Hydraulic Engineering

A.B. in Mechanical Engineering, Leland Stanford Junior University, 1909; M.E., 1914. Assistant in Mechanics, Leland Stanford Junior University, 1907-1908; Assistant in Hydraulics, 1908-1909; Instructor in Mechanical Engineering, 1909-1910; Assistant Professor of Hydraulics, Sibley College, Cornell University, 1910-1916; Professor of Hydraulic Engineering, Rensselaer Polytechnic Institute, 1916-1919. Member of Council, American Society of Mechanical Engineers, 1925-1928; Vice-President, 1928-1930. Vice-Chairman and Chairman, Board of Directors, City of Pasadena, 1927-1931. California Institute, 1919-

373 South Euclid Avenue

THEODOSIUS DOBZHANSKY

Professor of Genetics

Diploma, University of Kiev, 1921. Assistant in Zoology, Polytechnic Institute of Kiev, 1921-1924. Lecturer in Genetics, University of Leningrad, 1924-1927. Research Fellow, Bureau of Genetics, Russian Academy of Sciences, 1925-1927. Research Fellow in Biology of the International Education Board, Columbia University, 1927-1928; California Institute, 1928-1929; Assistant Professor, 1929-1936; Professor, 1936-

360 South Wilson Avenue

PAUL SOPHUS EPSTEIN, PH.D.

Professor of Theoretical Physics

C.Sc., Moscow University, 1906; M.Sc., 1909; Ph.D., University of Munich, 1914. Assistant in Physics, Moscow Institute of Agriculture, 1906-1907; Assistant in Physics, Moscow University, 1907-1909; Privat-docent, Moscow University, 1909-1913; Privat-docent, University of Zurich, 1919-1922. Member National Academy of Sciences. California Institute, 1921-

1484 Oakdale Street

PHILIP GUEDALLA, M.A.

Visiting Professor of History and Biography

B.A., Oxford University, 1910; M. A., 1912; Barrister, Inner Temple, 1913; Honorary Director, Ibero-American Institute of Great Britain. California Institute, 1938.

Athenæum

BENO GUTENBERG, PH.D.

Professor of Geophysics

Technische Hochschule, Darmstadt, 1907; Universität Göttingen, 1908; Ph.D., 1911. Assistant, Zentral Büro der Internationalen Seismologischen Vereinigung, Strassburg, 1913-1914; Reichszentrale fuer Erdbebenforschung, Strassburg, 1914-1919; Privat-dozent fuer Geophysik, Universität Frankfurt A/M, 1924-1926; A. O. Professor, 1926-1930. California Institute, 1930-

399 Ninita Parkway

FREDERIC W. HINRICHS, JR., M.A.

Professor of Mechanics
Dean of Upper Classmen

Graduate of the United States Military Academy, 1902; A.B., Columbia University, as of 1902; B.S., United States Military Academy, as of 1902; M.A. (hon.), Occidental College, 1926. Assistant Professor, Professor of Applied Mechanics, University of Rochester, 1910-1919. Assistant Professor, California Institute, 1920-1923; Professor and Dean, 1923-

1071 North Garfield Avenue

WILLIAM VERMILLION HOUSTON, PH.D.

Professor of Physics

B.A. and B.Sc. in Ed., Ohio State University, 1920; M.S., University of Chicago, 1922; Ph.D., Ohio State University, 1925. Instructor in Physics, Ohio State University, 1922-1925. National Research Fellow in Physics, 1925-1927. Foreign Fellow of the John Simon Guggenheim Foundation, 1927-1928. National Research Fellow, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

3207 Lombardy Road

CLINTON KELLY JUDY, M.A.

Professor of English Language and Literature

A.B., University of California, 1903; M.A., 1907; B.A., Oxford University, 1909; M.A., 1913; M.A., Harvard University, 1917. California Institute, 1909-

1325 Woodstock Road, San Marino

THEODORE VON KÁRMÁN, PH.D., DR. ING.

Professor of Aeronautics
Director of the Daniel Guggenheim Laboratory

M.E., Budapest, 1902; Ph.D., Göttingen, 1908. Doctor of Engineering (hon.), University of Berlin, 1929; Doctor of Science (hon.), University of Brussels, 1937. Privat-docent, Göttingen, 1910-1913; Professor of Mechanics and Aerodynamics, Director of the Aerodynamical Institute, University of Aachen, 1913-1934; Honorary Adviser of the Aeronautical Department of Tsing Hua University (China), 1933-. Member of Gesellschaft der Wissenschaften zu Göttingen, 1925; foreign member of the Royal Academy of Sciences, Torino, 1928; Honorary Fellow, Institute of Aeronautical Sciences, 1936. Rouse-Ball Lecturer at the University of Cambridge, 1937; C.R.B. Lecturer in Belgium, 1937; Wilbur Wright Lecturer of the Royal Aeronautical Soc., 1937. California Institute, 1928-

1501 South Marengo Avenue

WILLIAM NOBLE LACEY, PH.D.

Professor of Chemical Engineering

A.B. in Chemical Engineering, 1911, and Chemical Engineer, 1912, Leland Stanford Junior University; M.S., 1913; Ph.D., University of California, 1915. Assistant in Chemistry, Leland Stanford Junior University, 1911-1912; Assistant in Chemistry, University of California, 1912-1915; Research Chemist for Giant Powder Co., San Francisco, 1915; Research Associate, Massachusetts Institute of Technology, 1916. Instructor, California Institute, 1916-1917; Assistant Professor, 1917-1919; Associate Professor, 1919-1931; Professor, 1931-

2136 Minoru Drive, Altadena

GRAHAM ALLAN LAING, M.A.

Professor of Economics and Business Administration

B.A., University of Liverpool, 1908; M.A., 1909; Gladstone Prize in History and Political Science, Rathbone Prize in Economics, Liverpool University, 1907; Workers' Educational Association Lecturer in Economic History for Liverpool University, 1909-1913; Secretary, Department of Education, Government of British Columbia, 1913-1914; Director of Technical Education, Vancouver, B. C., 1914-1917; Instructor in Economics and History, University of California, 1917-1918; Assistant Statistician, United States Shipping Board, 1918-1919; Assistant Professor of Social Science, University of Arizona, 1919-1921. California Institute, 1921-

1642 Pleasant Way

CHARLES CHRISTIAN LAURITSEN, PH.D.

Professor of Physics

Odense Tekniske Skole, 1911; Ph.D., California Institute of Technology, 1929. Assistant in Physics, California Institute, 1927-1930; Assistant Professor, 1930-1931; Associate Professor, 1931-1935; Professor, 1935-

1444 Blanche Street

JOHN ROBERTSON MACARTHUR, PH.D.

Professor of Languages

B.A., University of Manitoba, 1892; Ph.D., University of Chicago, 1903. Lecturer in Modern Languages, Manitoba College, 1893-1898; Professor of English, New Mexico Agricultural College, 1903-1910, 1911-1913; Professor of English, Kansas State Agricultural College, 1914-1920. Agent of International Committee of Young Men's Christian Association, Ellis Island, 1910-1911. Associate Professor, California Institute, 1920-1923; Dean of Freshmen, 1923-1937; Professor of Languages, 1923-

866 South Pasadena Avenue

ROMEO RAOUL MARTEL, S.B.

Professor of Structural Engineering

S.B., Brown University, 1912. Instructor in Civil Engineering, Rhode Island State College, 1913-1914; Instructor in Civil Engineering, Mechanics Institute, 1914-1915. With Sayles Finishing Plants, Saylesville, R. I., 1915-1918; with Atchison, Topeka and Santa Fe Railway, Amarillo, Texas, 1918; Resident Engineer, California Highway Commission, Willits, California, summer of 1921. Consulting Engineer on Bridge Design for City of Pasadena, 1921-1924. Representative of Southern California Council on Earthquake Protection at Third Pan-Pacific Science Congress, Tokyo, 1926, and at the World Engineering Congress at Tokyo in 1929. Instructor, California Institute, 1918-1920; Assistant Professor, 1920-1921; Associate Professor, 1921-1930; Professor, 1930-

690 South Mentor Avenue

SEELEY G. MUDD, M.D.

Professor of X-Ray Therapy
Director of Radiological Research

B.S., Columbia University, 1917; M.D., Harvard University, 1924. Research Associate in Radiation, California Institute, 1931-1935; Professor, 1935-

1550 Oak Grove Avenue

ALLAN NEVINS, M.A.

Visiting Professor of American History

B.A., University of Illinois, 1912; M.A., 1913. Instructor in English, University of Illinois, 1912-1913; Editorial writer, New York Evening Post, 1913-1923; Literary editor, New York Sun, 1924-1925; Professor of American History, Cornell University, 1927-1928; Associate in History, Columbia University, 1928-1931; Professor of American History, 1931-. California Institute, 1937.

Athenæum

J. ROBERT OPPENHEIMER, PH.D.

Professor of Theoretical Physics

B.A., Harvard University, 1925; Ph.D., University of Göttingen, 1927. Associate Professor of Physics, University of California, 1930-1936; Professor, 1936-. Associate Professor, California Institute, 1928-1937; Professor, 1937-

LINUS PAULING, PH.D., SC.D.*

Professor of Chemistry
Director of the Gates and Crellin Laboratories of Chemistry

B.S., Oregon State College, 1922; Ph.D., California Institute of Technology, 1925. Sc.D. (hon.), Oregon State College, 1933. National Research Fellow in Chemistry, 1925-1926. Fellow of the John Simon Guggenheim Memorial Foundation, 1926-1927. Lecturer in Physics and Chemistry, University of California, 1928-1933; Massachusetts Institute of Technology, 1932; George Fisher Baker Lecturer, Cornell University, 1937-1938. Langmuir Prize of the American Chemical Society, 1931. Member of National Academy of Sciences and American Philosophical Society. Assistant in Chemistry, California Institute, 1922-1923; Teaching Fellow, 1923-1925; Research Fellow, 1926-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

1245 Arden Road

THEODORE GERALD SOARES, PH.D., D.D.

Professor of Ethics

A.B., University of Minnesota, 1891; A.M., 1892; Ph.D., University of Chicago, 1894; D.B., 1897; D.D., Knox College, 1901. Professor of Homiletics, University of Chicago, 1906-1908; Professor of Religious Education and Head of the Department of Practical Theology, 1908-1930. President, Religious Education Association, 1921-1924. California Institute, 1927-

1542 Morada Place, Altadena

ROYAL WASSON SORENSEN, E.E.

Professor of Electrical Engineering

B.S., in Electrical Engineering, University of Colorado, 1905; E.E., 1928. Associated with General Electric Co., Schenectady, N. Y., and Pittsfield, Mass., 1905-1910; Consulting Engineer, Pacific Light and Power Corporation, 1913-1917. Consulting Engineer, U. S. Electrical Manufacturing Company, 1917-1929, 1930-1932. Consulting Engineer, Circuit Breaker Research Department, General Electric Company, 1929-1930. Member, Board of Consulting Engineers, Metropolitan Water District of Southern California, 1931-. Vice-President, American Institute of Electrical Engineers, 1933-1935, and member of Board of Directors, 1936-. Associate Professor, California Institute, 1910-1911; Professor, 1911-

384 South Holliston Avenue

*On leave of absence, Fall term, 1937.

CHESTER STOCK, PH.D.

Professor of Paleontology

B.S., University of California, 1914; Ph.D., 1917; Research Assistant, Department of Paleontology, University of California, 1917-1919; Instructor, 1919-1921; Assistant Professor, Department of Geological Sciences, 1921-1925. Research Associate, Carnegie Institution of Washington. Curator of Vertebrate Paleontology, Los Angeles Museum. California Institute, 1926-

1633 Linda Vista Avenue

ALFRED HENRY STURTEVANT, PH.D.

Professor of Genetics

A.B., Columbia University, 1912; Ph.D., 1914. Research Assistant, Carnegie Institution, 1915-1928. Visiting Carnegie Professor, Birmingham, 1932; Leeds and Durham, 1933. Member of National Academy of Sciences, American Philosophical Society, American Society of Naturalists. California Institute, 1928-

1244 Arden Road

FRANKLIN THOMAS, C.E.

Professor of Civil Engineering

B.E., University of Iowa, 1908; C.E., 1913. Graduate work at McGill University, Montreal. Instructor in Descriptive Geometry and Drawing, University of Michigan, 1910-1912. Construction Foreman, Mines Power Company, Cobalt, Ontario, 1909-1910; Designer, Alabama Power Company, Birmingham, Alabama, 1912-1913. Assistant Engineer, U. S. Reclamation Service, 1919. Member and Vice-Chairman, Board of Directors, City of Pasadena, 1921-1927; Member and Vice-Chairman, Board of Directors, Metropolitan Water District, 1928-; Director, American Society of Civil Engineers, 1930-1933. Associate Professor, California Institute, 1913-1914; Professor, 1914-

685 South El Molino Avenue

ALEXANDER ROBERTUS TODD, DR.PHIL.NAT., D.PHIL., D.SC.

Visiting Lecturer in Organic Chemistry

B.Sc., University of Glasgow, 1928; Dr.phil.nat., University of Frankfurt A/M, 1931; D.Phil., University of Oxford, 1933; D.Sc., University of Glasgow, 1937. Meldola Medal of the Institute of Chemistry, 1936. Carnegie Research Scholar, 1928-1931; University of Glasgow, 1928-1929; University of Frankfurt A/M, 1929-1931. 1851 Exhibition Senior Student, University of Oxford, 1931-1934. Assistant in Chemistry in Relation to Medicine, and Medical Research Council Grantee, University of Edinburgh, 1934-1935; Beit Memorial Medical Research Fellow, 1935-1936. Member of Staff, Lister Institute of Preventive Medicine, London, 1936-. Reader in Biochemistry, University of London, 1937-. California Institute, 1938.

HARRY CLARK VAN BUSKIRK, PH.B.

Professor of Mathematics

Ph.B., Cornell University, 1897. Associate Professor, California Institute, 1904-1915; Registrar, 1915-1935; Professor, 1915-

390 South Holliston Avenue

EARNEST CHARLES WATSON, PH.B.

Professor of Physics

Ph.B., Lafayette College, 1914; Assistant in Physics, University of Chicago, 1914-1917. Assistant Professor, California Institute, 1919-1920; Associate Professor, 1920-1930; Professor, 1930-

1124 Mar Vista Avenue

FRITS WARMOLT WENT, PH.D.

Professor of Plant Physiology

A.B., Utrecht, 1922; A.M., 1925; Ph.D., 1927. Assistant in Botanical Laboratory, 1924-1927; Assistant, Lands Plantentuin, Buitenzorg, Java, 1927-1930; Director, Foreigners' Laboratory, Java, 1930-1932. Corresponding Member, Koninklijke Akademie van Wetenschappen te Amsterdam. Assistant Professor, California Institute, 1932-1935; Professor, 1935-

200 South Catalina Avenue

DINSMORE ALTER, PH.D.

Research Associate in Statistics

B.S., Westminster College (Pa.), 1909; M.S., University of Pittsburgh, 1910; Ph.D., University of California, 1916. Instructor in Physics and Astronomy, University of Alabama, 1911-1912; Assistant Professor, 1912-1913, Adjunct Professor, 1913-1914; Instructor in Astronomy, University of California, 1914-1917; Assistant Professor of Astronomy, University of Kansas, 1917-1919; Associate Professor, 1919-1924; Professor, 1924-1936. Director, Griffith Observatory, Los Angeles, 1935-. Fellow of the John Simon Guggenheim Memorial Foundation, 1929-1930. Fellow of the Royal Astronomical Society. California Institute, 1935-

Griffith Observatory, Los Angeles

JOHN AUGUST ANDERSON, PH.D.

Research Associate in Astrophysics†
Executive Officer of the Observatory Council

B.S., Valparaiso College, 1900; Ph.D., Johns Hopkins University, 1907. Associate Professor of Astronomy, Johns Hopkins University, 1908-1916; Physicist, Mount Wilson Observatory, 1916-. California Institute, 1928-

994 Poppy Street, Altadena

SAMUEL JACKSON BARNETT, PH.D.

Research Associate in Physics

A.B., University of Denver, 1894; Ph.D., Cornell University, 1898. Instructor in Physics and Biology, University of Denver, 1894-1895; Assistant in Astronomical Observatory, University of Virginia, 1895-1896; University Scholar and President White Fellow, Cornell University, 1896-1898; Instructor in Physics and later Professor of Physics, Colorado College, 1898-1900; Assistant Professor of Physics, Stanford University, 1900-1905; Professor of Physics, Tulane University of Louisiana, 1905-1911; Assistant Professor of Physics, 1911-1912, and Professor of Physics, 1912-1918, Ohio State University; Physicist, Carnegie Institution of Washington, 1918-1926 (Research Associate, 1924-1926); Professor of Physics, University of California at Los Angeles, 1926-. Recipient of Comstock Prize, National Academy of Sciences, 1918; Fellow of the American Academy of Arts and Sciences. California Institute, 1924-

939 Thayer Avenue, Westwood Hills, Los Angeles

HENRI COUTARD, M.D.

Research Associate in Radiology

M.D., University of Paris, 1902. Laboratory of Radioactivity and Radiations of Gif, 1908-1914; Chef du Service de Roentgentherapie de la Fondation Curie, Paris, France, 1918-. California Institute, 1937.

Athenæum

GODFREY DAVIES, M.A.

Associate in History

B.A., Honour School of Modern History, Oxford University, 1914; Secretary to C. H. Firth, then Regius Professor of Modern History, Oxford University, 1914-1916; Tutor in the School of Modern History, 1919-1924; Assistant Professor of History, University of Chicago, 1925-1930. Visiting Scholar of the Huntington Library, 1930-1931; Member of Research Staff, 1931-. California Institute, 1930-

395 South Bonnie Avenue

†Member of the staff of the Mount Wilson Observatory of the Carnegie Institution of Washington. Associated with the California Institute by special arrangement with the Carnegie Institution.

JESSE WILLIAM MONROE DUMOND, PH.D.*

Research Associate in Physics

B.S., California Institute of Technology, 1916; M.S. in E.E., Union College, 1918; Ph.D., California Institute, 1929. Teaching Fellow, California Institute, 1921-1925; Research Fellow, 1925-1931; Research Associate, 1931-

1585 Homewood Drive, Altadena

EDWIN FRANCIS GAY, PH.D., LL.D., LITT.D.

Associate in Economic History

A.B., University of Michigan, 1890; Ph.D., University of Berlin, 1902. Instructor, Assistant Professor, and Professor of Economics, Harvard University, 1902-1919; Dean of Graduate School of Business Administration, 1908-1919; Professor of Economic History, 1924-1936. LL.D., Harvard University, 1918; University of Michigan, 1920; Northwestern University, 1927; Tulane University, 1935. Litt.D., Manchester University, England, 1933. Member of Research Staff, Huntington Library, 1936-. California Institute, 1936-

2040 San Pasqual Street

JOSEPH BLAKE KOEPFLI, D.PHIL.

Research Associate in Chemistry

A.B., Leland Stanford Junior University, 1924; M.A., 1925; D. Phil., Oxford University, 1928. Research Fellow in Organic Chemistry, California Institute, 1928-1929. Instructor in Pharmacology, Johns Hopkins University School of Medicine, 1929-1931. California Institute, 1932-

955 Avondale Road, San Marino

CLYDE STANLEY MCDOWELL, Captain U. S. N., Retired

Supervising Engineer for the 200-inch Telescope

Graduate U. S. Naval Academy, 1904; promoted Commander, 1918; Captain, 1926. Sc.D. (hon.), University of Wisconsin, 1921. In charge of Physical and Electrical Laboratories, New York Navy Yard, 1912-1915; Staff Commander, U. S. Submarine Forces, 1915-1918; member and Executive Secretary, U. S. Anti-Submarine Board, 1917-1918; command Naval Experiment Station, New London, Connecticut, 1917-1918; Staff Commander, U. S. Naval Forces in European waters, 1918-1919; Naval Inspector of Machinery and Inspector of Ordnance, General Electric Company, Schenectady, 1919-1921; Vice-President, American Institute of Electrical Engineers, 1920-1921; New Construction Superintendent, New York Navy Yard, 1921-1922; Staff Commander, Base Forces, U. S. Fleet, 1922-1924; Chief Engineer, Mare Island Navy Yard, 1924-1927; Manager, Navy Yard, Pearl Harbor, T. H., 1929-1930; Inspector of Naval Material, San Francisco, 1930-1932; Inspector of Machinery, Westinghouse Electric and Manufacturing Company, 1932-1934; Inspector of Machinery, New York Shipbuilding Corporation, Camden, N. J., 1933-1934. Awarded Navy Cross for war work. California Institute, 1934-

745 South Oak Knoll Avenue

ROBERT THOMAS MOORE, A.M.

Associate in Vertebrate Zoology

A.B., University of Pennsylvania, 1903; A.M., Harvard University, 1904; University of Munich, 1904-1905. Fellow of the Royal Geographical Society (London), American Geographical Society; member of American Ornithological Union. California Institute, 1929-

Meadow Grove Place, Flintridge

*On leave of absence, Fall term, 1937.

Francis Gladheim Pease, D.Sc.

Associate in Optics and Instrument Design†

B.S., Armour Institute of Technology, 1901; M.S., 1924; D.Sc., 1927. Optician and Observer, Yerkes Observatory, 1901-1904; Instrument Designer, Mount Wilson Observatory, 1904-1913; Astronomer, 1911-; In Charge of Instrument Design, 1913-1928; Chief Draftsman, National Research Council, 1918. Fellow of Royal Astronomical Society, London. California Institute, 1928-

824 North Holliston Avenue

Russell Williams Porter, M.S.

Associate in Optics and Instrument Design

M.S. (hon.), Norwich University, 1917. Made eight trips to Arctic Regions with Peary, Fiala-Ziegler, and Baldwin-Ziegler as artist, astronomer, topographer, surveyor, or collector for natural history; three trips into Alaska, British Columbia, and Labrador. Instructor in architecture, Massachusetts Institute of Technology, 1916-1917; optical work, Bureau of Standards, Washington, D. C., 1917-1918; Optical Associate with the Jones & Lamson Machine Co., 1918-1928. California Institute, 1928-

615 South Mentor Avenue

Ricardo Quintana, Ph.D.

Associate in English Literature

A.B., Harvard College, 1920; M.A., Harvard University, 1921; Instructor in English, Washington University, St. Louis, Mo., 1921-1924; Instructor in English and Tutor in the Division of Modern Languages, Harvard University, 1924-1926; Austin Resident Fellow, Ph.D., Harvard University, 1927; Assistant Professor, Associate Professor and Professor of English, University of Wisconsin, 1927-; Huntington Library Fellow, 1937-1938. California Institute, 1938.

1833 North Allen Avenue, Altadena

Sinclair Smith, Ph.D.

Associate in Optics and Instrument Design†

B.S., California Institute of Technology, 1921; Ph.D., 1924; Fellow Commoner, Sidney Sussex College, Cambridge, 1924-1925; Mount Wilson Observatory, 1925-. California Institute, 1929-

3321 Grayburn Road

Carl Clapp Thomas, M.E., D.Eng.

Associate in Engineering Research

Stanford University, 1891-1894; M.E., Cornell University, 1895; D. Eng., Johns Hopkins University, 1937. Engaged in Design and Construction of Marine Machinery for Merchant and Naval Vessels, 1895-1904. Professor of Marine Engineering, Cornell University, 1904-1908. Chairman, Department of Mechanical Engineering, University of Wisconsin, 1908-1913; Head of Department of Mechanical Engineering, Johns Hopkins University, 1913-1920. Manager, Machinery Design and Fabrication, United States Government, Hog Island Shipyard, 1917-1919 (on leave from Johns Hopkins University). Vice-President, Dwight P. Robinson & Company, Inc., Engineers and Constructors, 1923. Member American Engineering Council, 1923-. Longstreth Medalist, Franklin Institute, for work on measurement of gases, 1912. California Institute, 1925-

165 Linda Vista Avenue

Harry Oscar Wood, A.M.

Research Associate in Seismology

A.B., Harvard University, 1902; A.M., 1904. Instructor in Mineralogy and Geology, University of California, 1904-1912; Research Associate in Seismology, Hawaiian Volcano Observatory of the Massachusetts Institute of Technology, 1912-1917; Research Associate in Seismology, Carnegie Institution of Washington, 1921-. California Institute, 1931-

220 North San Rafael Avenue

---

†Member of the staff of the Mount Wilson Observatory of the Carnegie Institution of Washington. Associated with the California Institute by special arrangement with the Carnegie Institution.

LOUIS BOOKER WRIGHT, PH.D.

Associate in English Literature

A.B., Wofford College, 1920; M.A., University of North Carolina, 1924; Ph.D., 1926. Instructor in English, University of North Carolina, 1925-1927; Johnston Research Scholar, Johns Hopkins University, 1927-1928; Fellow of the John Simon Guggenheim Memorial Foundation, 1928-1929; Visiting Professor, Emory University, winter quarter, 1929; Assistant Professor of English, University of North Carolina, 1929-1930; Associate Professor, 1930-1932. Visiting Scholar of the Huntington Library, 1931-1932; Member of the Research Staff, 1932-. California Institute, 1931-

580 South Berkeley Avenue

ARCHIBALD B. YOUNG, A.B., B.L.

Lecturer in Business Law

A.B., Central University, 1904; B.L., University of Louisville, 1907. California Institute, 1937-

808 South San Rafael Avenue

CARL DAVID ANDERSON, PH.D., SC.D., Nobel Laureate

Associate Professor of Physics

B.S., California Institute of Technology, 1927; Ph.D., 1930. Sc.D. (hon.), Colgate University, 1937. Recipient of the gold medal of the American Institute of the City of New York, 1935; of the Nobel Prize in Physics of the Swedish Royal Academy of Science, 1936; of the Elliott Cresson Medal of the Franklin Institute, 1937. Assistant and Teaching Fellow in Physics, California Institute, 1927-1930; Research Fellow, 1930-1933; Assistant Professor, 1933-1937; Associate Professor, 1937-

280 South Michigan Avenue

ERNEST GUSTAF ANDERSON, PH.D.

Associate Professor of Genetics

B.S., University of Nebraska, 1915; Ph.D., Cornell University, 1920. Research Associate, Carnegie Institution, 1920-1922; Instructor in Biology, College of the City of New York, 1922-1923. Fellow of the National Research Council, University of Michigan, 1923-1928. California Institute, 1928-

831 Sunset Boulevard, Arcadia

HUGO BENIOFF, PH.D.

Associate Professor of Seismology

B.A., Pomona College, 1921; Ph.D., California Institute of Technology, 1935. Assistant, Mount Wilson Observatory, summers, 1917-1921; Assistant, Lick Observatory, 1923-1924; Research Assistant in Seismology, Carnegie Institution of Washington, 1924-1937. Assistant Professor, California Institute, 1937; Associate Professor, 1937-

4327 Chevy Chase Drive, Flintridge

IAN CAMPBELL, PH.D.

Associate Professor of Petrology

B.A., University of Oregon, 1922; M.A., 1924; Ph.D., Harvard University, 1931. Assistant Professor of Geology, Louisiana State University, 1925-1928; Instructor in Mineralogy and Petrology, Harvard University, 1928-1931; Geologist, Wisconsin Geological Survey, 1924; Petrologist, Vacuum Oil Company, 1926-1927; Petrologist, Panama Corporation, 1927-1928; Junior Geologist, United States Geological Survey, 1929-. Assistant Professor, California Institute, 1931-1934; Associate Professor, 1934-. Research Associate, Carnegie Institution of Washington, 1935-

405 South Bonnie Avenue

ROSCOE GILKEY DICKINSON, PH.D.

Associate Professor of Physical Chemistry

S.B., Massachusetts Institute of Technology, 1915; Ph.D., California Institute of Technology, 1920. Assistant in Theoretical Chemistry, Massachusetts Institute of Technology, 1915-1916; Research Assistant in Physical Chemistry, 1916-1917. National Research Fellow in Chemistry, 1920-1923. Fellow of the International Education Board in Europe, 1924-1925. Instructor, California Institute, 1917-1920; National Research Fellow, 1920-1923; Research Associate, 1923-1926; Assistant Professor, 1926-1928; Associate Professor, 1928- 530 Bonita Avenue

STERLING EMERSON, PH.D.

Associate Professor of Genetics

B.S., Cornell University, 1922; M.S., University of Michigan, 1924; Ph.D., 1928. Instructor in Botany, University of Michigan, 1924-1928. California Institute, 1928-
391 South Wilson Avenue

HORACE NATHANIEL GILBERT, M.B.A.

Associate Professor of Business Economics

A.B., University of Washington, 1923; M.B.A., Harvard University, 1926. Instructor in Business Policy, Harvard University, 1926-1928; Instructor in Business Economics, 1928-929. Assistant Professor, California Institute, 1929-1930; Associate Professor, 1930-
385 South Bonnie Avenue

ALEXANDER GOETZ, PH.D.*

Associate Professor of Physics

Ph.D., University of Göttingen, 1921; Habilitation, 1923. Assistant Professor of Physics, University of Göttingen, 1923-1927; a.o. Professor, 1929-. Fellow in Physics of the International Education Board, 1927-1928. Visiting Professor, Imperial Universities of Japan and University of Tsin-Hua, China, 1930. Research Fellow of International Education Board, California Institute, 1927-1928; Research Fellow, 1928-1929; Associate Professor, 1929-
2400 N. Holliston Avenue

ARIE JAN HAAGEN-SMIT, PH.D.

Associate Professor of Biology

A.B., Utrecht, 1922; A.M., 1926; Ph.D., 1929. Head Assistant, Department of Organic Chemistry, Utrecht, 1929-1934; Lecturer in Organic Chemistry, Utrecht, 1934-1936; Lecturer in Biological Chemistry, Harvard University, 1936-1937; Associate Professor, California Institute, 1937-
359 South Wilson Avenue

ARTHUR LOUIS KLEIN, PH.D.

Associate Professor of Aeronautics

B.S., California Institute of Technology, 1921; M.S., 1924; Ph.D., 1925. Teaching Fellow in Physics, California Institute, 1921-1925; Research Fellow in Physics and in Aeronautics, 1927-1929; Assistant Professor, 1929-1934; Associate Professor, 1934-
2771 Glendower Avenue, Los Angeles

ROBERT TALBOT KNAPP, PH.D.

Associate Professor of Hydraulic Engineering

B.S., Massachusetts Institute of Technology, 1920; Ph.D., California Institute of Technology, 1929. Designer with C. M. Gay & Son, Refrigerating Engineers, 1920-1921; Consulting Engineer, Riverside Cement Company, 1927-1929; American Society of Mechanical Engineers Freeman Scholar in Europe, 1929-1930. Consultant, Metropolitan Water District of Southern California, 1934-1936; Collaborator, Soil Conservation Service, U. S. Department of Agriculture, 1935-1936; Cooperative Agent and Hydraulic Engineer, Soil Conservation Service, 1936-. Instructor, California Institute, 1922-1930; Assistant Professor, 1930-1936; Associate Professor, 1936-
1320 East California Street

*On leave of absence, Fall term, 1937.

FREDERICK CHARLES LINDVALL, PH.D.

Associate Professor of Electrical Engineering

B.S., University of Illinois, 1924; Ph.D., California Institute of Technology, 1928. Electrical Engineering Department, Los Angeles Railway Corporation, 1924-1925; Engineering General Department, General Electric Company, Schenectady, 1928-1930. Assistant in Electrical Engineering, California Institute, 1925-1927; Teaching Fellow, 1927-1928; Instructor, 1930-1931; Assistant Professor, 1931-1937; Associate Professor, 1937-

1860 Allen Drive, Altadena

HOWARD JOHNSON LUCAS, M.A.

Associate Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908; Chemist, United States Government, 1910-1913. Instructor, California Institute, 1913-1915; Associate Professor, 1915-

97 North Holliston Avenue

SAMUEL STUART MACKEOWN, PH.D.

Associate Professor of Electrical Engineering

A.B., Cornell University, 1917; Ph.D., 1923. Instructor in Physics, Cornell University, 1920-1923. National Research Fellow in Physics, California Institute, 1923-1926; Assistant Professor, 1926-1931; Associate Professor, 1931-

1240 Arden Road

GEORGE RUPERT MACMINN, A.B.*

Associate Professor of English Language and Literature

A.B., Brown University, 1905. Instructor in English, Brown University, 1907-1909; Iowa State College, 1909-1910; University of California, 1910-1918. Manager of the University of California Press, 1912-1913. Editor, University of California Chronicle, 1915. Member of the Faculty, Summer Sessions, University of California at Los Angeles, 1920-1931. California Institute, 1918-

255 South Bonnie Avenue

WILLIAM W. MICHAEL, B.S.

Associate Professor of Civil Engineering

B.S., in Civil Engineering, Tufts College, 1909. With New York City on topographic surveys, 1909-1911; with the J. G. White Engineering Corporation, 1912-1913 and 1915; Instructor, Department of Drawing and Design, Michigan Agricultural College, 1914; Office Engineer with the Power Construction Company of Massachusetts, 1914-1915; in private engineering practice, 1916-1918. Engineer, Palos Verdes Estates, summer of 1922; Associate and Consulting Engineer with County Engineer, Ulster County, N. Y., summers of 1925, 1928-1932; Chief of Surveys, 200-inch Telescope, Palomar Mt., Summer, 1935. California Institute, 1918-

388 South Oak Avenue

ARISTOTLE D. MICHAL, PH.D.

Associate Professor of Mathematics

A.B., Clark University, 1920; A.M., 1921; Ph.D., Rice Institute, 1924. Teaching Fellow in Mathematics, Rice Institute, 1921-1924; Instructor in Mathematics, Summer Quarter, University of Texas, 1924; Instructor in Mathematics, Rice Institute, 1924-1925; National Research Fellow in Mathematics, 1925-1927; Assistant Professor of Mathematics, Ohio State University, 1927-1929. Associate Professor of Mathematics, California Institute, 1929-

2002 Oakdale Street

CLARK BLANCHARD MILLIKAN, PH.D.

Associate Professor of Aeronautics

A.B., Yale University, 1924; Ph.D., California Institute of Technology, 1928. Assistant in Physics, California Institute, 1925-1926; Teaching Fellow in Physics and in Aeronautics, 1926-1929; Assistant Professor, 1929-1934; Associate Professor, 1934-

1500 Normandy Drive

*On leave of absence, Fall term, 1937.

GENNADY W. POTAPENKO

Associate Professor of Physics

Dipl. in Phys., University of Moscow, 1917; Habilitation, 1920. Assistant in Physics, Moscow Institute of Petrography, 1914-1916; Research Fellow, University of Moscow, 1917-1920; Docent of Physics, 1920-1932. Professor of Physics, University of Iaroslawl, 1924-1926; Associate Professor, Mining Academy of Moscow, 1917-1927. Professor of Physics and Director of the Physical Institute, Mining Academy of Moscow, 1927-1932. Professor of Physics and Director of the Physical Institute and of the Meteorological Observatory, Agriculture Academy of Moscow, 1929-1931. Research Associate, University of Berlin, 1927; Visiting Lecturer, University of Göttingen, 1929. Recipient of Silver Medal, University of Moscow, 1914; of the Prize in Physics, Russian Scientific Council, 1928. Fellow of the Rockefeller Foundation, California Institute, 1930-1931; Research Fellow, 1931-1932; Associate Professor, 1932-

1718 Oakdale Street

WILLIAM RALPH SMYTHE, PH.D.

Associate Professor of Physics

A.B., Colorado College, 1916; A.M., Dartmouth College, 1919; Ph.D., University of Chicago, 1921. Professor of Physics, University of the Philippines, 1921-1923. National Research Fellow, California Institute, 1923-1926; Research Fellow, 1926-1927; Assistant Professor, 1927-1934; Associate Professor, 1934-

674 Manzanita Avenue, Sierra Madre

RAY EDWARD UNTEREINER, J.D., PH.D.

Associate Professor of Economics and History
Dean of Freshman

A.B., University of Redlands, 1920; A.M., Harvard University, 1921; J.D., Mayo College of Law, 1925; Ph.D., Northwestern University, 1932. Instructor in Economics, Harvard University, 1921-1923; Professor of Public Speaking, Huron College, 1923-1924; Instructor in Economics and Social Science, Joliet Junior College, 1924-1925. Member of California Bar. Instructor, California Institute, 1925-1930; Assistant Professor, 1930-1937; Associate Professor, 1937-

1089 San Pasqual Street

MORGAN WARD, PH.D.

Associate Professor of Mathematics

A.B., University of California, 1924; Ph.D., California Institute of Technology, 1928. Research Worker in Mathematics, Institute for Advanced Study, 1934-1935. Assistant in Mathematics, California Institute, 1925-1926; Teaching Fellow, 1926-1928; Research Fellow, 1928-1929; Assistant Professor, 1929-1935; Associate Professor, 1935-

241 South Holliston Avenue

LUTHER EWING WEAR, PH.D.

Associate Professor of Mathematics

A.B., Cumberland University, 1902; Ph.D., Johns Hopkins University, 1913. Instructor in Mathematics, University of Washington, 1913-1918. California Institute, 1918-

2247 Lambert Drive

CORNELIS A. G. WIERSMA, PH.D.

Associate Professor of Physiology

B.A., University of Leiden, 1926; M.A., University of Utrecht, 1929; Ph.D., 1933. Assistant in Comparative Physiology, University of Utrecht, 1929, 1931; Dondersfonds Research Fellow, 1930-1931; Chief Assistant Medical Physiology, University of Utrecht, 1932-1934. California Institute, 1934-

1364 Cordova Street

DON M. YOST, PH.D.

Associate Professor of Inorganic Chemistry

B.S., University of California, 1923; Ph.D., California Institute of Technology, 1926. Teaching Fellow in Chemistry, University of Utah, 1923-1924; duPont Fellow, California Institute, 1924-1925; Teaching Fellow, 1925-1926; Research Fellow, 1926-1927; Instructor, 1927-1929; Fellow of the International Education Board, 1928-1929; Assistant Professor, 1929-1935; Associate Professor, 1935-

382 East California Street

FRITZ ZWICKY, PH.D.

Associate Professor of Theoretical Physics

Graduate, Eidg. Technische Hochschule, Zurich, 1920; Ph.D., 1922. Assistant in Physics, Eidg. Technische Hochschule, 1921-1925. Fellow of International Education Board, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-

1260 Lorain Road, San Marino

RICHARD MCLEAN BADGER, PH.D.

Assistant Professor of Chemistry

B.S., California Institute of Technology, 1921; Ph.D., 1924. International Research Fellow in Chemistry, 1928-1929. Assistant in Chemistry, California Institute, 1921-1922; Teaching Fellow, 1922-1924; Research Fellow, 1924-1928; Assistant Professor, 1929-

215 Highland Place, Monrovia

ARNOLD ORVILLE BECKMAN, PH.D.

Assistant Professor of Chemistry

B.S., University of Illinois, 1922; M.S., 1923; Ph.D., California Institute of Technology, 1928. Research Associate, Bell Telephone Laboratories, 1924-1926. Teaching Fellow, California Institute, 1923-1924; 1926-1928; Instructor, 1928-1929; Assistant Professor, 1929-

1970 Crescent Drive, Altadena

WILLIAM NOEL BIRCHBY, M.A.

Assistant Professor of Mathematics
Assistant Registrar

A.B., Hope College, 1899; M.A., Colorado College, 1905. Instructor, Colorado College, 1905 and 1907; Instructor in Physics, University of Southern California, Summer Session, 1916. Instructor, California Institute, 1918-1931; Assistant Professor, 1931-

1500 Sinaloa Avenue

DONALD SHERMAN CLARK, PH.D.

Assistant Professor of Mechanical Engineering
Resident Associate in Dabney House
Director of Placements

B.S., California Institute of Technology, 1929; M.S., 1930; Ph.D., 1934. Assistant and Teaching Fellow, California Institute, 1929-1934; Instructor, 1934-1937; Assistant Professor, 1937-

Dabney House

FREDERICK J. CONVERSE, B.S.

Assistant Professor of Civil Engineering

B.S. in Mechanical Engineering, University of Rochester, 1914. Appraisal Engineer, Cleveland Electric Illuminating Company, Cleveland, Ohio, 1914-1915. Student Engineer, General Electric Company, Lynn, Massachusetts, 1915-1916. Instructor in Applied Mechanics, University of Rochester, 1916-1917. Engineer in Charge of Materials Tests, General Laboratories, Bureau of Aircraft Production, U. S. A., 1917-1918. Assistant Production Engineer, Gleason Gear Works, Rochester, New York, 1919. Designer, Bureau of Power and Light, Los Angeles City, 1920. Member of firm, Labarre and Converse, Consulting Foundation Engineers, 1932-1936. Instructor, California Institute, 1921-1933; Assistant Professor, 1933-

2167 Lambert Drive

HARVEY EAGLESON, PH.D.

Assistant Professor of English Language and Literature
Resident Associate in Blacker House

B.A., Reed College, 1920; M.A., Stanford University, 1922; Ph.D., Princeton University, 1928. Instructor in English, University of Texas, 1922-1926. California Institute, 1928-

Blacker House

ROBERT EMERSON, PH.D.*

Assistant Professor of Biophysics

A.B., Harvard University, 1925; Ph.D., University of Berlin, 1927. National Research Fellow in Biology, Harvard University, 1927-1929. Instructor in Biophysics, Harvard University, 1929-1930. California Institute, 1930-

1175 Woodbury Road

CLYDE K. EMERY, M.D.

Assistant Professor of X-Ray Therapy

B.A., University of California, 1923; L.R.C.P., London, 1928; M.R.C.S., England, 1928. California Institute, 1931-

445 South Kingsley Drive, Los Angeles

PHILIP SHEARER FOGG, M.B.A.

Assistant Professor of Business Economics
Registrar

A.B., Stanford University, 1925; M.B.A., Harvard University, 1929. Instructor, American Institute of Banking, 1932-; Instructor in Economics, California Graduate School of Design, 1937-; California Institute, 1930-

1273 San Pasqual Street

HORACE J. FRASER, PH.D.

Assistant Professor of Mineralogy and Mineragraphy

B.Sc., University of Manitoba, 1925; M.Sc., 1927; M.A., Harvard University, 1928; Ph.D., 1930. Assistant in Geology, University of Manitoba, 1925-1927; University of Manitoba Travelling Fellow, 1927-1928; Instructor in Economic Geology, Harvard University, 1928-1930; National Research Fellow, 1930-1931; Research Associate in Geology, Harvard University, 1931-1932; Geologist, International Nickel Company of Canada, Ltd., 1932-1935. California Institute, 1935-

970 Old Mill Road, San Marino

HUGH MARTIN HUFFMAN, PH.D.

Assistant Professor of Biochemistry

A.B., Leland Stanford Junior University, 1925; M.A., 1926; Ph.D., 1928. Instructor in Chemistry, San Jose Teachers College, 1925-1927; Fellow of the American Petroleum Institute, Leland Stanford Junior University, 1927-1931. California Institute, 1931-

3280 Mount Curve Avenue, Altadena

WILLIAM HUSE, M.A.

Assistant Professor of English Language and Literature
Editor of Institute Publications

A.B., Stanford University, 1921; M.A., Princeton University, 1928. Instructor in English, Washington University, 1921-1923; Instructor in English, Princeton University, 1923-1924; Assistant Professor of English, University of Kansas, 1927-1929. California Institute, 1929-

3676 Yorkshire Road

LOUIS WINCHESTER JONES, A.B.

Assistant Professor of English Language and Literature
Faculty Associate of the Throop Club

A.B., Princeton University, 1922. California Institute, 1925-

351 California Terrace

*On leave of absence, 1937-1940.

IRVING PARKHURST KRICK, PH.D.

Assistant Professor of Meteorology

A.B., University of California, 1928; M.S., California Institute of Technology, 1933; Ph.D., 1934. Teaching Fellow, California Institute, 1932-1933; Instructor, 1933-1935; Assistant Professor, 1935-

2174 San Pasqual Street

LEO M. LEVI, M.D.

Assistant Professor of X-Ray Therapy

A.B., Ohio State University, 1923; M.D., Jefferson Medical College, 1927; Zeugnis, University of Vienna, 1932; California Institute, 1934-

95 South Los Robles Avenue

GEORGE EBER MACGINITIE, M.A.

Assistant Professor of Biology

A.B., Fresno State College, 1925; M.A., Stanford University, 1928. Instructor in Biology, Fresno State College, 1925-1928; Instructor in Zoology, Hopkins Marine Station of Stanford University, 1928-1929; Assistant Professor of Zoology, 1929-1932. California Institute, 1932-

Corona del Mar

FRANCIS WILLIAM MAXSTADT, PH.D.

Assistant Professor of Electrical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916; M.S., California Institute of Technology, 1925; Ph.D., 1931. Draftsman and Designer, Otis Elevator Company, 1916-1917. Assistant in the Electrical Research Division, Interborough Rapid Transit Company, 1917-1919. Assistant in the Thomas A. Edison Laboratories, 1919. Instructor, California Institute, 1919-1933; Assistant Professor, 1933-

1666 North Grand Oaks Avenue, Altadena

HENRY VICTOR NEHER, PH.D.

Assistant Professor of Physics

B.A., Pomona College, 1926; Ph.D., California Institute of Technology, 1931. Assistant in Physics, California Institute, 1928-1931; Research Fellow, 1931-1933; Instructor, 1933-

1773 Oakdale Street

CARL GEORGE NIEMANN, PH.D.*

Assistant Professor of Organic Chemistry

B.S., University of Wisconsin, 1931; Ph.D., 1934. Research Assistant, University of Wisconsin, 1929-1931; Fellow, 1931-1934; Research Associate, 1934-1935. Fellow in Chemistry of the General Education Board at the Rockefeller Institute for Medical Research, 1935-1936; Assistant in Chemistry, 1936-1937. California Institute, 1937-

ARTHUR EMMONS RAYMOND, M.S.

Assistant Professor of Aeronautics

S.B., Harvard University, 1920; M.S. in Aeronautics, Massachusetts Institute of Technology, 1921. Assistant Chief Engineer, Douglas Aircraft Co., Santa Monica, 1925-1935; Chief Engineer, 1935-. California Institute, 1929-

554 Moreno Avenue, Santa Monica

*On leave of absence, 1937-1938.

CHARLES FRANCIS RICHTER, PH.D.

Assistant Professor of Seismology

A.B., Stanford University, 1920; Ph.D., California Institute of Technology, 1928. Research Assistant in Seismology, Carnegie Institution of Washington, 1927-1937. Assistant Professor, California Institute, 1937-

1820 Kenneth Way

HUNTER ROUSE, DR.-ING.[1]

Assistant Professor of Fluid Mechanics

S.B., Massachusetts Institute of Technology, 1929; S.M., 1932; Dr.-Ing., Technische Hochschule, Karlsruhe, Germany, 1932. Massachusetts Institute of Technology Traveling Fellow in Hydraulics, 1929-1931; Assistant in Hydraulics, 1931-1933; Instructor in Civil Engineering, Columbia University, 1933-1936; Cooperative Laboratory, Soil Conservation Service, 1936-. California Institute, 1936-

1071 North Chester Avenue

BRUCE HORNBROOK SAGE, PH.D.

Assistant Professor of Chemical Engineering

B.S., New Mexico State College, 1929; M.S., California Institute of Technology, 1931; Ph.D., 1934. Teaching Fellow, California Institute, 1930-1934; Research Fellow, 1934-1935; Senior Fellow in Chemical Research, 1935-1937; Assistant Professor, 1937-

1410 La Solana Street, Altadena

ERNEST EDWIN SECHLER, PH.D.

Assistant Professor of Airplane Structures

B.S., California Institute, 1928; M.S., 1929; Ph.D., 1933. Assistant in Engineering, California Institute, 1928-1930; Instructor, 1930-1937; Assistant Professor, 1937-

2100 Dudley Street

ROGER STANTON, PH.D.

Assistant Professor of English Language and Literature

B.S., Colgate University, 1920; M.A., Princeton University, 1924; Ph.D., 1931. Instructor in English, Colorado College, 1924-1925. Instructor, California Institute, 1925-1931; Assistant Professor, 1931-

1672 Poppy Peak Drive

J. E. WALLACE STERLING, M.A.

Assistant Professor of History

B.A., University of Toronto, 1927; M.A., University of Alberta, 1930. Lecturer in History, Regina College, Saskatchewan, 1927-1928; Assistant in History, University of Alberta, 1928-1930; Research Assistant, Hoover War Library, Stanford University, 1930-1937; Research Associate, 1937; Instructor in History, Stanford University, 1935-1937. California Institute, 1937-

2650 Paloma Street

ERNEST HAYWOOD SWIFT, PH.D.

Assistant Professor of Analytical Chemistry

B.S. in Chemistry, University of Virginia, 1918; M.S., California Institute of Technology, 1920; Ph.D., 1924. Teaching Fellow, California Institute, 1919-1920; Instructor, 1920-1928; Assistant Professor, 1928-

3140 East California Street

EDWARD DUNSTER KREMERS, M.D.

Consulting Physician

M.D., University of Michigan, 1903; Graduate, Army Medical School, 1910. Lt.-Col. U. S. Army, Retired. California Institute, 1930-

2315 Mar Vista Avenue, Altadena

[1] Soil Conservation Service, Department of Agriculture.

HAROLD Z. MUSSELMAN, A.B.

Assistant Director of Physical Education and Manager of Athletics

A.B., Cornell College, 1920. Instructor in Science and Athletic Director, Sterling (Illinois) High School, 1920-1921. Instructor, California Institute, 1921-1935; Assistant Director, 1935-

824 East California Street

WILLIAM L. STANTON, B.A.

Physical Director

B.A., Dickinson College, 1903. Assistant Director of Physical Education, Pratt Institute, 1903-1904; Director of Athletics and Physical Education, Morristown School, 1905-1906; Professor of English and Director of Athletics, Hamilton Institute, 1906-1908; Director of Athletics, Pomona College, 1908-1916; Director of Athletics and Instructor in English and Dramatics, Occidental College, 1916-1917, 1919-1921. California Institute, 1921-

515 Manzanita Avenue, Sierra Madre

FRANCIS DASHWOOD BODE, PH.D.*

Instructor in Geology

B.S., California Institute of Technology, 1930; M.S., 1931; Ph.D., 1934. Assistant in Geology, California Institute, 1930-1931; Teaching Fellow, 1931-1934; Assistant Curator in Vertebrate Paleontology, 1934-1936; Instructor in Geology, 1936-

JAMES FREDERICK BONNER, PH.D.

Instructor in Plant Physiology

A.B., University of Utah, 1931; Ph.D., California Institute of Technology, 1934. National Research Fellow in Biology at Utrecht and Zürich, 1934-1935. Research Assistant, California Institute, 1935-1936; Instructor, 1936-

290 South Michigan Avenue

ROBERT B. COREY

Research Fellow
Associate of the Rockefeller Institute for Medical Research

B. Chem., University of Pittsburgh, 1919; Ph.D., Cornell University, 1924. Assistant in Inorganic Chemistry, Cornell, 1919-1922; Chemical Spectroscopy, 1922-1923; Instructor in Analytical Chemistry, 1923-1928; Assistant of the Rockefeller Institute for Medical Research, 1928-1930; Associate, 1930-. California Institute, 1937-

258 South Hudson Avenue

HARDIN CRAIG, JR., PH.D.

Instructor in History

B.A., Princeton University, 1929; M.A., Harvard University, 1931; Ph.D., 1937. Instructor in History, Hobart College, 1931-1933. California Institute, 1937-

211 South El Molino Avenue

ANTHONIE VAN HARREVELD, M.D.

Instructor in Physiology

B.A., Amsterdam University, 1925; M.A., 1928; M.D., 1929. Assistant in Physiology, Amsterdam University, 1926-1932; Chief Assistant in Physiology, Utrecht University, 1932-1934. Research Assistant, California Institute, 1934-1935; Instructor, 1935-

702 South Oak Knoll Avenue

*On leave of absence, 1937-38.

LINDSAY HELMHOLZ, PH.D.

Instructor in Chemistry

Ph.D., Johns Hopkins University, 1933. Research Fellow, California Institute, 1933-1934; National Research Fellow, 1934-1936; Instructor, 1936-

1659 Oakdale Street

ARTHUR THOMAS IPPEN, PH.D.

Instructor in Hydraulic Engineering

M.S., California Institute of Technology, 1935; Ph.D., 1936. Diplom-Ingenieur, Technische Hochschule, Aachen, 1931; Teaching and Research Assistant in Geodesy, Technischhe Hochschule, Aachen, 1932; German Exchange Fellow, State University of Iowa, 1932-1933; Teaching and Research Fellow, California Institute, 1934-1937; Instructor, 1937-

Dormitory

WALDEMAR ALEXANDER KLIKOFF, B.S.

Instructor in Aeronautics

B.S. in Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, 1923. Structural and Aerodynamic Analysis Engineer with several aircraft manufacturers, 1924-1934; Lecturer in Aerostatics (part time), University of Detroit, 1930-1932; Associate Aeronautical Engineer, Bureau of Air Commerce, 1937-. California Institute, 1934-

628 Tenth Street, Santa Monica

RUDOLPH M. LANGER, PH.D.

Senior Fellow in Astrophysical Research

Ph.D., California Institute of Technology, 1927. National Research Fellow in Physics, Bureau of Standards, 1927-1929; University of Berlin, 1929-1930; Senior Fellow in Astrophysical Research, 1935-

2415 Oswego Street

JOHN HAVILAND MAXSON, PH.D.

Instructor in Geology

B.S., California Institute, 1927; M.S., 1928; Ph.D., 1931. Assistant in Geology, California Institute, 1927-1928; Teaching Fellow, 1928-1931; Instructor, 1931-

JOHANNES VAN OVERBEEK, PH.D.

Instructor in Biology

B.Sc., University of Leyden, 1928; M.S., University of Utrecht, 1932; Ph.D., 1933. Assistant in Botany, University of Utrecht, 1933-1934. Research Assistant, California Institute, 1934-1937; Instructor, 1937-

863 North Sunset Boulevard, Arcadia

RAYMOND ALFRED PETERSON, PH.D.

Instructor in Geology

B.S., California Institute of Technology, 1931; Ph.D., 1935. California Institute, 1931-

623 South Lake Avenue

WILLIAM HAYWARD PICKERING, PH.D.

Instructor in History and Research Fellow in Physics

B.S., California Institute of Technology, 1932; M.S., 1933; Ph.D., 1936. Graduate Assistant and Teaching Fellow, California Institute, 1932-1936; Instructor, 1936-

426 South Michigan Avenue

W. CURTIS ROCKEFELLER, M.S.

Instructor in Meteorology and Mechanical Engineering

B.S., California Institute of Technology, 1932; M.S., 1934. Graduate Assistant and Teaching Fellow, California Institute, 1932-1936; Instructor, 1936-

1781 Oakdale Street

WILLIAM REES SEARS, B.AERO.E.

Instructor in Aeronautics

B. Aero. E., University of Minnesota, 1934. Assistant in Aeronautics, California Institute, 1934-1937; Instructor, 1937-

196 South Sierra Bonita Avenue

FRANCES HALSEY SPINING

Librarian

California Institute, 1914-

1067 North Catalina Avenue

DAVID LLOYD STEVENSON, M.A.

Instructor in English Language and Literature

A.B., University of California, 1933; M.A., 1935. Instructor in English, University of California, 1935; Lecturer, Cooper Institute, New York City, 1937. California Institute, 1937-

191 South Los Robles Avenue

JOHN DONOVAN STRONG, PH.D.

Senior Fellow in Astrophysical Research

A.B., University of Kansas, 1926; M.S., University of Michigan, 1928; Ph.D., 1930. National Research Fellow in Physics, California Institute, 1930-1932; Research Fellow in Astrophysics, 1932-1935; Senior Fellow in Research, 1935-

382 East California Street

JAMES HOLMES STURDIVANT, PH.D.[1]

Senior Fellow in Chemical Research

B.A., University of Texas, 1926; M.A., 1927; Ph.D., California Institute of Technology, 1930. Instructor in Mathematics, University of Texas, 1926-1927. Teaching Fellow, California Institute, 1927-1930; Research Fellow, 1930-1935; Senior Fellow in Research, 1935-

Athenæum

ALBERT TYLER, PH.D.

Instructor in Embryology

A.B., Columbia University, 1926; A.M., 1927; Ph.D., California Institute of Technology, 1929. National Research Fellow in Biology in Berlin and Naples, 1932-1933; California Institute, 1928-

1131 Lura Street

HOWELL NEWBOLD TYSON, B.S.

Instructor in Mechanical Engineering

B.S., Massachusetts Institute of Technology, 1920. Assistant Instructor in Thermodynamics, Massachusetts Institute of Technology, 1920-1921; Designer for Bureau of Power and Light, City of Los Angeles, 1921-1922; Managing Engineer, Industrial Engineering and Equipment Co., 1922-1929; Engineer, C. C. Moore & Co., 1929-1933. Instructor, California Institute, 1936-

505 South Wilson Avenue

NATHANIEL W. WILCOX, A.B.

Instructor in Engineering Drawing

A.B., Harvard University, 1917. California Institute, 1932-

369 South Lake Avenue

[1] Rockefeller Foundation Fund.

RESEARCH FELLOWS

VERNON LEROY BOLLMAN, PH.D.

Research Fellow in Physics

B.S. in E.E., University of Nebraska, 1931; M.S., 1933; Ph.D., California Institute of Technology, 1936. Instructor in Physics, Occidental College, 1936-. California Institute, 1933-

1585 Homewood Drive, Altadena

LEE REED BRANTLEY, PH.D.

Research Fellow in Physics

A.B., University of California at Los Angeles, 1927; M.S., California Institute of Technology, 1929; Ph.D., 1930. Instructor in Chemistry and Physics, Occidental College, 1930-1936; Assistant Professor, 1936-. California Institute, 1935-

412 South Chevy Chase Drive, Glendale

EDWIN R. BUCHMAN, DR. PHIL. NAT.

Research Fellow in Chemistry

Ch.E., Rensselaer Polytechnic Institute, 1922; S.M., Massachusetts Institute of Technology, 1925; Dr. Phil. Nat., University of Frankfurt, 1933. Columbia University, 1933-1935; Johns Hopkins University, 1936-1937; California Institute, 1937-

Athenæum

CHARLES DUBOIS CORYELL, PH.D.[1]

Research Fellow in Chemistry

B.S., California Institute of Technology, 1932; Ph.D., 1935. German-American Exchange Fellow, Münich, 1933-1934. California Institute, 1932-

2247 Prospect Street, Wilmar

GOTTFRIED DÄTWYLER, DR. ING.[2]

Research Fellow in Aeronautics

Mech. Eng., Eidgenössische Technische Hochschule, Zürich, 1929; Dr. Ing., 1934. California Institute, 1934-

1447 East Las Lunas Street

ALEXIS A. B. DEMBER, D.SC.[3]

Research Fellow in Physics

D.Sc., German University of Prague, 1935. Assistant in Physics, University of Istanbul, 1935-1936. California Institute, 1937-

490 Ellis Street

JOHN CHRISTOPHER DYKES, B.A., M.S.

Commonwealth Fund Fellow in Aeronautics

B.A., Cambridge University, 1936; M.S., California Institute, 1937. California Institute, 1936-

Athenæum

JAMES ENGLISH, JR., PH.D.

Lalor Foundation Fellow in Chemistry

B.A., Yale University, 1933; Ph.D., 1936. California Institute, 1936-

1295 San Pasqual Street

[1] Rockefeller Foundation Fund.
[2] Impact Research Fund.
[3] Agfa Ansco Fund.

WILLIAM ALFRED FOWLER, PH.D.

Research Fellow in Physics

B.Eng.Physics, Ohio State University, 1933; Ph.D., California Institute of Technology, 1936. California Institute, 1933-

Athenæum

ERWIN RUDOLF GAERTTNER, PH.D.

National Research Fellow in Physics

B.S., University of Denver, 1932; M.S., University of Michigan, 1933; Ph.D., University of Michigan, 1937. California Institute, 1937-

314 South Hill Avenue

GEORG HERRMANN MARTIN GOTTSCHEWSKI, D.PHIL.

International Research Fellow in Biology of the Rockefeller Foundation

D.Phil., University of Koenigsberg, Pr., 1932. International Research Fellow, Tihany, Hungary, 1933. Research Assistant, Kaiser Wilhelm Institut für Biologie, Berlin-Dahlem, 1934-. California Institute, 1936-

196 South Sierra Bonita Avenue

GEORGE CHARLESWORTH HAMPSON, D.PHIL.*

Commonwealth Fund Fellow in Chemistry

B.A., B.Sc., Oxford University, 1932; D.Phil., 1934. Ramsay Memorial Fellow, Oxford University, 1934-1936. California Institute, 1936-

Athenæum

FREDERICK RUDOLPH HIRSH, JR., PH.D.

Research Fellow in Physics

A.B., Cornell University, 1926; A.M., 1928; Ph.D., 1931. Graduate Assistant, Cornell, 1927-1931; Research Fellow, 1931-1937. California Institute, 1937-

1620 Casa Grande Street

PHILIP TRUMAN IVES, M.A.

Research Fellow in Biology

B.A., Amherst College, 1932; M.A., 1934; Rufus B. Kellogg University Fellow of Amherst College at the California Institute, 1934-

177 South Mentor Avenue

ULRICH JETTER

International Exchange Fellow in Physics

Technische Hochschule, Stuttgart, 1933-1937. California Institute, 1937-

JOSEF JEROME JOHNSON, PH.D.

Research Fellow in Astrophysics

B.S., California Institute of Technology, 1930; M.S., Ohio Wesleyan University, 1932; Ph.D., California Institute of Technology, 1935. California Institute, 1932-

1970 East California Street

LUIS E. KEMNITZER, PH.D.

Research Fellow in Geology

A.B., Stanford University, 1926; M.S., California Institute of Technology, 1933; Ph.D., 1937. California Institute, 1937-

2215 Hornet Road

*On leave of absence, Fall term, 1937.

HARRY ALLISTER KIRKPATRICK, PH.D.

Research Fellow in Physics

B.S., Occidental College, 1914; Ph.D., California Institute of Technology, 1931. Associate in Physics, University of California at Los Angeles, 1924-1928; Instructor in Physics, Occidental College, 1929-1930; Teaching Fellow in Physics, California Institute of Technology, 1930-1931; Assistant Professor of Physics, University of Hawaii, 1931-1935; Assistant Professor of Mathematics, Occidental College, 1935-1936; Assistant Professor of Physics and Acting Head of the Department, 1936-1937; Associate Professor of Physics and Head of Department, 1937-. California Institute, 1936-

1555 North Avenue Forty-Six, Los Angeles

PIO CHARLES KOLLER, PH.D., D.SC.

International Research Fellow in Biology of the Rockefeller Foundation

B.Sc., Budapest University, 1924; M.Sc., 1925; Ph.D., 1927; D.Sc., Edinburgh University, 1933. Lecturer in Cytogenetics, Institute of Animal Genetics, Edinburgh University, 1935-. California Institute, 1937-

404 South Mentor Avenue

SPIRO KYROPOULOS, PH.D.

Research Fellow in Physics

Ph.D., University of Leipzig, 1911. Assistant in Biology, University of Göttingen, 1912-1913; Assistant in Physical Chemistry, 1913-1925; Research Fellow in Fluid Mechanics and Assistant in Physics, 1928-1931. Habilitation, 1931; Privat-docent of Physical Technology, 1931-1935. California Institute, 1937-

2400 North Holliston Avenue

KENNETH MATHER, PH.D.

International Research Fellow in Biology of the Rockefeller Foundation

B.Sc., University of Manchester, 1931; Ph.D., University of London, 1933. Research Assistant in Genetics, Ministry of Agriculture and Fisheries, 1931-1934. Geneticist, Galton Laboratory, University College, London, 1934-. California Institute, 1937-

131 South Chester Avenue

DAVID P. MELLOR, M.SC.

Research Fellow in Chemistry

M.Sc., Tasmania, 1928; Lecturer in Chemistry, University of Sydney, Australia, 1929- (on leave of absence from University of Sydney for one year).

279 South Hudson Avenue

SETH HENRY NEDDERMEYER, PH.D.

Research Fellow in Physics

A.B., Stanford University, 1929; Ph.D., California Institute of Technology, 1935. California Institute, 1932-

963 East California Street

JOHN R. SCHULTZ, PH.D.

National Research Fellow in Paleontology

A.B., Northwestern University, 1931; M.S., 1933; Ph.D., California Institute of Technology, 1937. California Institute, 1937-

258 South Hudson Avenue

JACK SHERMAN, PH.D.[1]*

Research Fellow in Chemistry

B.S., University of California, 1929; Ph.D., California Institute of Technology, 1932. DuPont Fellow, 1930-1932; Research Fellow, 1932-1935; Department of Ceramics, Pennsylvania State College, 1936-1937; California Institute, 1937-

JOSHUA LAWRENCE SOSKE, PH.D.

Research Fellow in Geophysics

G.E., Colorado School of Mines, 1929; M.S., California Institute of Technology, 1932; Ph.D., 1935. California Institute, 1931-

1190 North Michigan Avenue

HANS STAUB, PH.D.

Fellow in Physics of the Institute of International Education

B.S., Zürich, Eidg. Tech. Hochschule, 1931; Ph.D., 1934. California Institute, 1937-

1069 San Pasqual Street

HAROLD DOUGLAS SPRINGALL, D.PHIL.*

Commonwealth Fund Fellow in Chemistry

B.A., Oxford University, 1933; B.Sc., 1934; D.Phil., 1936. California Institute, 1936-

Athenæum

HSUE-SHEN TSIEN, M.S.

National Tsing Hua University Fellow in Aeronautics

B.S. in M.E., Chiao-Tung University, 1934; M.S. in A.E., Massachusetts Institute of Technology, 1936. California Institute, 1936-

1134 Cordova Street

VITO AUGUST VANONI, M.S.

Research Fellow in Hydraulics[2]

B.S., California Institute of Technology, 1926; M.S., 1932. California Institute, 1932-. Project Manager, Cooperative Laboratory, Soil Conservation Service, 1935-

386 South Meridith Avenue

SIDNEY WEINBAUM, PH.D.[1]

Research Fellow in Chemistry

B.S., California Institute of Technology, 1924; Ph.D., 1933. California Institute, 1929-

325½ South Wilson Avenue

ROBERT W. WILSON

Research Fellow in Paleontology

B.S., California Institute of Technology, 1930; M.S., 1932; Ph.D., 1936. California Institute, 1937-

220 North Avenue 57, Highland Park

HUBERT J. YEARIAN, PH.D.

National Research Fellow in Physics

B.S., University of Oregon, 1927; M.S., 1929; Ph.D., Purdue University, 1934. Instructor in Physics, Purdue University, 1934-1936. California Institute, 1936-

1887 Monte Vista Street

*On leave of absence, Fall term, 1937.

[1] Molecular Structure Fund.

[2] Soil Conservation Service, Department of Agriculture.

J. PAUL YOUTZ, M.S.

Research Fellow in Physics

B.S., California Institute of Technology, 1917; M.S. in E.E., Union College, 1918; Specialist Course, General Electric Company, 1917-1919. With General Electric Company in Latin America and in Brazil, 1919-1932. California Institute, 1932-

1491 North Holliston Avenue

RESEARCH ASSISTANTS

GUSTAV ALBRECHT, M.A.[2]

Research Assistant in Chemistry

B.A., University of California at Los Angeles, 1935; M.A., 1936. California Institute, 1936-

1341 East Villa Street

GEORGE HAROLD ANDERSON, PH.D.

Curator in Physical Geology

A.B., Stanford University, 1917; A.M., 1920; Ph.D., California Institute of Technology, 1933. Instructor in Geology, University of Colorado, 1928-1929; Teaching Fellow in Geology, California Institute, 1929-1933; Research Fellow, 1933-1934; Curator, 1934-

2021 Santa Anita Avenue, Altadena

HUGH STEVENS BELL, A.B.

Research Assistant in Hydraulics[1]

A.B., Western Reserve University, 1922. With U. S. Indian Service, 1932-1935; in charge of Cooperative Field Laboratory, Soil Conservation Service, Mexican Springs, New Mexico, 1935-1937. California Institute, 1936-

1050 North Holliston Avenue

WILLIAM HAROLD BOWEN, M.S.

Research Assistant in Aeronautics

B.S., University of California, 1928; M.S., California Institute, 1932. California Institute, 1932-

2067 Paloma Street

SAMUEL J. BROADWELL, PH.D.

Research Assistant in Meteorology

B.S., California Institute of Technology, 1918; M.S., University of Chicago, 1920; Ph.D., California Institute of Technology, 1935. California Institute, 1937-

322 East Emerson Avenue, Monterey Park

NEPHI ALBERT CHRISTENSEN, M.S.

Research Assistant in Hydraulics[1]

B.S., Brigham Young University, 1925; B.S.C.E., University of Wisconsin, 1928; M.S., California Institute of Technology, 1934. Professor of Engineering, Ricks College, 1928-1933. California Institute, 1934-

119 South Temple Avenue, Temple City

[1] Soil Conservation Service, Department of Agriculture.
[2] Rockefeller Foundation Fund.

JACOB DUBNOFF, M.A.

Research Assistant in Biology

B.A., University of California at Los Angeles, 1930; M.A., University of California, 1933. Soil Chemist, Department of Agriculture, 1933; Research Biochemist, University of Kazan, U. S. S. R., 1934-1936. California Institute, 1936-

275 North Chester Avenue

EMORY L. ELLIS, PH.D.

Research Assistant in Biology

B.S., California Institute, 1930; M.S., 1932; Ph.D., 1934. Research Assistant in Biochemistry, California Institute, 1934-1935; Chemist, Food and Drug Administration, 1935-1936. California Institute, 1936-

432 North San Marino Avenue, San Gabriel

WALTER M. ELSASSER

Research Assistant in Meteorology

Ph.D., University of Göttingen, 1927. California Institute, 1937-

124 El Nido Avenue

DONALD FOLLAND, M.S.

Research Assistant in Physics

B.S., University of Utah, 1933; M.S., California Institute of Technology, 1936. California Institute, 1936-

177 South Mentor Avenue

EUSTACE L. FURLONG

Curator in Vertebrate Paleontology

Assistant in Paleontology, 1903-1910; Curator of Vertebrate Paleontology, University of California, 1915-1927. California Institute, 1927-

270 South Roosevelt Avenue

GEOFFREY KEIGHLEY, B.A.

Research Assistant in Biology

B.A., University of Toronto, 1926. California Institute, 1930-

237 Las Flores Drive

FRED DELBRIDGE KNOBLOCK, M.S.

Research Assistant in Aeronautics

B.Sc., University of Michigan, 1926; M.S., 1927. California Institute, 1935-

Dormitory

OSCAR CARL MAIER, M.S., Captain, U.S.A.

Research Assistant in Meteorology

Graduate United States Military Academy, 1925; Graduate Army Signal School, 1926; M.S., Yale University, 1931; M.S. in Meteorology, California Institute of Technology, 1936. California Institute, 1935-1936, 1937-

685 South Hudson Avenue

J. PAT O'NEILL, B.S.

Research Assistant in Hydraulics[1]

B.S., New Mexico State College, 1935. California Institute, 1935-

436 North Holliston Avenue

GEORGE HERMAN OTTO, S.B.

Research Assistant in Hydraulics[1]

S.B., University of Chicago, 1931. California Institute, 1935-

258 South Hudson Avenue

[1] Soil Conservation Service, Department of Agriculture.

KENNETH JAMES PALMER, B.S.[2]

Research Assistant in Chemistry

B.S., University of California, 1935; Teaching Fellow, California Institute, 1935-1937.

285 South Lake Avenue

GLEN PETERSON, M.S.

Research Assistant in Physics

B.S., Brigham Young University, 1929; M.S., California Institute of Technology, 1936. Member of Technical Staff, Bell Telephone Laboratories, 1929-1934. California Institute, 1936-

281 South Chester Avenue

WILLIS PARKISON POPENOE, PH.D.

Curator in Invertebrate Paleontology

B.S., George Washington University, 1930; M.S., California Institute of Technology, 1933; Ph.D., 1936. California Institute, 1930-

446 South Hudson Avenue

HAROLD FRANK RICHARDS, M.S.

Research Assistant in Hydraulics[1]

B.S., California Institute of Technology, 1926; M.S., 1935. Engineer, American Liquid Meter Company, 1926-1934. California Institute, 1935-

771 East Fourteenth Street, Los Angeles

EDWIN M. RICHARDSON, B.S.

Research Assistant in Chemistry

B.S. in Chemistry, Johns Hopkins University, 1933; California Institute, 1937-

304 South Mentor Avenue

JOHN L. RIDGWAY

Scientific Illustrator in Vertebrate Paleontology

Chief Illustrator, United States Geological Survey, 1898-1920; Artist, Carnegie Institution of Washington, 1910-. California Institute, 1929-

635 North Pacific Avenue, Glendale

FRANK J. ROSS, B.A.

Research Assistant in Biology

B.A., University of California at Los Angeles, 1932; Teaching and Research Assistant, 1932-1937. California Institute, 1937-

113 North Olive Avenue, Burbank

FLOYD L. HANES, D.O.

Physical Trainer

D.O., College of Osteopathic Physicians and Surgeons, Los Angeles, 1921. California Institute, 1923-

2115 Layton Avenue

AUDRE L. STONG, M.S.

Director of Music

B.S., University of Southern California, 1932; M.S., 1934. California Institute, 1931-

2051 Jefferson Drive, Altadena

---

[1] Soil Conservation Service, Department of Agriculture.
[2] Rockefeller Foundation Fund.

TEACHING FELLOWS AND GRADUATE ASSISTANTS

FREDERICK TAYLOR ADDICOTT . . . . . Biology
A.B., Stanford University, 1934

HUBERT ANDREW ARNOLD . . . . . Mathematics
A.B., University of Nebraska, 1933

LEE ARNOLD . . . . . Aeronautics
B.A., Duke University, 1937

IRVING LOUIS ASHKENAS . . . . . Mechanical Engineering
B.S., California Institute, 1937

JOHN SHOICHI ATSUMI . . . . . Aeronautics
B.S., University of Southern California, 1932; M.S.E., University of Michigan, 1935

HOWLAND HASKELL BAILEY . . . . . Physics
A.B., Haverford College, 1932

LAWRENCE WILLIAM BALDWIN . . . . . Electrical Engineering
B.S., California Institute, 1935; M.S., 1937

ROBERT ADOLPH BECKER . . . . . Physics
B.S., College of Puget Sound, 1935; M.S., California Institute, 1937

CARROL MENEFEE BEESON . . . . . Chemistry
A.B., University of California at Los Angeles, 1935

IRVING BERLER . . . . . Aeronautics
B.S., New York University, 1936; M.S., California Institute, 1937

JOHN ARTHUR BONELL, JR. . . . . Civil Engineering
B.S. in C.E., South Dakota State College, 1936

DAVID MAHLON BONNER . . . . . Biology
B.A., University of Utah, 1936

EUGENE MITTELL BRUNNER . . . . . Physics
B.S., California Institute, 1933; M.S., 1934

ROBERT PEARNE BRYSON . . . . . Geology
A.B., University of California at Los Angeles, 1934; M.S., California Institute, 1937

ROLAND ANTHONY BUDENHOLZER . . . . . Mechanical Engineering
B.S., New Mexico State College, 1935; M.S., California Institute, 1937

EMIL JOSEPH BURCIK . . . . . Chemistry
B.S., Carnegie Institute of Technology, 1937

WESLEY THEODORE BUTTERWORTH . . . . . Aeronautics
B.S., Northwestern University, 1936; M.S., California Institute, 1937

RALPH BYRNE, JR. . . . . Civil Engineering
B.S., California Institute, 1933; M.S., 1934

ALEXANDER CRANE CHARTERS . . . . . Aeronautics
B.S., California Institute, 1934; M.S., 1936

DONALD KENNEDY COLES . . . . . Physics
B.S., Illinois Wesleyan University, 1932; M.S., California Institute, 1937

H. DONALD CURRY . . . . . Geology
B.A., Iowa State University, 1929; M.S., 1930

JAMES WALLACE DAILY . . . . . Mechanical Engineering
A.B., Stanford University, 1935; M.S., California Institute, 1937

LEVERETT DAVIS, JR.[1] . . . . . Physics
B.S., Oregon State College, 1936
[2]Drake Fellow.

ALBERT ORNO DEKKER . . . . . Chemistry and the Humanities
B.S., California Institute, 1935

ROBERT J. DERY . . . . . Chemistry
B.S., University of Oregon, 1931

MELVILLE ARTHUR DIKE . . . . . Mechanical Engineering
Resident Associate of Fleming House
B.S., Northwestern University, 1936; M.S., California Institute, 1937

ROBERT PALMER DILWORTH . . . . . Mathematics
B.S., California Institute, 1936

EDWARD BUSHNELL DOLL . . . . . Electrical Engineering
B.S., California Institute, 1934; M.S., 1935

ARTHUR BERNARD DRESCHER . . . . . Geology
B.S., South Dakota School of Mines, 1937

ROBERT MARX DREYER[2] . . . . . Geology
B.S., Northwestern University, 1934; M.S., California Institute, 1937

LOUIS GERHARDUS DUNN . . . . . Aeronautics
B.S., California Institute, 1936; M.S., 1937

ANTHONY EASTON . . . . . Physics
B.S., University of Washington, 1932; M.S., California Institute, 1937

NORMAN ELLIOTT . . . . . Chemistry
B.A., Oberlin College, 1929; M.A., 1930

HARRY DEAN EVANS[3] . . . . . Chemistry
B.S., University of Illinois, 1937

EUGENE HENDERSON EYSTER[4] . . . . . Chemistry
B.Ch., University of Minnesota, 1935

IRWIN STANLEY FEUER . . . . . Mechanical Engineering
B.S., California Institute, 1937

PAUL CHARLES FINE[4] . . . . . Physics
B.A., University of Oklahoma, 1935; M.S., California Institute, 1936

MARK GARDNER FOSTER . . . . . Physics
A.B., Miami University, 1935

SIDNEY WALTER FOX . . . . . Biology
A.B., University of California at Los Angeles, 1933

CLIFFORD SYMES GARNER . . . . . Chemistry
B.S., California Institute, 1935

---

[1]Drake Fellow.
[2]Blacker Fellow.
[3]American Petroleum Institute.
[4]Henry Laws Fellow.

CHARLES F. GATES . . . . . Electrical Engineering
B.S., California Institute, 1937

WILLIAM HOLT GLENN, JR. . . . . Mathematics
A.B., University of California at Los Angeles, 1935; M.A., 1937

KENNETH JUSTIN GOERING . . . . . Chemistry
B.S., Montana State College, 1936

CALVIN ANDREW GONGWER . . . . . Mechanical Engineering
B.S. in M.E., Columbia University, 1937

WENDELL OLIVER GOULD[1] . . . . . Physics
B.S. and M.S., Washington State College, 1930

LEVAN GRIFFIS . . . . . Civil Engineering
B.S., California Institute, 1937

ELLSWORTH EUGENE GULLEKSON[2] . . . . . Chemistry
B.S., University of North Dakota, 1937

NEWMAN ARNOLD HALL . . . . . Mathematics
A.B., Marietta College, 1934

ARTHUR ELLIOTT HARRISON[3] . . . . . Electrical Engineering
B.S., University of California, 1936; M.S., California Institute, 1937

JOHN BURTON HATCHER[5] . . . . . Chemistry
B.S., California Institute, 1937

ROBERT GEORGE HELFER . . . . . Biology
B.S., Baldwin-Wallace College, 1936

PAUL C. HENSHAW . . . . . Geology
A.B., Harvard College, 1936

FRANKLIN ROSS HEPNER . . . . . Chemistry
A.B., University of Wyoming, 1937

BRUCE LATHAN HICKS[6] . . . . . Physics
B.S., California Institute, 1936; M.S., 1937

JOHN FRANCIS HINDS . . . . . Physics
B.A., Queen's University, 1935; M.A., 1936

ISYDORE HLYNKA . . . . . Biology
B.Sc., University of Alberta, 1935; M.Sc., 1937

BENJAMIN HOLZMAN . . . . . Meteorology
B.S., California Institute, 1931; M.S., 1933

RICHARD H. HOPPER[7] . . . . . Geology
A.B., University of California at Los Angeles, 1935; M.A., 1936

NORMAN HAROLD HOROWITZ . . . . . Biology
B.S., University of Pittsburgh, 1936

---

[1] Agfa Ansco Fund.
[2] Asphalt Institute.
[5] Union Petroleum Production Fellowship.
[6] Bridge Fellow.
[7] Blacker Fellow.
[8] Drake Fellow.

WALTER LAVERN HOWLAND . . . . . Aeronautics
B.S., California Institute, 1934; M.S., 1935 and 1936

ROBERT BECK HOY . . . . . Geology
B.S., Lafayette College, 1937

RICHARD HENRY JAHNS[4] . . . . . Geology
B.S., California Institute, 1935; M.S., Northwestern University, 1937

STEPHEN JENNINGS . . . . . Physics
B.S., Trinity College, 1936

ROBERT VOSE LANGMUIR[2] . . . . . Physics
A.B., Harvard College, 1935

JOSEPH PIERRE LASALLE . . . . . Physics
B.S., Louisiana State University, 1937

THOMAS LAURITSEN[2] . . . . . Physics
B.S., California Institute, 1936

HENRI ARTHUR LÉVY . . . . . Chemistry
B.S., California Institute, 1935

ALBERT EATON LOMBARD, JR.[5] . . . . . Aeronautics and Civil Engineering
B.S., California Institute, 1928; M.S., 1929

JAMES ELLIS LUVALLE . . . . . Chemistry
B.S., University of California at Los Angeles, 1936; M.A., 1937

ROBERT HARLAN MACKNIGHT . . . . . Biology
B.A., Columbia College, 1936

DONALD C. MACPHAIL . . . . . Mechanical Engineering
B.A.Sc., University of British Columbia, 1937

FRANK JOSEPH MALINA . . . . . Aeronautics
B.S., Agricultural and Mechanical College of Texas, 1934; M.S., California Institute, 1935 and 1936

GEORGE HEINEMANN MARMONT . . . . . Biology
B.S., California Institute, 1934

GILBERT DONALD MCCANN . . . . . Electrical Engineering
B.S., California Institute, 1934; M.S., 1935

ROBERT ALFRED MCINTYRE[3] . . . . . Mechanical Engineering
B.S., California Institute, 1936

WILLIAM BURDETTE MCLEAN[2] . . . . . Physics
B.S., California Institute, 1936; M.S., 1937

CHARLES WILLIAM MCLEISH . . . . . Electrical Engineering
B.A.Sc., University of British Columbia, 1937

ROBERT CHARLES MCMASTER . . . . . Electrical Engineering
B.S. in E.E., Carnegie Institute of Technology, 1936

[1] Elizabeth Thompson Stone Scholar.
[2] Henry Laws Fellow.
[3] Shell Oil Company Fellowship.
[4] Drake Fellow.
[5] Caroline W. Dobbins Fellow.

GEORGE ROLLAND MELLINGER . . . . . Aeronautics
Resident Associate of Ricketts House
B.A., Drake University, 1936; M.S., California Institute, 1937

EDWARD CLOPTON MEREDITH . . . . . Meteorology
B.S. in C.E., University of Alabama, 1928

DWIGHT MILLER . . . . . Biology
B.A., Whittier College, 1937

PARK HAYS MILLER, JR. . . . . Physics
B.S., Haverford College, 1936

WALTER LEON MOORE . . . . . Civil Engineering
B.S., California Institute, 1937

DONALD CHESTER NELLIS[1] . . . . . Chemistry
B.S., California Institute, 1937

DANIEL ALEXANDER OKUN . . . . . Civil Engineering
B.S. in C.E., Cooper Union Institute of Technology, 1937

BERNARD MORE OLIVER . . . . . Electrical Engineering
B.A., Stanford University, 1935; M.S., California Institute, 1936

GUY CLIFTON OMER, JR. . . . . Physics
B.S. in E.E., University of Kansas, 1936; M.S., 1937

FRANK OPPENHEIMER . . . . . Physics
B.A., Johns Hopkins University, 1933

DARRELL WAYNE OSBORNE[2] . . . . . Chemistry
A.B., University of California at Los Angeles, 1935

SIMON PASTERNACK[3] . . . . . Physics
B.S., University of Alberta, 1935

DANIEL CHAPIN PEASE . . . . . Biology
B.A., Yale University, 1936

FRANCIS HOWARD REXROAD . . . . . Chemistry
B.A., Marietta College, 1937

LEWIS BENNING RUMPH, JR. . . . . Aeronautics
B.S., Georgia School of Technology, 1933

ROBERT SORG SCHAIRER . . . . . Aeronautics
B.S., Swarthmore College, 1936; M.S., California Institute, 1937

VERNER FREDERICK HENRY SCHOMAKER . . . . . Chemistry
B.S., University of Nebraska, 1934; M.S., 1935

JACK WILLIAM SCHWARTZ . . . . . Civil Engineering
B.S., California Institute, 1935; M.S., 1936

HERBERT BARNETT SHAPIRO . . . . . Mechanical Engineering
B.S., California Institute, 1936; M.S., 1937

MAURICE SKLAR . . . . . Geology
B.S., California Institute, 1936

[1] American Petroleum Institute.
[2] Elizabeth Thompson Stone Scholar.
[3] Caroline W. Dobbins Fellow.

APOLLO MILTON OLEN SMITH . . . . . Aeronautics
B.S., California Institute, 1936; M.S., 1937

JACK CARLTON SMITH . . . . . Physics
B. of Eng. Phys., Ohio State University, 1935; M.S., 1936

WILBUR FISHER SNELLING . . . . . Mechanical Engineering
B.S., California Institute, 1937

WILLIAM EUGENE SNOW . . . . . Geology
B.A.Sc., University of British Columbia, 1935; M.A.Sc., 1936

WILLIAM EDWARDS STEPHENS[1] . . . . . Physics
B.A., Washington University, 1932; M.S., 1934

HOMER JOSEPH STEWART . . . . . Aeronautics
B.Aero.E., University of Minnesota, 1936

WILLIAM SHELDON STEWART . . . . . Biology
B.A., University of California at Los Angeles, 1936; M.A., 1937

ARTHUR JAMES STOSICK[2] . . . . . Chemistry
B.S., University of Wisconsin, 1936

JOHN FREDRICK STREIB, JR.[5] . . . . . Physics
B.S., California Institute, 1936

MARTIN SUMMERFIELD . . . . . Physics
B.S., Brooklyn College, 1936; M.S., California Institute, 1937

DONALD STINSON TAYLOR[3] . . . . . Chemistry
B.A., Linfield College, 1935

HODGE SCOTT TAYLOR, JR.[3] . . . . . Chemistry
B.S., University of Illinois, 1937

CHARLES HARD TOWNES . . . . . Physics
B.A. and B.S., Furman University, 1935; M.A., Drake University, 1936

ROBERT DAWSON TOWNSEND, JR.[4] . . . . . Mechanical Engineering
B.S., California Institute, 1937

ANGUS CAMPBELL TREGIDGA[5] . . . . . Physics
B.A., University of British Columbia, 1932; B.App.Sc., 1933; M.A., 1935

GEORGE TSUBOTA . . . . . Aeronautics
B.S., California Institute, 1937

JAY BOREAS VAN DER WERFF . . . . . Mechanical Engineering
B.S., California Institute, 1937

DELBERT GEORGE VAN ORNUM . . . . . Meteorology
B.A., University of Washington, 1936

JOSEPH ANTHONY VARGUS, JR.[6] . . . . . Physics
B.A., Amherst College, 1934; B.A., Cambridge University, 1936

WARREN ORVAL WAGNER . . . . . Civil Engineering
B.S., State College of Washington, 1934; M.S., University of Michigan, 1936

---

[1] High Potential Radiation Research Fund.
[2] Elizabeth Thompson Stone Scholar.
[3] The Standard Oil Company of California Technical Fellowship.
[4] Rare Metals Research Fellowship.
[5] Caroline W. Dobbins Fellow.
[6] Cosmic Ray Fund.

KENICHI WATANABE[1] . . . . . Physics
B.S., California Institute, 1936

JOHN LEYDEN WEBB . . . . . Biology
B.S., California Institute, 1936

JOHN CAWSE WELLS . . . . . Geology
B.S., University of Idaho, 1936

WILLIAM OWEN WETMORE[2] . . . . . Mechanical Engineering
B.S., California Institute, 1937

THOMAS WIANCKO . . . . . Physics
B.S., University of Oklahoma, 1937

JOHN SHEARON WIGGINS[1] . . . . . Physics
A.B., Earlham College, 1936

HARRY DAIRD BRUCE WILSON . . . . . Geology
B.S., University of Manitoba, 1936

JOHN NORTON WILSON . . . . . Chemistry
B.A., University of British Columbia, 1934; M.A., 1936

SAUL WINSTEIN . . . . . Chemistry
A.B., University of California at Los Angeles, 1934; M.A., 1935

LOUVAN ELBERT WOOD . . . . . Meteorology
B.Sc., Alma College, 1929; M.S., California Institute, 1935

FREDERICK HAMILTON WRIGHT . . . . . Physics
A.B., Haverford College, 1934

MAX WYMAN . . . . . Mathematics
B.S., University of Alberta, 1937

LUKE CHIA-LIU YUAN . . . . . Physics
B.S., Yenching University, 1932; M.S., 1934

LLOYD ROBERT ZUMWALT . . . . . Chemistry
B.S., University of California, 1936

[1] Caroline W. Dobbins Fellow.
[2] Rare Metals Research Fellowship.

STAFF OF INSTRUCTION AND RESEARCH SUMMARY

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

ROBERT A. MILLIKAN, *Chairman*

PROFESSORS

HARRY BATEMAN . . . . . Mathematics, Theoretical Physics, Aeronautics
ERIC T. BELL . . . . . Mathematics
IRA S. BOWEN . . . . . Physics
PAUL S. EPSTEIN . . . . . Theoretical Physics
WILLIAM V. HOUSTON . . . . . Physics
CHARLES C. LAURITSEN . . . . . Physics
ROBERT A. MILLIKAN . . . . . Physics
SEELEY G. MUDD . . . . . X-Ray Therapy
J. ROBERT OPPENHEIMER . . . . . Theoretical Physics
ROYAL W. SORENSEN . . . . . Electrical Engineering
RICHARD C. TOLMAN . . . . . Physical Chemistry, Mathematical Physics
HARRY C. VAN BUSKIRK . . . . . Mathematics
EARNEST C. WATSON . . . . . Physics

RESEARCH ASSOCIATES

DINSMORE ALTER . . . . . Statistics
SAMUEL J. BARNETT . . . . . Physics
HENRI COUTARD . . . . . Radiology
JESSE W. M. DUMOND . . . . . Physics

ASSOCIATE PROFESSORS

CARL D. ANDERSON . . . . . Physics
ALEXANDER GOETZ . . . . . Physics
FREDERICK C. LINDVALL . . . . . Electrical Engineering
S. STUART MACKEOWN . . . . . Electrical Engineering
ARISTOTLE D. MICHAL . . . . . Mathematics
GENNADY W. POTAPENKO . . . . . Physics
WILLIAM R. SMYTHE . . . . . Physics
MORGAN WARD . . . . . Mathematics
LUTHER E. WEAR . . . . . Mathematics
FRITZ ZWICKY . . . . . Theoretical Physics

ASSISTANT PROFESSORS

WILLIAM N. BIRCHBY . . . . . Mathematics
CLYDE K. EMERY . . . . . X-Ray Therapy
LEO LEVI . . . . . X-Ray Therapy
FRANCIS W. MAXSTADT . . . . . Electrical Engineering
H. VICTOR NEHER . . . . . Physics

NATIONAL RESEARCH FELLOWS IN PHYSICS

ERWIN R. GAERTTNER
HUBERT J. YEARIAN

RESEARCH FELLOWS IN PHYSICS

VERNE L. BOLLMAN
L. REED BRANTLEY
ALEXIS DEMBER[4]
WILLIAM A. FOWLER[2]
FREDERICK R. HIRSH, JR.
HARRY KIRKPATRICK
SPIRO KYROPOULOS
SETH H. NEDDERMEYER
WILLIAM H. PICKERING
J. PAUL YOUTZ

FELLOW OF THE INSTITUTE OF INTERNATIONAL EDUCATION

HANS STAUB . . . . . Physics

INTERNATIONAL EXCHANGE FELLOW

ULRICH JETTER . . . . . Physics

RESEARCH ASSISTANTS

DONALD FOLLAND . . . . . Physics
GLEN PETERSON . . . . . Physics

TEACHING FELLOWS AND ASSISTANTS

HUBERT ARNOLD
HOWLAND H. BAILEY
LAWRENCE W. BALDWIN
ROBERT A. BECKER
EUGENE BRUNNER
DONALD K. COLES
LEVERETT DAVIS, JR.[6]
ROBERT P. DILWORTH
EDWARD B. DOLL
ANTHONY EASTON
PAUL C. FINE[1]
MARK G. FOSTER
CHARLES F. GATES
WILLIAM H. GLENN, JR.
WENDELL O. GOULD[4]
NEWMAN A. HALL
ARTHUR E. HARRISON[6]
BRUCE L. HICKS[7]
JOHN F. HINDS
STEPHEN JENNINGS
ROBERT V. LANGMUIR[1]
JOSEPH P. LASALLE
THOMAS LAURITSEN[1]
GILBERT D. MCCANN
WILLIAM B. MCLEAN[1]
CHARLES W. MCLEISH
ROBERT C. MCMASTER
PARK H. MILLER, JR.
BERNARD M. OLIVER
GUY C. OMER, JR.
FRANK OPPENHEIMER
SIMON PASTERNACK[3]
JACK C. SMITH
WILLIAM E. STEPHENS[2]
JOHN F. STREIB, JR.[3]
MARTIN SUMMERFIELD
CHARLES H. TOWNES
ANGUS C. TREGIDGA[3]
JOSEPH A. VARGUS, JR.[5]
KENICHI WATANABE[3]
THOMAS WIANCKO
JOHN S. WIGGINS[3]
FREDERICK H. WRIGHT
MAX WYMAN
LUKE C. L. YUAN

[1] Henry Laws Fellow.
[2] High Potential Radiation Research Fund.
[3] Caroline W. Dobbins Fellow.
[4] Agfa Ansco Fund.
[5] Cosmic Ray Fund.
[6] Drake Fellow.
[7] Bridge Fellow.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

LINUS PAULING, *Chairman*

PROFESSORS

STUART J. BATES . . . . . Physical Chemistry
JAMES E. BELL . . . . . Chemistry
WILLIAM N. LACEY . . . . . Chemical Engineering
LINUS PAULING[1] . . . . . Chemistry
ALEXANDER R. TODD (Visiting Lecturer) . . . . . Organic Chemistry
RICHARD C. TOLMAN . . . . . Physical Chemistry, Mathematical Physics

ASSOCIATE PROFESSORS

ROSCOE G. DICKINSON . . . . . Physical Chemistry
HOWARD J. LUCAS . . . . . Organic Chemistry
DON M. YOST . . . . . Inorganic Chemistry

RESEARCH ASSOCIATE

JOSEPH B. KOEPFLI . . . . . Chemistry

ASSISTANT PROFESSORS

RICHARD M. BADGER . . . . . Chemistry
ARNOLD O. BECKMAN . . . . . Chemistry
CARL NIEMANN[6] . . . . . Organic Chemistry
BRUCE H. SAGE . . . . . Chemical Engineering
ERNEST H. SWIFT . . . . . Analytical Chemistry

SENIOR FELLOW IN RESEARCH

JAMES H. STURDIVANT[2]

INSTRUCTOR

LINDSAY HELMHOLZ . . . . . Chemistry

LALOR FOUNDATION FELLOW

JAMES ENGLISH, JR.

RESEARCH FELLOWS

EDWIN R. BUCHMAN
ROBERT B. COREY[3]
CHARLES D. CORYELL[2]
DAVID P. MELLOR[4]
JACK SHERMAN[5]
SIDNEY WEINBAUM[5]

[1] On leave of absence, Fall term, 1937.
[2] Rockefeller Foundation Fund.
[3] Associate of Rockefeller Institute of Medical Research.
[4] Lecturer in Chemistry, University of Sydney.
[5] Molecular Structure Fund.
[6] On leave of absence, 1937-38.

COMMONWEALTH FUND FELLOWS

GEORGE C. HAMPSON HAROLD D. SPRINGALL

RESEARCH ASSISTANTS

GUSTAV ALBRECHT[1] KENNETH J. PALMER[1]

EDWIN M. RICHARDSON

TEACHING FELLOWS AND ASSISTANTS

CARROL M. BEESON
EMIL J. BURCIK
ROBERT J. DERY
NORMAN ELLIOTT
HARRY D. EVANS[4]
EUGENE H. EYSTER[3]
CLIFFORD S. GARNER
KENNETH J. GOERING
ELLSWORTH E. GULLEKSON[2]
JOHN B. HATCHER[6]
FRANKLIN R. HEPNER
HENRI A. LÉVY
JAMES E. LUVALLE
DONALD C. NELLIS[4]
DARRELL W. OSBORNE[5]
F. HOWARD REXROAD
VERNER F. H. SCHOMAKER
ARTHUR J. STOSICK[5]
DONALD S. TAYLOR
HODGE S. TAYLOR, JR.[7]
J. NORTON WILSON
SAUL WINSTEIN
LLOYD R. ZUMWALT

[1] Rockefeller Foundation Fund.
[2] The Asphalt Institute.
[3] Henry Laws Fellow.
[4] American Petroleum Institute.
[5] Elizabeth Thompson Stone Scholar.
[6] Union Petroleum Production Research Fellowship.
[7] Standard Oil Company of California Technical Fellowship.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING

FRANKLIN THOMAS, *Chairman*

PROFESSORS

HARRY BATEMAN . . . . . Mathematics, Theoretical Physics, Aeronautics
W. HOWARD CLAPP . . . . . Mechanism and Machine Design
ROBERT L. DAUGHERTY . . . . . Mechanical and Hydraulic Engineering
FREDERIC W. HINRICHS, JR. . . . . Mechanics
THEODORE VON KÁRMÁN . . . . . Aeronautics
R. R. MARTEL . . . . . Structural Engineering
FRANKLIN THOMAS . . . . . Civil Engineering

ASSOCIATE

CARL C. THOMAS . . . . . Engineering Research

ASSOCIATE PROFESSORS

ARTHUR L. KLEIN . . . . . Aeronautics
ROBERT T KNAPP . . . . . Hydraulic Engineering
WILLIAM W. MICHAEL . . . . . Civil Engineering
CLARK B. MILLIKAN . . . . . Aeronautics

ASSISTANT PROFESSORS

DONALD S. CLARK . . . . . Mechanical Engineering
FRED J. CONVERSE . . . . . Civil Engineering
IRVING P. KRICK . . . . . Meteorology
ARTHUR E. RAYMOND . . . . . Aeronautics
HUNTER ROUSE . . . . . Fluid Mechanics[1]
ERNEST E. SECHLER . . . . . Airplane Structures

INSTRUCTORS

ARTHUR T. IPPEN . . . . . Hydraulic Engineering
W. A. KLIKOFF . . . . . Aeronautics
WILLIAM C. ROCKEFELLER . . . . . Meteorology and Mechanical Engineering
WILLIAM R. SEARS . . . . . Aeronautics
HOWELL N. TYSON . . . . . Mechanical Engineering
NATHANIEL W. WILCOX . . . . . Engineering Drawing

RESEARCH FELLOWS

GOTTFRIED DÄTWYLER . . . . . Aeronautics[2]
VITO A. VANONI . . . . . Hydraulics[1]

[1] Soil Conservation Service, Department of Agriculture.
[2] Impact Research Fund.

COMMONWEALTH FUND FELLOW

JOHN C. DYKES . . . . . Aeronautics

NATIONAL TSING HUA UNIVERSITY FELLOW

HSUE-SHEN TSIEN . . . . . Aeronautics

RESEARCH ASSISTANTS

HUGH S. BELL[1] . . . . . Hydraulics
WILLIAM H. BOWEN . . . . . Aeronautics
SAMUEL J. BROADWELL . . . . . Meteorology
N. ALBERT CHRISTENSEN[1] . . . . . Hydraulics
WALTER M. ELSASSER . . . . . Meteorology
FREDERICK D. KNOBLOCK . . . . . Aeronautics
OSCAR C. MAIER . . . . . Meteorology
J. PAT O'NEILL[1] . . . . . Hydraulics
GEORGE H. OTTO[1] . . . . . Hydraulics
HAROLD F. RICHARDS[1] . . . . . Hydraulics

TEACHING FELLOWS AND ASSISTANTS

LEE ARNOLD
IRVING L. ASHKENAS
JOHN S. ATSUMI
IRVING BERLER
JOHN A. BONELL, JR.
ROLAND A. BUDENHOLZER
WESLEY T. BUTTERWORTH
RALPH BYRNE, JR.
ALEXANDER C. CHARTERS
JAMES W. DAILY
MELVILLE A. DIKE
LOUIS G. DUNN
I. STANLEY FEUER
CALVIN A. GONGWER
LEVAN GRIFFIS
BENJAMIN HOLZMAN
WALTER L. HOWLAND
ALBERT E. LOMBARD, JR.[4]
DONALD C. MACPHAIL
FRANK J. MALINA
ROBERT A. MCINTYRE[2]
GEORGE R. MELLINGER
EDWARD C. MEREDITH
WALTER L. MOORE
DANIEL A. OKUN
LEWIS B. RUMPH, JR.
ROBERT S. SCHAIRER
JACK W. SCHWARTZ
HERBERT B. SHAPIRO
APOLLO SMITH
WILBUR F. SNELLING
HOMER J. STEWART
ROBERT D. TOWNSEND, JR.[3]
GEORGE TSUBOTA
JAY B. VAN DER WERFF
DELBERT G. VAN ORNUM
WARREN O. WAGNER
WILLIAM O. WETMORE[3]
LOUVAN E. WOOD

[1] Soil Conservation Service, Department of Agriculture.
[2] Shell Oil Co. Fellowship.
[3] Rare Metals Research Fellowship.
[4] Caroline W. Dobbins Fellow.

DIVISION OF THE GEOLOGICAL SCIENCES

J. P. BUWALDA, Chairman

PROFESSORS

J. P. BUWALDA . . . . . Geology
BENO GUTENBERG . . . . . Geophysics
CHESTER STOCK . . . . . Paleontology

RESEARCH ASSOCIATES

ROBERT T. MOORE . . . . . Vertebrate Zoology
HARRY O. WOOD . . . . . Seismology

ASSOCIATE PROFESSORS

HUGO BENIOFF . . . . . Seismology
IAN CAMPBELL . . . . . Petrology

ASSISTANT PROFESSORS

HORACE J. FRASER . . . . . Mineralogy and Mineragraphy
CHARLES F. RICHTER . . . . . Seismology

INSTRUCTORS

FRANCIS D. BODE . . . . . Geology[2]
JOHN H. MAXSON . . . . . Geology
RAYMOND A. PETERSON . . . . . Geology

CURATORS

GEORGE H. ANDERSON . . . . . Geology
EUSTACE L. FURLONG . . . . . Vertebrate Paleontology
WILLIS P. POPENOE . . . . . Invertebrate Paleontology

SCIENTIFIC ILLUSTRATOR

JOHN L. RIDGWAY

NATIONAL RESEARCH FELLOW

JOHN R. SCHULTZ . . . . . Paleontology

RESEARCH FELLOWS

LUIS E. KEMNITZER . . . . . Geology
JOSHUA L. SOSKE . . . . . Geophysics
ROBERT W. WILSON . . . . . Paleontology

TEACHING FELLOWS AND ASSISTANTS

ROBERT P. BRYSON
H. DONALD CURRY
ARTHUR B. DRESCHER
ROBERT M. DREYER[1]
PAUL C. HENSHAW
RICHARD H. HOPPER[1]
ROBERT B. HOY
RICHARD H. JAHNS[3]
MAURICE SKLAR
WILLIAM E. SNOW
JOHN C. WELLS
H. D. BRUCE WILSON

[1] Blacker Fellow.
[2] On leave of absence, 1937-1938.
[3] Drake Fellow.

DIVISION OF BIOLOGY

THOMAS HUNT MORGAN, *Chairman*

PROFESSORS

HENRY BORSOOK . . . . . Biochemistry
THEODOSIUS DOBZHANSKY . . . . . Genetics
THOMAS HUNT MORGAN . . . . . Biology
ALFRED H. STURTEVANT . . . . . Genetics
FRITS W. WENT . . . . . Plant Physiology

ASSOCIATE PROFESSORS

ERNEST G. ANDERSON . . . . . Genetics
STERLING EMERSON . . . . . Genetics
ARIE JAN HAAGEN-SMIT . . . . . Biology
CORNELIS A. G. WIERSMA . . . . . Physiology

ASSISTANT PROFESSORS

ROBERT EMERSON . . . . . Biophysics[1]
HUGH M. HUFFMAN . . . . . Biochemistry
GEORGE E. MACGINITIE . . . . . Biology

INSTRUCTORS

JAMES F. BONNER . . . . . Plant Physiology
ANTHONIE VAN HARREVELD . . . . . Physiology
JOHANNES VAN OVERBEEK . . . . . Plant Physiology
ALBERT TYLER . . . . . Embryology

INTERNATIONAL RESEARCH FELLOWS OF THE ROCKEFELLER FOUNDATION

GEORG H. M. GOTTSCHEWSKI
P. C. KOLLER
KENNETH MATHER

RESEARCH ASSISTANTS

JACOB DUBNOFF
EMORY L. ELLIS
GEOFFREY KEIGHLEY
FRANK J. ROSS

KELLOGG UNIVERSITY FELLOW[2]

PHILIP TRUMAN IVES

TEACHING FELLOWS AND ASSISTANTS

FREDERICK T. ADDICOTT
DAVID M. BONNER
SIDNEY W. FOX
ROBERT G. HELFER
ISYDORE HLYNKA
NORMAN H. HOROWITZ
ROBERT H. MACKNIGHT
GEORGE H. MARMONT
DWIGHT MILLER
DANIEL C. PEASE
WILLIAM S. STEWART
JOHN L. WEBB

[1] On leave of absence, 1937-1940.
[2] Of Amherst College.

DIVISION OF ASTROPHYSICS

OBSERVATORY COUNCIL

GEORGE E. HALE, *Chairman*

MAX MASON, *Vice-Chairman*

WALTER S. ADAMS — A. B. MACBETH

ALLAN C. BALCH — ROBERT A. MILLIKAN

HENRY W. O'MELVENY

JOHN A. ANDERSON, *Executive Officer*

EDWARD C. BARRETT, *Secretary*

ADVISORY COMMITTEE

WALTER S. ADAMS, *Chairman*

CHARLES G. ABBOT — THEODORE VON KÁRMÁN

IRA S. BOWEN — R. R. MARTEL

VANNEVAR BUSH — R. R. MCMATH

JOHN P. BUWALDA — HENRY N. RUSSELL

W. HOWARD CLAPP — FREDERICK H. SEARES

PAUL S. EPSTEIN — ROYAL W. SORENSEN

HANNIBAL FORD — RICHARD C. TOLMAN

EDWIN HUBBLE — VLADIMIR K. ZWORYKIN

RESEARCH ASSOCIATE

JOHN A. ANDERSON

SUPERVISING ENGINEER FOR THE 200-INCH TELESCOPE

CAPTAIN C. S. MCDOWELL, U.S.N., Retired

ASSOCIATES IN OPTICS AND INSTRUMENT DESIGN

FRANCIS G. PEASE — RUSSELL W. PORTER

SINCLAIR SMITH

SENIOR FELLOWS IN RESEARCH

RUDOLPH M. LANGER — JOHN D. STRONG

RESEARCH FELLOW

JOSEF J. JOHNSON

DIVISION OF THE HUMANITIES

CLINTON K. JUDY, *Chairman*

PROFESSORS

CLINTON K. JUDY . . . . . English Language and Literature
GRAHAM A. LAING . . . . . Economics and Business Administration
JOHN R. MACARTHUR . . . . . Languages
WILLIAM B. MUNRO . . . . . History and Government
THEODORE G. SOARES . . . . . Ethics

ASSOCIATES

GODFREY DAVIES . . . . . History
EDWIN F. GAY . . . . . Economic History
RICARDO QUINTANA . . . . . English Literature
LOUIS B. WRIGHT . . . . . English Literature

VISITING PROFESSORS

PHILIP GUEDALLA . . . . . History and Biography
ALLAN NEVINS . . . . . American History

LECTURER

ARCHIBALD B. YOUNG . . . . . Business Law

ASSOCIATE PROFESSORS

HORACE N. GILBERT . . . . . Business Economics
GEORGE R. MACMINN . . . . . English Language and Literature[1]
RAY E. UNTEREINER . . . . . Economics and History

ASSISTANT PROFESSORS

HARVEY EAGLESON . . . . . English Language and Literature
PHILIP S. FOGG . . . . . Business Economics
WILLIAM HUSE . . . . . English Language and Literature
L. WINCHESTER JONES . . . . . English Language and Literature
ROGER STANTON . . . . . English Language and Literature
J. E. WALLACE STERLING . . . . . History

INSTRUCTORS

HARDIN CRAIG, JR. . . . . History
WILLIAM H. PICKERING . . . . . History
DAVID L. STEVENSON . . . . . English Language and Literature

GRADUATE ASSISTANT

ALBERT O. DEKKER . . . . . Modern Languages

[1] On leave of absence, Fall term, 1937-38.

DIVISION OF PHYSICAL EDUCATION

R. W. SORENSEN, *Chairman*

PHYSICAL DIRECTOR

WILLIAM L. STANTON

ASSISTANT DIRECTOR

HAROLD Z. MUSSELMAN

CONSULTING PHYSICIAN

EDWARD D. KREMERS

PHYSICAL TRAINER

FLOYD L. HANES

ASSISTANTS

ROBERT C. BRUMFIELD

EDWARD B. DOLL

RICHARD H. DUVAL

EDGAR H. KIENHOLZ

GEORGE R. MELLINGER

JOHN L. NOLLAN

STUART L. SEYMOUR

CALIFORNIA INSTITUTE ASSOCIATES

The California Institute Associates are a group of public-spirited citizens, interested in the advancement of learning, who have been incorporated as a non-profit organization for the purpose of promoting the interests of the California Institute of Technology.

OFFICERS

ALBERT B. RUDDOCK, *President*
SHANNON CRANDALL, *1st Vice-Pres.*
W. L. VALENTINE, *2nd Vice-Pres.*
ARCHIBALD B. YOUNG, *3rd Vice-Pres.*
SEELEY G. MUDD, *4th Vice-Pres.*
PRESTON HOTCHKIS, *Secretary*
DONALD O'MELVENY, *Treasurer*
EDWARD C. BARRETT, *Asst. Secy.-Asst. Treas.*

DIRECTORS

C. F. Braun
R. R. Bush
Frank R. Capra
I. C. Copley
Shannon Crandall
Thomas Fleming, Jr.
S. M. Haskins
William C. Hay
John E. Jardine
Ralph B. Lloyd
R. H. Moulton
Seeley G. Mudd
Donald O'Melveny
John O'Melveny
Albert B. Ruddock
W. L. Valentine
Archibald B. Young

MEMBERS

Fred S. Albertson
George W. H. Allen
William H. Allen, Jr.
Mrs. Noel Arnold
Mrs. James G. Bailey
Allan C. Balch
Mrs. Allan C. Balch
Franklin Baldwin
Mrs. Russell H. Ballard
John E. Barber
Harry J. Bauer
Mrs. Albert C. Bilicke
Mrs. Ellis Bishop
Miss Eleanor M. Bissell
Fred H. Bixby
E. J. Blacker
Mrs. R. R. Blacker
Edward W. Bodman
Franklin Booth
Victor von Borosini
J. G. Boswell
Mrs. Rebecca F. Boughton
C. F. Braun
Scott Brown
Mrs. E. A. Bryant
Mrs. Clara B. Burdette
Carleton F. Burke
R. R. Bush
Robert W. Campbell
Frank R. Capra
Harry Chandler
Stuart Chevalier
Norman W. Church
Mrs. E. P. Clark
Miss Lucy Mason Clark
Arthur M. Clifford
George I. Cochran
Mrs. James M. Cockins
Thomas F. Cole
I. C. Copley
Hamilton H. Cotton
S. Houghton Cox
Mrs. Margaret R. Craig-McKerrow
Shannon Crandall
John S. Cravens
E. W. Crellin
William C. Crowell
Mrs. James A. Culbertson
Mrs. Joseph B. Dabney
Addison B. Day
Thomas R. Dempsey
Mrs. Donald R. Dickey
Mrs. Edward L. Doheny
E. E. Duque
John H. Eagle
Harry B. Earhart
Edward Elliott
Mrs. Meyer Elsasser
Melville G. Eshman
George E. Farrand
John H. Fisher
Arnold K. Fitger
Herbert Fleishhacker
Arthur H. Fleming
Thomas Fleming, Jr.

Mrs. Frank P. Flint
F. W. Flint, Jr.
E. T. Foley
Freeman A. Ford
Stanton W. Forsman
Stuart W. French
Robert N. Frick
Mrs. Robert N. Frick
Mrs. John Gaffey
Mrs. Charles W. Gates
Robert C. Gillis
E. S. Gosney
Mrs. Herbert J. Goudge
Claude M. Griffeth
George E. Hale
Mrs. Girard van B. Hale
Miss Evelyn Hamburger
Mrs. F. A. Hardy
Mrs. E. C. Harwood
Arnold D. Haskell
S. M. Haskins
William C. Hay
Mrs. Arthur Hill
Mrs. Frank P. Hixon
Mrs. Joseph M. Hixon
Collis H. Holladay
Mrs. W. I. Hollingsworth
Webster B. Holmes
Herbert B. Holt
William L. Honnold
Mrs. William L. Honnold
W. S. Hook, Jr.
Louis J. Hopkins
Preston Hotchkis
Mrs. William F. Howard
Rupert Hughes
Myron Hunt
Willis G. Hunt
Willard C. Jackson
John E. Jardine
Mrs. S. Herbert Jenks
S. Fosdick Jones
F. W. Kellogg
A. N. Kemp
H. H. Kerckhoff
Mrs. William G. Kerckhoff
J. O. Koepfli
R. H. Lacy
Mrs. William Lacy
Oscar Lawler
Fred B. Lewis
R. C. Lilly
Ralph B. Lloyd
Edward D. Lyman
Leonard S. Lyon
I. H. Lyons
Alexander B. Macbeth
James E. MacMurray
Mrs. James G. Macpherson
Fred S. Markham
Alonzo C. Mather
Mrs. George H. Maxwell
Mrs. Anna Bissell McCay
William C. McDuffie
J. Wallace McKenzie
Malcolm McNaghten
Mrs. E. A. Merrill
Edwin A. Meserve
Ben R. Meyer
Mrs. Ben R. Meyer
Mrs. John B. Miller
Robert A. Millikan
Ernest E. Millikin
Robert T. Moore
Alan E. Morphy
Lindley C. Morton
R. H. Moulton
Harvey S. Mudd
Seeley G. Mudd
Mrs. Seeley W. Mudd
W. C. Mullendore
William B. Munro
Daniel Murphy
Mrs. Arthur Noble
E. J. Nolan
Donald O'Melveny
Henry W. O'Melveny
John O'Melveny
Stuart O'Melveny
Mrs. Benjamin E. Page
James R. Page
Mrs. James R. Page
Mrs. Lee A. Phillips
Mrs. June Braun Pike
Clarence B. Piper
J. Hudson Poole
Mrs. J. Hudson Poole
Mrs. Francis F. Prentiss
William M. Prindle
Charles H. Prisk
Charles McCormick Reeve
Louis D. Ricketts
Mrs. Louis D. Ricketts
Mrs. Henry M. Robinson
Albert B. Ruddock
Mrs. Albert B. Ruddock
Howard J. Schoder
Silsby M. Spalding
Charles F. Stern
Mrs. Frederick H. Stevens
Mrs. Charles Stinchfield
Leonard G. Strater
Reese H. Taylor
Charles H. Thorne
Mrs. Joseph E. Tilt
Mrs. John Treanor
Mrs. John K. Urmston
Edward R. Valentine
W. L. Valentine
Mrs. W. L. Valentine
William W. Valentine
J. Benton Van Nuys
Charles B. Voorhis
Mrs. Paul M. Warburg
Thomas W. Warner
Mrs. Gurdon W. Wattles
Philip Wiseman
Casey A. Wood
Archibald B. Young
Gerald C. Young

HISTORICAL SKETCH

The California Institute of Technology had its real origin in 1891, with the founding of Throop University. At that time the opportunities for obtaining systematic vocational training on the west coast were meager, if they existed at all. It was primarily to meet this need that the Hon. Amos G. Throop founded the institution to which he gave his name and to which he later left the bulk of his estate. Throop Polytechnic Institute—the name was changed in 1892—while it offered work of college grade, concentrated most of its energies on instruction in manual training, domestic science, and kindred subjects, preparing its graduates mainly for teaching positions which were opened by the addition of manual arts to the curricula of the public schools. And to round out its general educational program, Throop Polytechnic also maintained an academy and an elementary school.

Thus it continued for nearly two decades, with no change in its principal aims, and still housed in three buildings on a small campus in the present business section of Pasadena. The impulse toward change originated with Dr. George E. Hale, who had come to Pasadena to direct the building of the Mount Wilson Observatory of the Carnegie Institution of Washington. The need which had been met by the founding of Throop Polytechnic Institute was now being met by other institutions; Dr. Hale perceived a new and greater need, growing out of changed conditions; and he became enthusiastic over the possibility of developing an institution which would give sound engineering training, but which might in time, with the friendly association of the Mount Wilson Observatory, make Southern California a center for distinguished scientific work.

The possibility which he envisaged fired the enthusiasm and enlisted the support of a number of outstanding citizens of the community, notably Messrs. Arthur H. Fleming, Norman Bridge, Henry M. Robinson, James A. Culbertson, Charles W. Gates, and Hiram and John Wadsworth. Mr. Fleming and his daughter, Marjorie, pre-

sented the institution with twenty-two acres of land which, with the addition of eight acres later, comprise the present campus. The Flemings were also largely instrumental in providing the first building to be erected on the new site, the present Throop Hall. In 1910, under the presidency of Dr. James A. B. Scherer, the institute moved to its new quarters. A few years earlier the elementary school had been set up as a separate institution, the present Polytechnic Elementary School; and by 1911 the normal school and the academy had been discontinued.

For the first few years in its new location, Throop Polytechnic Institute—or Throop College of Technology as it was called after 1913—gave degrees only in electrical, civil, and mechanical engineering. Gradually, however, it was able to add to its objectives. In 1913, Dr. A. A. Noyes, who was founder and director of the Institute of Physical Chemistry at the Massachusetts Institute of Technology and who had also served as president of that institution, became associated on part-time with the College. In 1916 a chemical laboratory was assured. It was completed in 1917, and instruction and research in chemistry and chemical engineering were inaugurated under Dr. Noyes' direction. In that same year, Dr. Robert A. Millikan, then professor of physics at the University of Chicago, arranged to spend a part of each year at Throop, where, as Director of Physical Research, he was to develop a program of graduate work in physics.

The war necessitated a temporary diversion of energies. Numerous members of the faculty went into service, and undergraduate instruction was radically revised to meet the immediate needs of the national emergency. With the close of the war, however, normal activities were resumed, and in the next few years the institution entered on the most rapid and consistently sustained phase of its development. In 1919 Dr. Noyes resigned from the faculty of the Massachusetts Institute of Technology to give his whole time to Throop College. In 1920 the name was changed to the California Institute of Technology. In that same year, Dr. Scherer resigned because of ill health.

Nineteen hundred and twenty-one was marked by developments which made it one of the most important years in the history of the

Institute. When a laboratory of physics was assured by Dr. Norman Bridge, Dr. Millikan severed his connection with the University of Chicago to become director of the laboratory and Chairman of the Executive Council of the Institute. The setting up of the Executive Council, which was the principal feature of an administrative reorganization, was designed to achieve two results: to avoid the burden of single responsibility which a college presidency usually entails, and to bring about a closer relationship between the Board of Trustees and the faculty. The Executive Council, which under the Board of Trustees administers the affairs of the Institute, is composed of both trustees and faculty members, and as a body it discharges the duties ordinarily performed both by a college president and the executive committee of a board of trustees.

In the same year, 1921, financial stability was assured by Mr. Arthur H. Fleming's agreement to give the California Institute his personal fortune as permanent endowment. In November of that year, the Board of Trustees formulated in the "Educational Policies of the Institute" an explicit statement of the principles which were to govern the present conduct of the Institute and its future development. Recognition by the Southern California community of the value of these aims has resulted in a steady growth of the physical facilities and has made possible the addition of work in geology, biology, and aeronautics. There has been also, during the past fifteen years, a steady growth in enrollment, both in the undergraduate and graduate groups. But all of these developments have involved no changes of fundamental purpose; they have, in fact, only enabled that purpose to be fulfilled more completely.

EDUCATIONAL POLICIES

In pursuance of the plan of developing an institute of science and technology of the highest grade, the Trustees in 1921 adopted the following statement of policies:

(1) The Institute shall offer two four-year undergraduate courses, one in Engineering and one in Science. Both of these courses shall lead

to the degree of Bachelor of Science and they shall also possess sufficient similarity to make interchange between them not unduly difficult.

(2) The four-year Undergraduate Course in Engineering shall be of a general, fundamental character, with a minimum of specialization in the separate branches of engineering. It shall include an unusually thorough training in the basic sciences of physics, chemistry, and mathematics, and a large proportion of cultural studies; the time for this being secured by eliminating some of the more specialized technical subjects commonly included in undergraduate engineering courses. It shall include, however, the professional subjects common to all branches of engineering. It is hoped in this way to provide a combination of a fundamental scientific training with a broad human outlook, which will afford students with engineering interests the type of collegiate education endorsed by leading engineers—one which avoids on the one hand the narrowness common among students in technical schools, and on the other the superficiality and the lack of purpose noticeable in many of those taking academic college courses.

(3) Fifth-year courses leading to the degree of Master of Science shall be offered in the various branches of engineering—for the present in civil, mechanical, electrical, aeronautical, and chemical engineering. In these courses the instruction in basic engineering subjects shall be maintained at the highest efficiency so that the graduates from them may be prepared with especial thoroughness for positions as constructing, designing, operating, and managing engineers.

(4) The four-year Undergraduate Course in Science shall afford, even more fully than is possible in the engineering course, an intensive training in physics, chemistry, and mathematics. In its third and fourth years groups of optional studies shall be included which will permit either some measure of specialization in one of these basic sciences or in geology, paleontology, biology, astrophysics, or in the various branches of engineering. This course shall include the same cultural studies as does the engineering course, and in addition, in-

struction in the German and French languages. Its purpose will be to provide a collegiate education which, when followed by one or more years of graduate study, will best train the creative type of scientist or engineer so urgently needed in our educational, governmental, and industrial development, and which will most effectively fit able students for positions in the research and development departments of manufacturing and transportation enterprises.

(5) Fifth-year courses leading to the degree of Master of Science shall be offered in the sciences of physics, astrophysics, mathematics, chemistry, geology, geophysics, paleontology, and biology. A considerable proportion of the time of these courses shall be devoted to research. These will continue the training for the types of professional positions above referred to.

(6) Throughout the period of undergraduate study every effort shall be made to develop the character, ideals, breadth of view, general culture, and physical well-being of the students of the Institute. To this end the literary, historical, economic, and general scientific subjects shall continue to be taught by a permanent staff of men of mature judgment and broad experience; the regular work in these subjects shall be supplemented by courses of lectures given each year by men of distinction from other institutions; and the weekly assemblies, addressed by leading men in the fields of education, literature, art, science, engineering, public service, commerce, and industry, shall be maintained as effectively as possible. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs, shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural games or contests affording recreation.

(7) In all the scientific and engineering departments of the Institute research shall be strongly emphasized, not only because of the importance of contributing to the advancement of science and thus to the intellectual and material welfare of mankind, but also because

research work adds vitality to the educational work of the Institute and develops originality and creativeness in its students.

(8) In order that the policies already stated may be made fully effective as quickly as possible, and in order that the available funds may not be consumed merely by increase in the student body, the registration of students at any period shall be strictly limited to that number which can be satisfactorily provided for with the facilities and funds available. And students shall be admitted, not on the basis of priority of application, but on that of a careful study of the merits of individual applicants, so that the limitation may have the highly important result of giving a select body of students of more than ordinary ability. A standard of scholarship shall also be maintained which rapidly eliminates from the Institute those who, from lack of ability or industry, are not fitted to pursue its work to the best advantage.

BUILDINGS AND FACILITIES

THROOP HALL, 1910.

The administration building; erected with funds supplied by a large number of donors, and named for the Honorable Amos G. Throop, founder of Throop Polytechnic Institute, from which the California Institute developed.

GATES AND CRELLIN LABORATORIES OF CHEMISTRY: first unit, 1917; second unit, 1927; third unit, 1937.

The first two units were the gift of the late Messrs. C. W. Gates and P. G. Gates, of Pasadena; the third unit was the gift of Mr. and Mrs. E. W. Crellin, of Pasadena.

CULBERTSON HALL, 1922.

The Institute auditorium; named in honor of the late Mr. James A. Culbertson, trustee of the Institute and Vice-President of the Board 1908-1915.

NORMAN BRIDGE LABORATORY OF PHYSICS: first unit, 1922; second unit, 1924; third unit, 1925.

The gift of the late Dr. Norman Bridge.

HIGH-POTENTIAL RESEARCH LABORATORY, 1923.
Erected with funds provided by the Southern California Edison Company Ltd.

ENGINEERING RESEARCH LABORATORY AND HEATING PLANT, 1926.
Erected with funds provided in part by the late Dr. Norman Bridge and in part from other sources.

DABNEY HALL OF THE HUMANITIES, 1928.
The gift of the late Mr. Joseph B. Dabney and Mrs. Dabney, of Los Angeles.

SEISMOLOGICAL RESEARCH LABORATORY (of the Division of the Geological Sciences), 1928.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY, 1929.
Erected with funds provided by the Daniel Guggenheim Fund for the Promotion of Aeronautics.

WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES: first unit, 1929; second unit under construction, to be finished 1938.

The gift of the late Mr. William G. Kerckhoff and Mrs. Kerckhoff, of Los Angeles.

EXPERIMENTAL STATION (of the Division of Biology), Arcadia, California, 1929.

PLANT PHYSIOLOGY LABORATORY (of the Division of Biology), 1930.

WILLIAM G. KERCKHOFF MARINE BIOLOGICAL LABORATORY (of the Division of Biology), Corona del Mar, California, 1930.

ATHENÆUM, 1930.
The gift of Mr. and Mrs. Allan C. Balch, of Los Angeles.

STUDENT HOUSES, 1931.
Blacker House.
The gift of the late Mr. R. R. Blacker and Mrs. Blacker, of Pasadena.

Dabney House.
The gift of the late Mr. Joseph B. Dabney, and Mrs. Dabney, of Los Angeles.

Fleming House.
Erected with funds provided by some twenty donors, and named in honor of Mr. Arthur H. Fleming, of Pasadena, President of the Board of Trustees of the Institute 1918-1932.

Ricketts House.
The gift of Dr. and Mrs. L. D. Ricketts, of Pasadena.

ASTROPHYSICAL INSTRUMENT SHOP, 1931.
Erected with funds provided by the International Education Board and the General Education Board.

W. K. KELLOGG LABORATORY OF RADIATION, 1932.
The gift of Mr. W. K. Kellogg, of Battle Creek, Michigan.

ASTROPHYSICAL LABORATORY, 1932.
Erected with funds provided by the International Education Board and the General Education Board.

HYDRAULIC STRUCTURES LABORATORY, 1932.

ASTROPHYSICAL OPTICAL SHOP, 1933.
Erected with funds provided by the International Education Board and the General Education Board.

SOIL CONSERVATION LABORATORY, 1936.
Provided by the Department of Agriculture of the United States Government.

CHARLES ARMS LABORATORY OF THE GEOLOGICAL SCIENCES: under construction, to be finished 1938.

The gift of the late Mr. Henry M. Robinson and Mrs. Robinson, of Pasadena, in memory of Mrs. Robinson's father, the late Mr. Charles Arms.

SEELEY W. MUDD LABORATORY OF THE GEOLOGICAL SCIENCES: under construction, to be finished 1938.

The gift of Mrs. Seeley W. Mudd, of Los Angeles, in memory of her husband, the late Mr. Seeley W. Mudd.

TEMPORARY BUILDINGS

The Steam, Gas Engine, and Hydraulic Laboratories for undergraduate work in the fields of thermodynamics and hydraulics are housed in a building of temporary construction.

Another such building contains living quarters for graduate students, a restaurant for non-resident students, and a club-room for the Throop Club.

Other temporary structures contain a gymnasium locker room and showers, exercise rooms, and a practice room for the musical organizations of the Institute.

LIBRARIES

The library of the Institute comprises the General Library, housed in the Norman Bridge Laboratory of Physics, and six departmental libraries for physics, chemistry, geology, biology, aeronautics, and the humanities.

ATHENÆUM

The Athenæum, a structure in the Mediterranean style of architecture, fittingly furnished and equipped, with grounds attractively landscaped, is situated at the Hill Avenue end of the campus. The purpose of the donors, Mr. and Mrs. Allan C. Balch, was to provide a place and opportunity for contact between the distinguished foreign scientists and men of letters temporarily in residence from time to time at the California Institute, the Mount Wilson Observatory, and the Henry E. Huntington Library and Art Gallery, the staffs and graduate students of those institutions, and the patrons and friends of science and education in Southern California making up the California Institute Associates.

The Athenæum contains on the first floor a large and beautiful lounge, a library, a main dining-room, three small dining-rooms, and, adjoining the main dining-room—and planned so that the two rooms can be thrown together for large banquets—a room for scientific and other lectures, known as the "Hall of the Associates." On the upper floors are very attractively furnished rooms and suites, each with private bath, for visiting professors, members of the staffs and graduate students of the three institutions named, and other members of the Athenæum. An attractive writing room and lounge are provided on a mezzanine floor for the exclusive use of women. On the third floor a loggia and dressing rooms provide additional accommodations for graduate students.

STUDENT HOUSES

The four Student Houses are situated on the California Street side of the campus. Planned in the Mediterranean style to harmonize with the Athenæum, they were, like the latter building, designed by Mr. Gordon B. Kaufmann. While the four houses constitute a unified group, each house is a separate unit providing accommodations for about seventy-five students; each has its own dining-room and lounge, but all are served from a common kitchen.

All four houses have attractive inner courts surrounded by portales. Most of the rooms are single, but there is a limited number of rooms for two. All the rooms are simply but adequately and attractively furnished. The plans of the buildings are such that within each of the four houses there are groupings of rooms for from twelve to twenty students, with separate entries for each group.

The completion of this first group of residence halls marks the initial step in a plan to meet the housing and living problems of the students in such a way as to develop a series of eight residence halls, "each to have its own distinctive atmosphere, each to be the center about which the loyalties developed in student days and the memories of student life shall cluster."

By action of the Board of Trustees, all undergraduate students are expected to live in the Student Houses unless permission is given by one of the Deans to live elsewhere. This permission normally will not be given except for reasons of emergency.

EXTRA-CURRICULAR OPPORTUNITIES

LECTURES

A series of lectures is presented in the weekly Assembly, which all students are required to attend. These lectures are designed to be of general interest and deal with science, literature, the arts, and current economic and political history. The Humanities division offers occasional lectures by eminent authorities in philosophy, history, and literature. Weekly public lectures in science, illustrated by experiments, are given by the members of the Institute faculty in the lecture rooms of the Norman Bridge Laboratory of Physics and the Gates Chemical Laboratory. Lectures given from time to time at the Institute under the auspices of Sigma Xi and of the Astronomical Society of the Pacific are open to the students. They may also arrange to visit the Huntington Library and Art Gallery, and preceding the visits to the art gallery, members of the Institute staff give talks to small groups of students on the pictures there exhibited.

STUDENT ORGANIZATIONS AND ACTIVITIES

The students are organized as the "Associated Students of the California Institute of Technology, Incorporated," of which all are members, to deal with affairs of general concern to the students, and with such matters as may be delegated to them by the faculty. The student body elects a Board of Directors and a Board of Control, which investigates breaches of the honor system, or cases of misconduct, and recommends disciplinary penalties to the faculty.

Coordination in regard to campus affairs between faculty and students is obtained through periodic conferences of the Faculty Committee on Student Relations, the Board of Directors of the Student Body, and the Board of Control.

The Faculty Committee on Student Relations, in conjunction with the Board of Directors of the Student Body, arranges each year a series of lectures for the freshmen emphasizing (a) social

usage and Institute traditions; (b) the value of undergraduate activities and the recognition by the business world of the character and qualities developed through participation in those activities; (c) the fact that studies need not keep students from a reasonable participation in extra-curricular interests; and (d) the fact that every student can find at the Institute a wide range of activities from which to choose.

The Associated Students exercise general direction of matters of undergraduate concern in cooperation with the faculty. Athletic contests are managed by the Athletic Council, composed of faculty and student representatives. The student body, through its elected representatives, manages THE CALIFORNIA TECH, a weekly paper, the BIG T, the annual, and the LITTLE T, the handbook. A glee club, an orchestra, and a band are maintained, with assistance from the Institute. There are at the Institute student branches of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Society of Civil Engineers. A Chemists' Club and a Geology-Paleontology Club include men interested in these particular fields. Other organizations are the Walrus, the Cosmopolitan, the Photo, the Aero, and the Newman Clubs, and the Episcopalian Group.

In addition to national honorary fraternities there are four local honorary groups: the Beavers, the Drama Club, the Press Club, and the Varsity Club.

The Throop Club is a social organization for non-resident undergraduates. Graduate students are also eligible to membership. The center of the group's activity is the recently completed Throop Club lounge on the campus, made possible through friends of the Institute, the Institute, and members of the Throop Club.

The Astronomy and Physics Club, while composed of members of the faculty, graduate students of the Institute, and members of the staffs of neighboring scientific institutions, admits to its meetings undergraduate students who may be interested in its discussions.

Sigma Xi is represented at the Institute by an active chapter. Graduate students who have demonstrated their ability to prosecute research are eligible for membership. Undergraduate students who have shown particular interest and aptitude in research are elected to associate membership.

A chapter of Tau Beta Pi, the national scholarship honor society of engineering colleges, is maintained at the Institute. Elections are made each year from the highest eighth of the junior class, and from the highest quarter of the senior class.

A chapter of Pi Kappa Delta, national forensic honor society, elects to membership students who have represented the Institute in intercollegiate debate, oratorical or extempore speaking contests. The forensic interests of the Institute include also membership in the Southern California Public Speaking Association. Under the auspices of this association the Institute debaters engage in an annual schedule of six debates with other Southern California colleges, and in annual oratorical and extempore contests. Debates are also scheduled with near-by colleges, and frequently with eastern teams traveling through California. On the Pi Kappa Delta trips to the national conventions, debates are scheduled with the best of the institutions that can be met en route.

To train the Institute speakers for these various intercollegiate contests, a debate course is offered by the English department, and much individual coaching is given the members of the teams. During the second and third terms a special class for freshmen gives the members of that class an opportunity to prepare for the freshman debates, in which the first-year men of six other colleges are met. A number of intramural practice debates, and the annual contest for the Conger Peace Prize, afford all men interested in public speaking an opportunity to develop their abilities.

Exceptional facilities in dramatic work are afforded the student. Each year a classical play, Greek or Roman, is presented under the auspices of Pi Kappa Delta, participation in it, however, being open

to the whole student body. A modern play is given under the auspices of the English Department, open likewise to all students. Both of these plays are produced under the direction of Professors Eagleson and Stanton of the English department.

To aid the student journalists in improvement in their technique a journalism course is offered during each of the three terms.

A Young Men's Christian Association has its office in Dabney Hall and performs many valuable services. Receptions for new students, hikes, bi-weekly luncheons, meetings, classes for the study of life and other problems are conducted by this organization. Its program and membership are open to all students at no expense.

STUDENT HEALTH AND PHYSICAL EDUCATION

PHYSICAL EDUCATION

The work in physical education requires all undergraduate students to carry on a program designed to promote their physical development, and provides graduate students with opportunities for recreational exercise. The required work is divided into three parts: (1) corrective exercises for those physically deficient; (2) group games; (3) fundamentals of highly organized athletics. This work is modified by various activities designed to encourage voluntary recreational exercises, including intercollegiate and intramural games and sports.

HEALTH SERVICE

A. PHYSICAL EXAMINATION

The Institute provides for undergraduates entering the Institute, without cost to them, a complete physical examination by a group of physicians at the Huntington Memorial Hospital.

B. SERVICES OF THE INSTITUTE PHYSICIAN

1. The services of the Institute Physician are available for consultation and treatment at his office on the campus between the hours of 12:30 and 1:30 p.m. daily except Sunday, while the Institute is in session, without charge to undergraduate and graduate students.

2. Provided time is available, the services of the Institute Physician are available during his regular consulting hours on the campus for members of the staff, and employees of the Institute, and their immediate families and those of graduate students. A small fee is charged by the Institute for each such call.

3. Any members of the above groups will receive a 50% discount on all laboratory work done at the Huntington Memorial Hospital.

C. EMERGENCY HOSPITALIZATION FUND

In addition, in order to meet the hospital and certain other emergency medical and surgical expenses, incurred by students who develop serious illnesses which require immediate attention, or suffer accidents, an emergency hospitalization fee of three dollars ($3.00) a year is assessed against every undergraduate and every graduate student. This fee must be paid with the tuition charge for the first term of the academic year.

It is to be clearly understood that the Emergency Hospitalization Fund cannot adequately make provision in case of a serious epidemic; and furthermore because the amount of the annual emergency hospitalization fund fee is small, *this is not to be construed as a contract.*

The following regulations have been established:

1. The funds derived from this fee will be deposited at interest in a special account known as the Emergency Hospitalization Fund. The Institute will be the custodian of the fund. Money in this fund shall not be used for any other purpose than for the payment of surgical and medical expenses. Whether a case is an emergency or not will be decided by the Institute Physician. Whenever an emergency arises, the Institute Physician will decide whether hospitalization is necessary, and will then put into operation the provisions of the Emergency Hospitalization Fund.

Illnesses and injuries which are not emergencies do not come within the scope of the fund.

2. In any emergency case arising under the jurisdiction of the Institute Physician, and when necessary, hospital care will be allowed for a period not to exceed one month. Other necessary hospital expenses during this period of one month, such as the use of operating-room, surgical supplies and dressings, laboratory service, etc., will be allowed. Payment of surgical fees, anaesthetic fees and necessary special nursing fees will also be allowed whenever possible, provided the total amount of payment, exclusive of the hospital charge in any one case, shall not exceed one hundred dollars. Neither the Emergency Hospitalization Fund, nor the California Institute of Technology, is responsible for the payment of physicians', surgeons' and nurses' fees, etc., in excess of the above $100.

3. The fund is not available for those students who require, after returning to their classes, further attention or special equipment. No distinction will be made between injuries incurred in athletics or otherwise, in judging whether the case is an emergency or not, or the extent to which expenses will be paid out of the fund.

4. Whenever the expenses for emergency care in any one fiscal year are less than the total collected in fees for that year, the balance of money remaining shall be kept in the Emergency Hospitalization Fund, and shall remain deposited at interest to increase for the benefit of the fund. A balance kept over from one year will be used to render emergency medical aid to the students in later years. It is probable that the plan can be liberalized by the building up of the fund in this manner.

5. Students are not required to accept the services of the Institute Physician, but may choose physicians and surgeons privately. Whomever they choose, whether the Institute Physician or not, they must pay for such services themselves without reference to the Emergency Hospitalization Fund.

6. The responsibility for securing adequate medical attention in any contingency, whether an emergency or not, is solely that of the patient. This is the case whether

the patient is residing in one of the Student Houses, the Athenæum, or off the Institute grounds. Apart from providing the opportunity for free consultation with the Institute Physician at his office on the Institute grounds between 12:30 and 1:30 p.m. daily, unless otherwise stated, except Sunday, during term time, the Institute bears no responsibility for providing medical attention in case of illness.

7. Any expenses incurred in securing medical advice and attention in any case are entirely the responsibility of the patient. For instance: students who are ill and confined to their rooms in the dormitories or elsewhere, and are unable to visit the Institute Physician's office at the Institute, at the regular time, and who call in any physician, including the Institute Physician, are themselves solely responsible for the payment of all the bills incurred.

8. The Emergency Hospitalization Fund does not provide for the families of graduate or undergraduate students. The arrangements mentioned above for these classes will hold.

9. Donations to the Emergency Hospitalization Fund will be gratefully received.

10. The Faculty Committee on Student Health supervises, and authorizes, expenditures by the fund. All questions regarding the administration of this fund are to be referred to this Committee. The Committee will review the facts of every emergency case, and may, if they feel it desirable, recommend an extension of payments for specific purposes cited by the Committee.

REQUIREMENTS FOR ADMISSION TO UNDERGRADUATE STANDING

ADMISSION TO THE FRESHMAN CLASS

By action of the Trustees of the Institute the freshman class is limited to 160 students. These students are selected from the group of applicants on the basis of (a) high grades in certain required high school subjects and (b) satisfactory completion of entrance examinations in mathematics, physics, chemistry, and English. The specific requirements in each of these groups are described below.

HIGH SCHOOL CREDITS

Each applicant must be thoroughly prepared in at least fifteen units of preparatory work, each unit representing one year's work in a given subject in an approved high school at the rate of five recitations weekly. Each applicant must offer all of the units in Group A and five units in Groups B and C. At least three of the latter must be in Group B.

Group A:	English	3
	Algebra	2
	Plane and Solid Geometry	1½
	Trigonometry	½
	Physics	1
	Chemistry	1
	United States History and Government	1
Group B:	Foreign Languages, Shop (up to 1 unit); additional English, Mathematics, Laboratory Science, or History.	
Group C:	Drawing, Commercial subjects, additional Shop, etc.	

Applicants who offer for entrance a total of fifteen recommended units, but whose list of subjects is not in accord with this table, may be admitted at the discretion of the faculty, if they are successful in passing the general entrance examinations; but no applicant will be

admitted whose preparation does not include English 2 units, algebra 1½ units, geometry 1 unit, trigonometry ½ unit, physics 1 unit. All entrance deficiencies must be made up before registration for the second year.

Each applicant is expected to show that he has satisfactorily completed the above-stated required preparation, by presenting a complete scholastic record from an approved school[1].

ENTRANCE EXAMINATIONS

In addition to the above credentials, all applicants for admission to the freshman class are required to take entrance examinations. These examinations do not take the place of the high school credentials, but serve to supplement them. The subjects covered are chemistry, physics, mathematics, and English. The examinations are general in character; they are intended to show the applicant's ability to think and express himself clearly, and his fitness for scientific and engineering training, rather than to test memorized information. Specimens or samples of the examination questions for admission to the freshman class of the Institute are not available for distribution.

Prospective freshmen are expected to take the entrance examinations in chemistry and English near the end of their junior year in high school, or one year prior to the date of expected admission to the Institute. The remaining examinations, in mathematics and physics, are ordinarily taken during April or May of the spring prior to expected admission. Those students who have failed, for sufficient reason, to take the chemistry and English examinations during the junior year may be permitted to take all four examinations during the spring prior to admission.

Regular entrance examinations will be held at the Institute Saturday, March 26, and Saturday, April 2, 1938. Applicants should report in the Lounge of Dabney Hall March 26, at 8:30 a.m. The examina-

[1] Incomplete scholastic records may be supplemented by examinations in particular subjects taken at the Institute. The scope of subject matter for these examinations is the same as that covered by standard high schools. Applicants taking examinations in United States history and Government must present their notebooks at the time of the examination. The schedule for 1938 is as follows: Tuesday, September 20, 9:00 a.m., mathematics; Wednesday, September 21, 9:00 a.m., history and foreign languages.

tions on March 26 will be chemistry and English and on April 2 mathematics and physics. The examinations in chemistry and English for high school juniors will be held in Dabney Hall on June 11, 1938.

Students living at a distance from Pasadena may, upon request, be allowed to take the entrance examinations under the supervision of their local school authorities. Arrangements for examinations in absentia should include a letter to the Registrar from the individual directing the tests stating that the required supervision will be given.

PHYSICAL EXAMINATION

Each applicant must pass a physical examination prior to admission to the Institute. These examinations will be conducted for the Institute by the staff of the Huntington Memorial Hospital. At the time of his registration each new student will be assigned an appointment for his examination. Registrations are tentative pending such examinations, and are subject to cancellation if the examinations are unsatisfactory. Students living at a distance are advised to consult their family physicians before coming to Pasadena in order to avoid unnecessary expense if physical defects exist which would prevent successful scholastic work. All students entering the Institute for the first time are required to be vaccinated or to submit satisfactory evidence of recent vaccination.

APPLICATION FOR ADMISSION

Application for admission to the Institute may be made at any time, but there is a distinct advantage in doing so by the first of March, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants should submit their scholastic records before taking the entrance examinations. Each student taking the entrance examinations must have his high school mail a transcript of his final semester's work to this Institute as soon as possible after completion of his senior year.

Blanks for application for admission to the Institute will be provided upon request.

Final selections are ordinarily made and the applicants notified of their admission or rejection not later than June 1.

Upon receipt of the registration fee of $10.00 (which will be credited toward the first-term tuition), each accepted applicant will be sent a registration card which will entitle him to register, provided his physical examination is satisfactory. The registration card should be presented at the Dabney Hall Lounge September 20, 1938, at 1:30 p.m.

Checks or money orders should be made payable to the California Institute of Technology.

ADMISSION TO UPPER CLASSES BY TRANSFER FROM OTHER INSTITUTIONS

The Institute admits to its upper classes (i.e., sophomore year and beyond) a limited number of able men who have made satisfactory records at other institutions of collegiate rank. In general only students whose average grade corresponds to at least a B in courses in mathematics and science can expect to be admitted.

Because of the very thorough, intensive study of these subjects required in the first two years, students from other colleges, unless of ability above the average of Institute students, cannot hope to transfer to the higher years of the Institute courses without incurring loss of time and difficulty in the pursuit of the more advanced subjects. Students intending to complete the Institute courses are therefore recommended, as far as possible, to take their freshman and sophomore work also at the Institute.

An applicant for admission must present a transcript of his record to date showing in detail the character of his previous training and the grades received both in high school and college. In addition, he should file an application for admission; the necessary blanks for this will be forwarded from the Registrar's office upon request. If at all possible the transcript and application should be received not later than May. A supplementary transcript covering the work of the last term should be filed as soon as such grades are available. A personal

interview is desirable. If this is not convenient during the regular college session, it is possible to arrange in advance for an interview during the Christmas, spring, or summer vacation periods.

Before their admission to the upper classes of the Institute all students are required to take entrance examinations in mathematics, physics and chemistry covering the work for which they desire credit, except that the examination in chemistry is required only of those desiring to pursue the course in science. Students must offer courses, both professional and general, substantially the same as those required in the various years at the Institute (see pages 162-174), or make up their deficiencies as soon as possible after admission. In case there is a question regarding either the quality or the extent of the previous work, examinations in the subjects concerned may be arranged.

Applicants are advised to read the descriptions of the freshman and sophomore courses, particularly those in physics, mathematics, and chemistry, and to note that the work in freshman mathematics is chiefly calculus.

The examinations in mathematics, physics and chemistry taken by students planning to transfer to the third and fourth-year classes are the comprehensive review examinations required of all students of the Institute before they undertake the work of the third year, and are taken at the same time by students in the Institute and those desiring to transfer from other institutions. For men planning to enter the sophomore year similar review examinations covering the work of the freshman year are required. A representative set of previous examination papers will be sent to approved applicants upon request. From a study of these and of the content of the courses at the Institute, prospective students may judge for themselves which examinations they are prepared to take. Students are not required to take all of the examinations for admission to the classification of a given year as junior or sophomore, but may take examinations in one or more subjects for admission to one class and in others for admission to the work of another class. Their ultimate classification will be determined by the Committee on Admission to Upper Classes on the

basis of their previous record and of the results of all the examinations taken.

No fee is charged for the entrance examinations, but only those whose records are good will be permitted to write upon them. In order to be approved for admission to the examinations, a student's application and a transcript of his record must be on file at least ten days before the date of the examination.

In 1938 the examinations will be held both in June and in September. Since the upper classes may be practically filled by those admitted to the Institute following the examinations in June, applicants are strongly advised to take them at the earlier date. The schedule for 1938 is as follows:

June 4, 9 a.m. . . . . Chemistry	Sept. 16, 9 a.m. . . . Mathematics
June 10, 9 a.m. . . . Mathematics	Sept. 17, 9 a.m. . . . . Physics
June 11, 9 a.m. . . . . Physics	Sept. 17, 1 p.m. . . . . Chemistry

Applicants residing at a distance may take the June examinations under the supervision of their local college authorities, provided definite arrangements are made well in advance. Arrangements for examinations in absentia should include a letter to the Registrar from the person directing the tests stating that the required supervision will be given.

Applicants for admission to the third and fourth years whose credentials have been approved may take advantage of the summer review courses in mathematics and physics to prepare for their examinations. These courses are offered during the three weeks preceding the opening of the fall term. The fee is $20 for each course.

Since the majority of the courses at the Institute continue throughout the year, new students are admitted in September only. For the same reason students whose status may be irregular cannot expect to complete their work at any time other than at the end of the college year in June.

The Institute offers no summer work. However, students who have a few deficiencies in non-professional subjects may be able to remove

them by taking summer work at some other institution of collegiate rank. The details of such summer work should be approved by the Registrar before the work is undertaken.

The attention of students planning to transfer to junior or senior standing is called to the fact that, until they have satisfactorily completed three full terms of residence at the Institute, they are subject to the same scholastic requirements as are freshmen and sophomores. See pages 91 and 92. In addition, they should note that to be permitted to register for any science or engineering options during their junior and senior years they must meet the scholastic requirements of the divisions concerned. See page 92.

Physical examinations and vaccination are required as in the case of students entering the freshman class. If reports of these examinations are delayed until after registration it will be understood that registrations are tentative pending such reports and are subject to cancellation if the reports are unsatisfactory.

EXPENSES

The following is a list of student expenses at the California Institute of Technology for the academic year 1937-38, together with the dates on which the various fees are due. The Student House charges are subject to change, at the discretion of the Institute, for 1938-39. The deposits listed, while uniform in the freshman year, will vary in subsequent years according to the individual course chosen. In addition to the total amount given, approximately $50 a year should be allowed for books and supplies.

Date	Fee	Amount	
		Resident Student	Non-Resident Student
Upon notification of admission to the Institute	Registration Fee	$ 10.00*	$ 10.00*
At time contract for Student House reservation is signed	Student House Deposit	10.00	
Sept. 6, 1937	1st instalment of Room and Board, payable in advance		
	15 meals a week	58.50	
	21 meals a week	69.00	
Sept. 22, 1937	Tuition, 1st term	100.00	100.00
	Associated Student Body Dues, 1st term	5.00	5.00
	Emergency Hospitalization Fee, 1937-38	3.00	3.00
	Chemistry Breakage Deposit	15.00	15.00
	Drawing Padlock Deposit	2.00	2.00
	Physical Education Locker Padlock Deposit	1.00	1.00
	Locker Key Deposit	.50**	.50**
	Locker Rent, 1st term	.50**	.50**
	Parking Fee, 1st term	1.00**	1.00**
	Student House Telephone, 1st term	1.00	
	Student House Dues, 1st term	2.50	
	Student House Radio Fee, 1st term	.50**	
Nov. 8, 1937	2nd instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	

*This fee is paid by Freshmen only, and is automatically applied on the first term's tuition.
**Optional.

Date	Fee	Amount Resident Student	Amount Non-Resident Student
Jan. 3, 1938	Tuition, 2nd term	$100.00	$100.00
	Associated Student Body Dues, 2nd term	5.00	5.00
	Locker Rent, 2nd term	.50**	.50**
	Parking Fee, 2nd term	1.00**	1.00**
	3rd instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	
	Student House Telephone, 2nd term	1.00	
	Student House Dues, 2nd term	2.50	
	Student House Radio Fee, 2nd term	.50**	
Feb. 14, 1938	4th instalment of Room and Board		
	15 meals a week	48.75	
	21 meals a week	57.50	
Mar. 28, 1938	Tuition, 3rd term	100.00	100.00
	Associated Student Body Dues, 3rd term	4.00	4.00
	Locker Rent, 3rd term	.50**	.50**
	Parking Fee, 3rd term	1.00**	1.00**
	5th instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	
	Student House Telephone, 3rd term	1.00	
	Student House Dues, 3rd term	2.50	
	Student House Radio Fee, 3rd term	.50**	
May 9, 1938	6th instalment of Room and Board		
	15 meals a week	48.75	
	21 meals a week	57.50	

TOTAL

For student taking 15 meals	$693.50
For student taking 21 meals	753.00
For non-resident student	$340.00

Students withdrawing from the Institute during the first three weeks of a term, for reasons deemed satisfactory to the Institute, are entitled to a refund of tuition fees paid, less a reduction of 20% and a pro rata charge for the time in attendance.

EMERGENCY HOSPITALIZATION FEE

The emergency hospitalization fee, payable by each student at the beginning of each year, provides a certain amount of hospitalization and medical and surgical care in accordance with regulations pre-

**Optional.

scribed by the Board of Trustees and administered by the Institute Physician and the Faculty Committee on Student Health (see pages 72-74).

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee is payable by all undergraduate students. Of this fee $5.50 is used for the support of athletics, $3.00 as a subscription to the BIG T, and the remainder for other student activities. The subscription to the CALIFORNIA TECH, 55 cents a year, is collected from every undergraduate.

STUDENT HOUSES

Students in the Houses must supply their own blankets but bed linen and towels are furnished and laundered by the Institute.

Application for rooms in the Student Houses may be made by addressing the Comptroller of the Institute.

SCHOLARSHIPS, PRIZES, AND STUDENT AID

FRESHMAN PRIZE SCHOLARSHIPS

Twelve or more freshmen scholarships carrying $150 or $300 are awarded by the Institute upon the basis of a competition open to properly qualified male students in the senior classes of high schools or college preparatory schools. A group of competitors for these scholarships is selected by the committee from among the regular candidates for admission who take the entrance examinations given by the Institute. There is no special application blank for these scholarships.

The scholarships are awarded on the basis of all the information available in regard to the applicants—the results of their examinations, their high-school records and recommendations, the statements submitted as to their student activities and outside interests, and results of personal interviews. The awards are made without reference to financial need; but any successful student with adequate resources may relinquish the money payment in favor of the next most deserving competitor, while retaining the scholarship as an honorary recognition. The winners of these scholarships are designated Blacker Scholars or Drake Scholars, in recognition of the donors of the scholarship funds, Robert Roe Blacker and Nellie Canfield Blacker, or Mr. and Mrs. A. M. Drake.

DRAKE SCHOLARSHIPS

In addition to the foregoing, Mr. and Mrs. A. M. Drake of Pasadena have made provision for an annual scholarship available for a graduate of the high schools of St. Paul, Minnesota, and a similar annual scholarship available for a graduate of the high school of Bend, Oregon.

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

The Institute has established about thirty scholarships known as the Sophomore and Junior Prize Scholarships. These scholarships,

which carry half tuition, are awarded at the end of each school-year to those students who as the result of their work, during the freshman and sophomore years, are granted honor standing on the basis described on page 93 of this Catalogue. In addition, a smaller number of tuition grants may be awarded to students of high standing who are in need of financial assistance.

It is expected that all students awarded scholarships or tuition-grants will maintain high scholastic standing. Failure to do so at any time during the school year may result in the termination of the award.

HARRIET HARVEY SCHOLARSHIP
WALTER HUMPHRY SCHOLARSHIP

Miss Harriet Harvey and Mrs. Emily A. Humphry have made provision for two scholarships. The first of these, the Harriet Harvey Scholarship, is to be awarded preferably to a well-qualified candidate from the state of Wisconsin. If there is no such candidate the Institute may award the scholarship elsewhere.

The second, the Walter Humphry Scholarship, is to be awarded preferably to a well-qualified candidate from the state of Iowa. If there is no such candidate, the Institute may award the scholarship elsewhere.

THE CONGER PEACE PRIZE

Everett L. Conger, D.D., for the promotion of interest in the movement toward universal peace and for the furtherance of public speaking, established in 1912 the Conger Peace Prize. The income from one thousand dollars is given annually as a prize for the composition and delivery in public of the best essay on some subject related to the peace of the world. The general preparation for the contest is made under the direction of the department of English.

LOAN FUNDS

The Cleveland Loan Fund was established by Miss Olive Cleveland for the purpose of aiding students to obtain an education. The income is lent without interest to worthy students who may need such assistance.

In 1923, Mr. Howard R. Hughes, of Galveston, Texas, gave $5,000 to constitute an additional fund for loans to students. Mr. Raphael Herman, of Los Angeles, has provided a like sum to establish the Raphael Herman Loan Fund, which may be used for loans or for scholarships at the discretion of the Institute. A further gift of $5,000 has been made by Mr. and Mrs. Arthur Noble of Pasadena to establish the Noble Loan and Scholarship Fund.

In 1932, Mr. and Mrs. Willard C. Jackson established at the Institute the Thomas Jackson Memorial Loan Fund in memory of their son, a member of the sophomore class of that year, who died during the fall term, at the beginning of a very promising career. The original gift for this fund was $10,000 and the donors have since added $10,000 to this amount. Loans from the fund are made to undergraduate or graduate students of superior ability who are in need of such assistance to meet the expenses of their education.

Applications for loans should be made to the Comptroller of the Institute.

STUDENT EMPLOYMENT

The Institute tries to help students to find suitable employment when they cannot continue their education without thus supplementing their incomes. The requirements of the courses at the Institute are so exacting, however, that under ordinary circumstances students who are entirely or largely self-supporting should not expect to complete a regular course satisfactorily in the usual time.

Students wishing employment are advised to write, before coming to the Institute, to the Secretary of the Institute Y. M. C. A. or the officer in charge of the National Youth Administration program conducted by the Institute.

The National Youth Administration program provides at the Institute during the year 1937-38 the sum of $870 per month, which represents 58 units of $15 each per month, which amount may be earned by needy students assigned to socially desirable tasks, including research work carried on at the Institute.

PLACEMENT SERVICE

The Institute in cooperation with the Alumni Association maintains a Placement Office under the direction of a member of the faculty. With the services of a full-time secretary, this office assists graduates to find employment. Graduates who are unemployed or desire improvement in their positions should register with the Placement Secretary. It should be understood that the Institute assumes no responsibility in obtaining employment for its graduates, although the Placement Office will make every effort to find employment for those men who wish to make use of this service.

REGISTRATION AND GENERAL REGULATIONS

Registration for the second term, 1937-1938, will take place January 3, 1938 (9 a.m. to 3 p.m.); for the third term, March 28, 1938 (9 a.m. to 3 p.m.). Registration for the first term, 1938-1939, will take place, for freshmen, September 20, 1938 (1:30 p.m.), for transfers from other colleges, September 22, 23, 1938 (9 a.m. to 3 p.m.), and for other students, September 23, 1938 (9 a.m. to 3 p.m.). A special fee of two dollars is charged for registration after these dates.

The schedule of studies for each student is made out by the Registration Committee, and the student, after payment of his tuition and fees, is enrolled by the Registrar. No student is admitted to classes without an assignment card from the Registrar's office.

Any change of schedule is made by the Registrar, and after the first week of the term involves a fee of one dollar, unless made at the suggestion of officers of the Institute.

Every student is required to attend all class and assembly exercises for which he is registered, and to satisfy the requirements in each of the subjects in such ways as the instructors may determine.

Students are held responsible for any carelessness or wilful destruction or waste, and at the close of the year, or upon the severance of their connection with any part of the work of the Institute, they are required to return immediately all locker keys and other Institute property.

It is taken for granted that students enter the Institute with serious purpose. The moral tone is exceptionally good; and the honor system prevails in examinations, and in all student affairs. A student who is known to be exercising a harmful influence on the student life of the Institute may be summarily dismissed, whatever be his scholastic standing.

SCHOLASTIC GRADING AND REQUIREMENTS

SCHOLASTIC GRADING

The following system of grades is used to indicate the character of the student's work in his various subjects of study:

4 denotes Marked Distinction,
3 denotes Above Average,
2 denotes Average,
1 denotes Below Average,
C denotes Conditioned,
F denotes Failed,
inc denotes Incomplete.

In giving the grade *incomplete* the "inc" must be followed by a number indicating the grade of work and by another number in parenthesis indicating approximately the percentage of the work completed. When so reported the grade of "inc" may, in summing grades, be provisionally considered to correspond to such a number of credits as the Registrar shall determine; but if reported without these specifications it shall not be counted. The instructor's reason for giving the grade and the manner by which the incomplete may be removed must be entered in the space provided for that purpose.

When an incomplete is given because of absence from examinations it may be removed by examinations only if the student has a leave of absence issued by one of the Deans covering the examinations missed.

It is recommended that the grade incomplete be given only in the case of sickness or other emergency which justifies the non-completion of the work at the usual time.

Conditioned indicates deficiencies other than incomplete that may be made up without actually repeating the subject. A grade of 1 is given when the work is completed.

A condition in any term's work must be removed during the next

term in residence on the date fixed for the removal of conditions. Each student should consult with his instructor at least a week in advance of this date. Any condition not so removed automatically becomes a failure, unless otherwise recommended by the instructor at the time the condition is given.

Failed means that credit may be secured only by repeating the subject, except that in special cases the Registration Committee may, with the instructor's approval, authorize a removal of an "F" by three three-hour examinations.

Term examinations will be held in all subjects unless the instructor in charge of any subject shall arrange otherwise. No student will be exempt from these examinations. Leave of absence from examinations may be obtained only from the Deans, and will be granted only in the case of sickness or other emergency.

SCHOLASTIC REQUIREMENTS

All freshman and sophomore students are required to meet certain scholastic standards as outlined below. Students transferring from other colleges into the junior, senior, or Master of Science divisions are also subject to these restrictions until they have satisfactorily completed three full terms of residence at this Institute. In addition, students who have been reinstated to junior standing after having failed to make the required number of credits in the sophomore year are subject to these scholastic requirements in the junior year and also in the senior year if the junior work is not satisfactory.

Each course in the Institute is assigned a number of *units* corresponding to the total number of hours per week devoted to that subject, including classwork, laboratory, drawing, and field work, and normal outside preparation. The number of *credits* allowed for each subject is the number of units multiplied by the grade received: thus, a student receiving a grade of "3" in a twelve unit course receives 36 credits for this course.

Credits are not given for work in physical education or in assembly.

Probation. Any freshman, sophomore, or new transfer student who fails to receive 72 credits during any one term will be placed on

probation. A student on probation must withdraw from all extra-curricular activities and outside employment or must reduce the number of subjects he is carrying sufficiently to enable him to meet the scholastic requirements in succeeding terms. His program of scholastic and outside activities must be arranged with and approved by his Dean.

Ineligibility for registration. A freshman, sophomore, or new transfer student is ineligible to register:

(a) If he fails during any one term to receive 54 credits.
(b) If, after being placed on probation, he fails during *any* subsequent term to receive 72 credits.
(c) If he fails for the school year to receive a total of 270 credits.

A student ineligible for registration because of failure to meet the requirements stated in the preceding paragraph may, if he desires, submit immediately to the Registrar a petition for reinstatement, giving any reasons that may exist for his previous unsatisfactory work and stating any new conditions that may lead to better results. Each such application will be considered on its merits. A reinstated student who again fails to fulfil the scholastic requirements for registration will be granted a second reinstatement only under very exceptional conditions.

Departmental regulations. Any student whose grade-point average (credits divided by units) is less than 1.9 in the subjects listed under his division* may, at the discretion of his department, be refused permission to continue the work of that option. Thus, a student finishing his junior year in electrical engineering, whose grade-point average in the freshman, sophomore, and junior courses in his *division* (including physics, mathematics, and electrical engineering) was less than 1.9, could be refused permission by the electrical engineering depart-

*The curriculum of the Institute is organized under six divisions, as follows:
Division of Physics, Mathematics, and Electrical Engineering.
Division of Chemistry and Chemical Engineering.
Division of Civil and Mechanical Engineering and Aeronautics.
Division of the Geological Sciences.
Division of Biology.
Division of the Humanities.

ment to continue with *senior* courses in the electrical engineering option. Such disbarment, however, does not prevent the student from continuing in some other department provided permission is obtained, or from repeating courses to raise his average in his original option.

Freedom from scholastic restrictions. After a student has completed at least three full terms of residence at the Institute and has been registered for his junior year, he shall not be placed on probation nor shall he be refused registration on account of failure to receive a prescribed number of credits during the preceding term or terms, except that a student who is *reinstated* to enter the junior year is subject to the above-outlined scholastic requirements during his junior year, *and with the further exception that any junior or senior student who fails to make 54 credits in any one term is ineligible for registration.*

Graduation requirement. To qualify for graduation a student must complete the prescribed work in some one option of the course in engineering or of the course in science with an average grade of 1.9 and with a total of at least 1080 credits.

Honor standing. At the close of each school-year the Committee on Honor Students awards *honor standing* to approximately 15 students who have completed the freshman year, and to 10-15 students who have completed the sophomore year. To each of these students is also awarded a *prize scholarship* carrying half tuition. These awards are based primarily on the scholastic records of the students. Any holder of such a scholarship who in any subsequent term fails to maintain a scholastic standard set by the Committee automatically loses his honor standing and scholarship for the remainder of the school-year.

Honor standing entitles the student to such special privileges and opportunities as excuse from some of the more routine work, instruction in "honor sections," and admittance to more advanced subjects and to research work, but a student in honor standing may not be admitted to an honor section in a particular subject unless he has obtained a grade of 3 or better in the work prerequisite to that subject.

A student will be *graduated with honor* who has received on the average throughout his course 130 credits per term which result from grades of 3 and 4, provided also that he maintains such an average through the three terms of the *senior* year. In addition, a student may be graduated with honor under joint recommendation of his department and the Honors Committee, and approval of the faculty.

Excess or less than normal units. If for any reason a student is carrying less than 40 units, the credits required (as stated on page 92) shall be prorated on the basis of 40 as a standard. For example, a freshman, sophomore, or new transfer carrying 30 units of work shall be expected to obtain three-fourths of 72, or 54 credits, to remain off probation.

Applications for registration in excess of the prescribed number of units, or for less than 25 units, must be approved by the Registration Committee.

Leave of absence. Prolonged leave of absence must be sought by written petition to the faculty, and the student must indicate the length of time, and the reasons, for which absence is requested. In case of brief absences from any given exercise, arrangements must be made with the instructor in charge.

Freshmen should make application, shortly before the close of the school year, for admission to the second year of the Course in Engineering or of the Course in Science.

CANDIDACY FOR THE BACHELOR'S DEGREE

A student must file with the Registrar a declaration of his candidacy for the degree of Bachelor of Science on or before the first Monday of November preceding the date at which he expects to receive the degree. His record at the end of that term must show that he is not more than 21 units behind the requirement in the regular work of his course. All subjects required for graduation, with the exception of those for which the candidate is registered during the last term of his study, must be completed by the second Monday of May preceding commencement.

STUDY AND RESEARCH AT THE CALIFORNIA INSTITUTE

PHYSICS

The distinctive feature of the undergraduate work in physics at the California Institute is the creative atmosphere in which the student at once finds himself. This results from the combination of a large and very productive graduate school with a small and carefully selected undergraduate body.

Since the best education is that which comes from the contact of youth with creative and resourceful minds, the members of the staff of the Norman Bridge Laboratory of Physics have been from the beginning productive physicists rather than merely teachers. The instruction is done by the small group method, twenty to a section, save for one rather elaborate demonstration lecture each week throughout the freshman and sophomore years. All the members of the staff participate in these lectures and almost all give at least one undergraduate course. The entering freshman thus makes some contact in his first year with practically all of the members of the staff, and he has the opportunity to maintain that contact throughout his four undergraduate years, and his graduate work as well, if he elects to go on to the higher degrees.

In order to provide the thorough training in physics required by those who are going into scientific or engineering work, two full years of general physics are required of all students. Those who desire to major in physics take during their junior, senior and fifth years intensive problem type courses that provide a more than usually thorough preparation for graduate work. For those who do not expect to go on into graduate work, an "Applied Physics Option" is provided, in which some of the mathematics and problem courses are replaced by engineering subjects. Many of the undergraduate students who elect physics are given also an opportunity to participate in some one of the thirty to sixty research projects which are always under way in the

Norman Bridge Laboratory of Physics, and the graduate seminars are open to undergraduates at all times.

Graduate students should complete as soon as possible the courses required for admission to candidacy for the doctor's degree. (See pp. 146-152.) These provide an unusually thorough grounding in the fundamentals of physics, and the student learns to use these principles in the solution of problems of all kinds.

In general, also, graduate students should begin research during their first year and continue it through their whole graduate period. The Norman Bridge Laboratory of Physics is equipped to carry on research in all the principal fields of physics.

It provides 65 rooms for research in addition to class and lecture rooms, the physics library, offices, laboratories for advanced and undergraduate instruction, shops, switchboard, apparatus, storage-battery, and machinery rooms. Equipment for making liquid air, hydrogen, and helium has been installed, and liquid air and liquid hydrogen are available in sufficient quantities for low temperature researches. Special facilities for research in the field of radiation are provided in the W. K. Kellogg Laboratory of Radiation and the High-Potential Research Laboratory with their million-volt transformers and high potential X-ray equipment. In the Kellogg Laboratory selected cases of inoperable cancer are being treated with 850,000 volt X-rays, and in both laboratories important work in nuclear physics and the purely physical phases of high-voltage X-rays are being carried on.

The student may either select his own problem in consultation with the department or may work into some one of the research projects already under way. The list of "Publications of the Staff" on pp. 119 to 135 of this catalogue may be consulted for information regarding the type of work in progress. The average yearly output of the laboratory for many years has been from fifty to sixty major papers.

There are three general seminars or research conferences per week which are regularly attended by all research workers and all graduate students. In addition, there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics

and several seminars on special fields of work such as "X-Radiation," "Nuclear Physics," "Metals," "Physics of Solids," and "Ultra-Short Electromagnetic Waves."

The main outlets for the graduates in physics of the Institute are positions in colleges and universities and in the increasing number of industrial research laboratories of the country.

MATHEMATICS

Work in pure mathematics leading to the degree of Doctor of Philosophy was initiated by the Institute in 1926-1927. Candidates for the degree are expected to acquire a reasonable familiarity with some of the major applications of mathematics to the physical sciences. The attention of those intending to take advanced courses in mathematics is particularly directed to the foreign language requirements of mathematical work beyond the bachelor's degree.

CHEMISTRY AND CHEMICAL ENGINEERING

The Gates and Crellin Laboratories of Chemistry consist of three adjacent units. The first two are the gift of the late Messrs. C. W. Gates and P. G. Gates. The third unit, which has just been completed and which affords new space approximately equal to that of the first two units, is the gift of Mr. and Mrs. E. W. Crellin.

These three units include laboratories used for undergraduate instruction in inorganic, analytical, organic, and physical chemistry, and instrumental analysis; they also include class-rooms, demonstration lecture rooms, and a chemistry library. The remaining space in these buildings is largely devoted to facilities for research. There are numerous individual laboratories for inorganic, physical, organic, and biochemical research. Special research facilities include an instrument shop, a students' shop, storage battery rooms, and photographic dark rooms as well as the usual machinery, switchboard, and service rooms.

With the Gates and Crellin Laboratories is associated the Research Laboratory of Applied Chemistry, which is located in the Engineering Research Building. This research laboratory has available a variety of

equipment for carrying on chemical reactions on a fifty or a hundred pound scale. The machinery for the various unit operations is as nearly like commercial plant equipment as is consistent with its size. The laboratory is especially well equipped for the investigation of the thermodynamic properties of fluids at moderately high pressures.

The undergraduate instruction is so arranged that in the last two years of the undergraduate course in science there are offered to students an Option in Chemistry and an Option in Applied Chemistry. These options, especially when followed by the fifth-year courses in these subjects, prepare students for positions as teachers and investigators in colleges and universities, as research men in the government service and in industrial laboratories, as chemists in charge of the operation and control of manufacturing processes, and, in the case of the fifth-year Chemical Engineering Course, for the management and development of chemical industries on the chemical engineering side. For students who desire to enter the field of chemical research, for which there are now professional opportunities both on the scientific and applied sides, more specialized study and research leading to the degree of Doctor of Philosophy are provided at the Institute in the fields of inorganic, physical, and organic chemistry.

First year chemistry, which is taken by all freshman students of the Institute, puts special emphasis on the fundamental principles of chemistry. For two terms this course centers around the chemistry of acids, bases, salts, metals, and non-metals. The third term is devoted to elementary qualitative analysis in class and laboratory, accompanied by lectures in the various fields of chemistry by staff members of the division.

In the conduct of the course much effort is given to provide opportunities for interesting and fruitful experiments in the laboratory and to coordinate the work of the laboratory, class room, and lectures.

The second-year work in chemistry, which is taken by all students in the course in science, consists on the laboratory side of gravimetric and volumetric, advanced qualitative, and electrometric analysis: in the class work emphasis is placed on the principles relating to mass-action, the ionic theory, oxidation, and the periodic law. In the

second and third terms, and also in the subjects of physical and organic chemistry taken in the later years, the abler students, after a few weeks of introductory work, may undertake minor researches in place of the regular work.

The chemical subjects of the junior and senior year consist of courses in physical, advanced inorganic, organic, and applied chemistry. The junior and senior courses in physical chemistry, here known as "Chemical Principles," are not descriptive courses of the usual type; but from beginning to end are presented as a series of problems to be solved by the student. Also in the subjects of organic and applied chemistry problems are a feature.

The supervision of the research work of graduate students is distributed among the whole staff of the Division of Chemistry. Each staff member takes charge of only a small number of students who desire to work in his special field, so that each student receives a large amount of attention. Thus in physical chemistry the lines of research now being actively pursued by graduate students in cooperation with the staff are: thermodynamic studies including low temperature calorimetry, reduction-potentials in solution, especially of the rarer elements; rates of homogeneous reactions; photochemical reactions; band spectra and Raman spectra in their chemical relations; crystal and molecular structure determined by the diffraction of X-rays and of electrons and correlated with the newer quantum theories; and application of magnetic methods to chemical problems. In organic chemistry the main lines of research now in progress are investigation on plant hormones; studies of the Walden inversion; work on unsaturated compounds, with especial reference to isomerism, hydration, and complex formation; and the study of the chemistry of blood.

ENGINEERING

Courses are offered at the Institute in Civil, Mechanical and Electrical Engineering. There are also courses in Aeronautical Engineering and Applied Chemistry, which are described under the respective heads of Aeronautics and Chemistry.

The plan of instruction in Engineering and Applied Chemistry embodies a four-year course for the degree of Bachelor of Science, and a fifth year of graduate study, quite definitely outlined within the selected field, leading to the degree of Master of Science. Additional work is offered leading to the degree of Doctor of Philosophy. The civil, mechanical and electrical engineering groups are not separated until the third year, all students following the same program of the fundamental subjects, mathematics, physics and chemistry, supplemented by their general applications in surveying, mechanism, mechanics, strength of materials, direct and alternating currents, heat engines and hydraulics. The divergence between the different branches occurs in the third and fourth years when the study of the professional subjects of specialized nature is introduced. Courses in the humanities—English, history, and economics—are included in each year of the curriculum.

The four-year undergraduate courses in engineering are well balanced foundations for entrance into many opportunities within the respective fields. However, those students who wish to prepare for careers in the more intensive technical phases of engineering and who have shown capacity to do advanced work are expected to take the fifth year, which represents additional professional subjects and work in both design and research. While the work of the fifth year is prescribed to a considerable extent, it offers time and encouragement for the student to engage in research in a field of his own selection under the guidance of a staff representing a wide range of experience and current activity.

CIVIL ENGINEERING

The branches of Civil Engineering in which advanced work is offered include the control, development and conservation of water; the analysis of structures with particular reference to those types achieving economy through continuity of arrangement; the study of earthquake effects and means of resisting them; investigation of stresses in dams and the design of different types of dams; the study of the increasingly important problems of sanitation, sewage treat-

ment and disposal works; the location, design, construction and operation of railroads and highways; and the study of soil mechanics as related to foundations, earth dams, stability of slopes, and other earthwork problems.

MECHANICAL ENGINEERING

Advanced work in Mechanical Engineering is offered in the following fields: machine design, involving the properties of materials and the processes of production; metallography, the structure of metallic alloys and effects of heat treatment; thermodynamics and power plant design and analysis; internal combustion engines; refrigeration; heating and ventilating; air conditioning; hydrodynamics; and hydraulic machinery.

HYDRAULIC ENGINEERING

Due to the recent establishment of research laboratories at the Institute covering several of the broader fields of hydraulic engineering, both from the hydraulic machinery and the hydraulic structures point of view, the opportunities for advanced study and research in such fields are exceptionally good. The following researches are now being carried on or are just being completed in these laboratories in cooperation with the Metropolitan Water District of Southern California, the Los Angeles County Flood Control District, and the Soil Conservation Service of the U. S. Department of Agriculture:

(a) Investigation of the characteristics of high head centrifugal pumps.

(b) Investigation of the velocity distribution in the case and at impeller exit of a centrifugal pump.

(c) Study of friction losses at partial openings of large control valves at high Reynolds' numbers.

(d) Effect of entering velocity distribution upon the coefficient and the performance of Venturi meters with low contraction ratios.

(e) Study of performance characteristics of centrifugal pumps under reverse flow conditions.

(f) Study of friction losses in vane elbows used with liquids.

(g) Study of superelevation in curved channels with supercritical velocities of flow.

(h) Investigation of effect of suspended load on the velocity distribution in channels.

(i) Determination of rate of reduction of bed load in natural streams.

(j) Model studies of economic control of river channels.

HYDRAULIC STRUCTURES LABORATORY. The hydraulic structures laboratory is located out of doors adjoining the undergraduate hydraulic laboratory. At present the equipment includes: (a) A model basin of about 2000 square feet in which river, harbor, and beach problems can be studied. In addition to metered water inlets and outlets at three points, it is provided with a wave machine the full width of the basin and an automatic tide machine which together make it possible to superimpose waves of various magnitudes, frequencies, and directions upon any desired tide cycle. This was first constructed in cooperation with the Los Angeles Gas and Electric Corporation and the Los Angeles County Flood Control District for use in a study of the effect of proposed changes in the outlet of the San Gabriel River at Alamitos Bay. Since the completion of that work it has been in use on other cooperative river and harbor studies. (b) A channel platform 10 feet wide and 100 feet long for studying high velocity flow. This platform can be adjusted to any gradient up to 12 per cent and is provided with a metered water supply of 6 cubic feet per second. It has been installed in cooperation with the Los Angeles County Flood Control District to study the phenomena encountered in flood control channels in foothill regions where the flow velocity is above the critical. (c) A concrete flume 5 feet wide, 5 feet deep, and 35 feet long for use in weir, spillway, and allied problems requiring a deep basin. This flume is provided with a metered water supply at two points. It has been constructed in cooperation with the California Forest Experiment Station of the U. S. Forest Service for the study of some of the problems arising at the San Dimas Experimental Forest installation.

HYDRAULIC MACHINERY RESEARCH LABORATORY. The hydraulic machinery laboratory initially installed at the Institute for studies of the pumping problems of the Metropolitan Water District of Southern California, offers unique opportunities for research on centrifugal pumps and hydraulic turbines and for various other investigations in hydrodynamics. Included in the facilities are an electric dynamometer of special design capable of absorbing or delivering 500 h.p. and operating at speeds up to 5,500 r.p.m.; main service pumps capable of delivering 16 cu. ft. of water per sec. and developing heads up to 750 ft. of water; two pressure tanks of 1,000 cu. ft. capacity each and designed for a working pressure of 300 lbs. per sq. in.; two accurately calibrated volumetric measuring tanks of 300 and 1,000 cu. ft. capacity; and other smaller pumps and miscellaneous apparatus. Instrumental equipment designed by the Institute staff provides means for measuring pressures, rates of flow, torques, and speeds with a precision of approximately 0.1 per cent. Included in this is a system of speed regulation for the dynamometer which insures constant speed independent of the load in steps of ½ revolution per minute from 500 r.p.m. to 5,500 r.p.m. To insure precision of measurements an independent time standard of the quartz crystal type has been installed. This laboratory is available for the use of the staff and qualified students.

SOIL CONSERVATION LABORATORY. During the early part of 1935 an agreement was reached between the Soil Conservation Service of the U. S. Department of Agriculture and the California Institute of Technology which resulted in the establishment of a cooperative laboratory for the purpose of studying the hydraulic aspects of soil erosion and the flow characteristics of streams carrying suspended and bed loads. To house that part of the work to be carried out on the campus a one-story building has been erected. It has a floor space of about 4,500 square feet and contains the equipment used in the study of the more fundamental aspects of soil erosion. This equipment includes: (a) a transportation flume designed to study primarily the flow of a fluid carrying a suspended load. It is of the closed

circuit type and circulates both the water and the solids in suspension. It is about 70 feet long and has an adjustable gradient. The maximum rate of flow is 5 cubic feet per second. (b) A flume for the study of rate of reduction of bed load. This is also of the circulating type with a mechanical elevator for the larger particles of the bed material. (c) A glass-walled flume for special studies. In addition to this apparatus, the building provides space for a fineness laboratory and shop space for the construction of models and instruments for use in the investigations. (d) For studies of field problems an outdoor model basin has been erected with provision for either clear or silt-laden flow. The length is 60 feet and the maximum rate of flow is 5 cubic feet per second.

ELECTRICAL ENGINEERING

The field of electrical engineering affords opportunity for many choices of life work. Some of these require only the preparation provided in the four-year undergraduate courses, whereas adequate preparation for the more technical work incident to the design and operation of electrical equipment requires the completion of the five-year course. Still other fields of endeavor call for a knowledge of mathematics, physics, and electrical engineering far in excess of that obtainable in the four- and five-year courses. To meet this need the Institute has provided courses of graduate study and research in electrical engineering which may be taken by students who have completed the five-year engineering course at the Institute, or by students from other colleges who have substantially the same preparation. These courses provide for advanced work in the application of mathematical analysis and physical laws to mechanical and electrical problems incident to electrical design and research, electric transients including lightning phenomena, high voltage production and transmission, electrical engineering problems involving the use of vacuum tubes, and problems relating to the generation and distribution of electrical power for lighting and industrial purposes.

Students desiring to become research men, college teachers or

professional experts in electrical engineering may continue their work for the degree of Doctor of Philosophy.

This graduate work in electrical engineering also greatly strengthens the undergraduate courses by bringing students who feel the five and four-year courses are best adapted to their needs in close touch with research men and problems, and provides special work for undergraduate students wishing to do a limited amount of research.

Of the several electrical engineering laboratories at the California Institute, the High-Potential Research Laboratory is the most outstanding. This building and the million-volt transformer were provided by the Southern California Edison Company, Ltd. The million-volt transformer, which was designed by Professor R. W. Sorensen, has a normal rating of 1,000 kilovolt amperes but is capable of supplying several times the rated load at the above potential, with one end of the winding grounded, and a 1,000 kilovolt surge generator supplemented by cathode-ray oscillographs and other apparatus used in the study of electric surges (artificial lighting) and its effect upon electrical machinery. This laboratory is used both for the pursuit of special scientific problems connected with the structure of matter and the nature of radiation, and for the conduct of the pressing engineering problems having to do with the improvement in the art of transmission at high potentials. It also provides opportunities for instruction in this field, such as are not at present easily obtainable by students of science and engineering. The other facilities include well-equipped laboratories for undergraduate, graduate, and special research work in dynamo-electric machinery and electronics. Also, seven research rooms are available for graduate students working on special problems.

AERONAUTICS

The Graduate School of Aeronautics and the Daniel Guggenheim Laboratory of Aeronautics connected with this school were established at the Institute with the aid of the Daniel Guggenheim Fund for the Promotion of Aeronautics in 1928. Since this time an inten-

sive program of instruction and research has been pursued in the fields of Aeronautics, Meteorology and the allied sciences. The Director of the Laboratory, Dr. Theodore von Kármán, serves also as advisor for the Daniel Guggenheim Airship Institute in Akron, Ohio. The cooperation between the two institutions permits the inclusion of problems connected with "lighter-than-air" craft in the school's activities.

The following program of instruction and research is now in progress:

1. A comprehensive series of theoretical courses in aerodynamics, hydrodynamics, meteorology and elasticity, with the underlying mathematics, mechanics, thermodynamics and physics of metals.

2. A group of practical courses in airplane design conducted by the Institute's experimental staff in cooperation with practicing engineers in the vicinity.

3. A course in meteorology, with special reference to the problems of weather forecasting for aeronautical operations. The course includes an introduction to modern dynamic meteorology and to the theory and practice of weather forecasting and mapping, using the "air mass analysis" methods.

4. Experimental and theoretical researches on
   (a) the basic problems of flow in real fluids with regard to the scientific foundations of technical hydro- and aerodynamics;
   (b) the basic problems of Applied Mechanics which relate to the properties of materials and the theory of elasticity;
   (c) practical problems in aerodynamics and structures, especially as applied to aeronautics;
   (d) meteorological problems dealing in particular with the properties and behavior of air masses;
   (e) the development of meteorological instruments, especially of the radiometeorograph type.

The largest item of equipment available for experimental research is a wind tunnel of the Göttingen closed circuit type with a working section 10 feet in diameter. Provision is made for using the working section either as an open or closed type. A 750 horsepower, direct-current motor drives a 15-foot propeller, and a wind velocity of considerably more than 200 miles per hour has been produced. A complete set of aerodynamical balances permits the rapid testing of complete airplane models as well as the undertaking of all types of scientific investigations in the wind tunnel. A fluid mechanics laboratory contains several smaller wind tunnels and a considerable amount of auxiliary apparatus especially suitable for the study of the basic problems connected with turbulent flows. A large structures laboratory has been equipped with specially designed testing machines for researches dealing chiefly with the problems connected with the modern use of stressed skin or monocoque structures. A completely equipped photoelasticity laboratory is being used for researches on the distribution of stresses in various complicated types of structure. The practical work in synoptic meteorology is facilitated by a teletype installation connecting the laboratory with the U. S. Weather Bureau network of observing stations. Complete instrumental equipment is available for meteorological instruction and research. In addition to the above special types of equipment, shop facilities are available to students engaged in research problems.

The facilities of the Institute are available for students desirous of taking higher degrees, and for qualified workers who wish to carry out researches in the fields detailed above. A few fellowships can be granted to selected men.

As in the older divisions of physics, chemistry, and mathematics, emphasis is placed primarily upon the development of graduate study and research; but provision has also been made in the four-year undergraduate course in Engineering for work leading to such graduate study and research. This affords a broad and thorough preparation in the basic science and engineering upon which aeronautics rests.

As in the other branches, there are offered in aeronautics definite graduate courses leading to the degree of Master of Science. Since not less than two years of graduate work are required to attain proficiency in Aeronautics or Meteorology, there may be awarded at the end of the first year the degree of "Bachelor of Science for the completion of a Course in Aeronautics (or Meteorology)" while the degree of "Master of Science for the completion of a Course in Aeronautics (or Meteorology)" is granted after the complete two-year course.

The graduate courses may be taken either by students who have completed a four-year course at the Institute, or by students from other colleges who have had substantially the same preparation. The field of aeronautical engineering is so many-sided that a student who has completed the undergraduate course either in engineering or in science will be admitted to the fifth-year course. The sixth-year work, however, may be taken only by students who have completed the fifth-year course at the Institute or who have had substantially the same preparation elsewhere.

Still more advanced study and research are offered for the degree of Doctor of Philosophy. This degree is given under the same general conditions as those that obtain in the other courses offered at the Institute.

GEOLOGICAL SCIENCES

BALCH GRADUATE SCHOOL

Through the generosity of Mr. and Mrs. Allan C. Balch the Balch Graduate School of the Geological Sciences was established at the California Institute in 1929. This school comprises the staff offering instruction in the various branches of geology, vertebrate and invertebrate paleontology, geophysics and geophysical prospecting, and seismology, research in the last named field being conducted in cooperation with the Carnegie Institution of Washington.

Graduate courses in the geological sciences may be pursued either by students who have completed the four-year course at the Institute

or by students from other colleges who present substantially the same preparation.

The curriculum outlined for undergraduate students provides a broad and thorough preparation in the basic sciences of physics, chemistry, and mathematics and in certain engineering subjects, followed by an introduction to the fundamental principles of geology, paleontology and geophysics. Fifth-year courses lead to the degree of Master of Science. During the senior year of the undergraduate curriculum in the geological sciences and throughout the fifth and later years much time is devoted to investigation and field work. Students desiring to become research workers in the geological sciences or professional geologists, paleontologists, or geophysicists should continue their studies at least two years beyond the master's degree as candidates for the degree of Doctor of Philosophy.

NEW GEOLOGICAL BUILDINGS

Two new buildings are being constructed on the Institute campus for the geological sciences, to be ready for use in the Summer of 1938. Both structures are memorials to men who were very active in the mining industry. The eastern of the two is to be known as the Charles Arms Laboratory of the Geological Sciences and is the gift of the late Mr. Henry M. Robinson and Mrs. Robinson in memory of Mrs. Robinson's father. It is 125 feet in length by 56 feet in width, with a south wing about 45 feet by 40 feet to be used for museum purposes. The western of the two structures is given by Mrs. Seeley W. Mudd as a memorial to her late husband. Its dimensions are 166 feet by 56 feet. Each building has five floors and the total space available for instruction and research in the geological sciences will probably exceed that devoted to these purposes in any other institution in America. The internal arrangement of the buildings is such as to provide suites of rooms adapted to and equipped for the different branches of the geological sciences. Adequate office space will be available for all graduate students in geology, paleontology, and geophysics.

INSTRUCTION AND RESEARCH IN THE GEOLOGICAL SCIENCES

Professional careers comparable to those of physicists, chemists, attorneys, or physicians are open to those who complete successfully the curricula for training geologists, paleontologists, or geophysicists. Students who attain a master's degree in geology are prepared to join the geological staffs of oil or mining companies or federal or state geological surveys. For those desiring more complete training, or preparing for university posts, or planning to be consulting geologists, it is desirable that additional graduate work and research be undertaken, leading to the doctor's degree.

Exceptional opportunities for research in the geological sciences exist at the Institute. An almost unrivalled variety of rock types, geologic structures, and physiographic forms occurs within convenient reach of Pasadena. The relatively mild climate permits field studies throughout practically the entire year, and consequently field training is an unusually important part of the department program.

Stratigraphic and faunal studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the Southern Coast Ranges, in which oil fields are located, and in the Mojave Desert region. Thick sections of Paleozoic sediments in southeastern California remain almost unexplored. Structural and physiographic problems in the Coast and Basin Ranges and along the coastal front await critical investigation and frequently involve an interpretation of folding and faulting on a large scale. The many productive oil fields in southern California afford exceptional opportunities to students interested in economic geology. Moreover, the gold, silver, quicksilver, and copper deposits of the Sierra Nevada and Coast Ranges of California are within comparatively easy reach, and the varied metalliferous deposits of Arizona and southern Nevada are also available for visit and research.

Collections available from many invertebrate and vertebrate faunal horizons in the sedimentary record of western North America permit the student interested in paleontology to secure an intimate knowledge of the history of life. Attractive field and laboratory problems are presented by the sequence, correlation, and ecologic relationships

of western faunas, their significance in an interpretation of geologic history, and by the structure, relationships and evolution of specific groups of fossil organisms.

A very wide range of graduate courses is offered in both theoretical geophysics and in geophysics as applied to prospecting for oil and other mineral substances. The geophysical staff comprises four members, devoting themselves to different phases of the subject. Instruction is given in seismic, gravity, electrical, magnetic and other methods of prospecting. Considerable geophysical equipment is available and is used for practical training, and the design and construction of instruments in the shop of the seismological laboratory receive attention. Geophysical researches of various types are constantly being carried on.

SEISMOLOGICAL RESEARCH LABORATORY

The Seismological Research Laboratory is located about three miles west of the Institute on a granite ridge affording firm bedrock foundation for the instrument piers. The investigations at the laboratory relate mainly to earth movements originating within a radius of about two hundred miles. The seismograms from six branch stations, built and maintained with the aid of cooperating agencies in southern California, contribute greatly to these studies.

While devoted mainly to research, the laboratory is open to qualified students registered at the California Institute who desire advanced training in seismology.

The laboratory is operated jointly by the California Institute and the Carnegie Institution of Washington. The general program of research is outlined by a committee consisting of J. P. Buwalda, chairman, and Messrs. J. A. Anderson, Arthur L. Day, Beno Gutenberg, and H. O. Wood.

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology, paleontology and geophysics, as in other branches of science; see pages 153-157.

BIOLOGICAL SCIENCES

A department of Biology, rather than the traditional departments of Botany and Zoölogy, has been established, in order to emphasize the unity of the phenomena of living organisms rather than their manifold diversities. That there are many properties common to the two great branches of the living world has become abundantly manifest in recent years. For example, the same principles of heredity that obtain among flowering plants apply also to human traits, and in their response to light, animals and plants conform to common laws of physics. It is true that, at what may be called the biological level, an immense diversity of form and function manifests itself, but enough insight has already been gained to make evident that this diversity is in large part due to permutations and combinations of relatively few fundamental and common properties. It is in the search for these properties that the zoologist and botanist may profitably pool their interests.

As in the other departments of the Institute, emphasis is placed primarily on research and graduate study; and, even in these directions, no attempt is made to cover at once the whole science of biology, but rather efforts are concentrated on the development of those of its branches which seem to offer the greatest promise as fields of research. Several groups of investigators have been organized in general physiology, biophysics, biochemistry, genetics and experimental embryology. The choice of these fields of modern research implies that emphasis will be laid on the intimate relations of biology to the physical sciences. That a closer association of these sciences with biology is imperative is becoming more and more apparent as indicated by the development of special institutes for such work.

The first unit of the William G. Kerckhoff Laboratories of the Biological Sciences, the present quarters of the department, contains over 60 rooms, including lecture rooms, seminar rooms, undergraduate laboratories, private research rooms, and four constant temperature rooms. For work in plant genetics there is a ten-acre farm with

greenhouses and laboratory located at Arcadia about five miles from the Institute.

A new laboratory, to be devoted mainly to Biochemistry and Physiology, will be completed during the course of the present year. It will be the second unit of the William G. Kerckhoff Laboratories of the Biological Sciences and will more than double the space of the present building. There will be a lecture room seating about 175 persons and a large library which will be a memorial to Mr. William G. Kerckhoff for his generous gift to the Institute.

A marine station has also been established at Corona del Mar. The building contains four large rooms and several smaller ones which give ample opportunity for research work in experimental biology in general. The proximity of the marine station to Pasadena (about 50 miles) makes it possible to supply the biological laboratories with living materials for research and teaching. The fauna at Corona del Mar and at Laguna Beach, which is near-by, is exceptionally rich and varied, and is easily accessible.

There is a small laboratory near the Institute for the study of plant hormones and in connection with this there is to be constructed another laboratory for Plant Physiology, especially equipped for automatic control of light, heat and humidity.

ASTROPHYSICS

The General Education Board provided in 1928 for the construction by the Institute of an Astrophysical Observatory, now well under way, equipped with a 200-inch reflecting telescope and many auxiliary instruments. A prime purpose of the gift is to secure for the new Observatory the advantage, in its design, construction, and operation, of the combined knowledge and experience of the investigators in the research laboratories of the Institute and in the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington. This new project thus continues and extends in a more formal way the cooperation which has been in progress between the

California Institute and the Mount Wilson Observatory for several years, especially in the study of the astronomical, physical, and chemical aspects of the constitution of matter.

The purpose of the Astrophysical Observatory is thus to supplement, not to duplicate, the Mount Wilson Observatory. The increased light-collecting power of the 200-inch telescope will permit further studies of the size, structure and motion of the galactic system; of the distance, motion, radiation, and evolution of stars; of the spectra of the brighter stars under very high dispersion; of the distance, motion, and nature of remote nebulæ; and of many phenomena bearing directly on the constitution of matter.

The new observatory will consist of two main features. One of these is the 200-inch telescope, with its building, dome, and auxiliary equipment, now being erected on Palomar Mountain in San Diego County. The other will be an Astrophysical Laboratory located on the Institute campus, which will serve as the headquarters in Pasadena of the observatory staff and of the Graduate School of Astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations, and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the Institute and the Pasadena laboratory of the Mount Wilson Observatory. Well-equipped shops for the development of new instruments have been erected on the campus, and the Astrophysical Laboratory has been completed, though some of its chief instruments are still in process of construction.

The value of a telescope depends as much upon the efficiency of the instruments and apparatus used to receive, record, and interpret celestial images as upon its optical and mechanical perfection and its light-collecting power. In the present plan, especial emphasis is therefore laid upon the development of all forms of auxiliary apparatus, such as spectrographs and their optical parts; photographic

plates of the various types required for astrophysical and spectroscopic research; radiometers, thermocouples, and photoelectric cells; recording microphotometers and other forms of measuring machines; and laboratory apparatus for reproducing or interpreting celestial phenomena.

An Observatory Council, comprising four members of the Executive Council of the Institute, and also including Dr. Walter S. Adams, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the Observatory Council as its Executive Officer, in direct charge of design and construction. An Advisory Committee, including the Director and Assistant Director of the Mount Wilson Observatory and many other prominent men of science, aid the Observatory Council in determining matters of policy. The organization of the Observatory Council and the personnel of its Advisory Committee are shown on page 52 of this Catalogue.

Any great increase in the size of telescopes requires a long study of the most promising methods of making large paraboloidal mirrors. After much experimental work, a new form of Pyrex glass was chosen as the best available material and a 120-inch disc was received in 1934. The 200-inch disc was received in 1936 and is now in process of being shaped up in the optical shop.

The extensive investigation of primary and auxiliary instruments, which forms such a vital part of the general scheme, has also made marked progress, through the active cooperation of many leading men of science and engineers. Microphotometers, radiometers, photoelectric cells and other instruments of various types have been carefully studied and tested in difficult research problems. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. The short focus spectrograph objective devised by Rayton has greatly increased

the range of the 100-inch telescope and has made possible the recent researches of Hubble and Humason on the expanding universe. A new objective of still shorter focal length has been completed by Beck after the design of the British Scientific Research Association, and successfully tested on Mount Wilson. A very advantageous method of coating telescope mirrors with aluminum instead of silver has been applied by Dr. John Strong to several large mirrors, including that of the 36-inch Crossley reflector on Mount Hamilton and the 60-inch and 100-inch reflectors on Mount Wilson.

It is expected that, after the Astrophysical Laboratory on the campus has been completely equipped, the Institute will offer to competent students the opportunity of pursuing advanced courses of study and research in astrophysics, leading to the degrees of Master of Science and Doctor of Philosophy. Undergraduate students who desire to prepare themselves for such graduate work should take the Physics Option of the course in science.

It should be remembered that the number of positions open to able young men well trained in astrophysics and its related subjects is small. For this reason only those exceptionally well qualified for such work should undertake graduate study and research.

THE HUMANITIES

One of the distinctive features of the California Institute is its emphasis upon the humanistic side of the curriculum. In the degree and genuineness of this emphasis the Institute has differentiated itself from other American schools of science, most of which accord little more than a gesture of recognition to the liberal arts. As a rule, in schools of science and engineering, the professional studies monopolize nearly all the available time and money, leaving the humanities to take what it left, which often turns out to be very little.

The California Institute has been a pioneer in recognizing the desirability of providing for a generous amount of instruction in the humanities. The faculty, in thorough sympathy with this aim, has

cooperated by eliminating some of the more specialized technical subjects commonly included in undergraduate courses. As a result, it has been found possible to require every student to take, in each of his four undergraduate years, one or more courses of a humanistic character. These courses in the Division of the Humanities cover the field of English and foreign literatures, European and American history, philosophy and social ethics, economics and government. All of them are so planned and articulated that the student obtains a solid grounding, and not merely the superficial acquaintance which is too often the outcome of a free elective system. The standards of intellectual performance in these studies are maintained on the same plane as in the professional subjects. Every effort is made to impress upon undergraduates the fact that there is an essential unity to all knowledge, and that no man can master science if he sets out to master science only. The history of human achievement has but a single page.

One of the largest and most attractive buildings on the Institute campus is devoted to the work in literature, languages, philosophy, economics, history and government. This Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. It contains lecture rooms, a treasure room for the exhibition of pictures and other works of art, a library—reading room, conference rooms, together with a commodious lounge, which opens upon a walled garden of olive trees. In connection with the acceptance of this gift, a special endowment fund of $400,000 was raised for the support of instruction in the humanistic fields, this amount being subscribed by several friends of the Institute. In 1937 an additional endowment of $750,000 was received from a donor who desires to remain anonymous.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction in the Division of the Humanities during the current year. Among these are Professor Edwin F. Gay, formerly of Harvard University, Professor Allan

Nevins of Columbia University, Mr. Philip Guedalla of London, Mr. Godfrey Davies and Mr. Louis B. Wright, of the Huntington Library, and Professor Ricardo Quintana of the University of Wisconsin. It is anticipated that with the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars.

PUBLICATIONS OF THE STAFF

OCTOBER 1, 1936, TO SEPTEMBER 30, 1937

Books and Pamphlets

The Production and Properties of Positrons. (Nobel Lecture presented at Stockholm, Dec. 12, 1936).
Carl D. Anderson, P. A. Norstedt & Söner, 1937; reprinted, Bulletin of the California Institute of Technology, 46, 1 (1937).

The Handmaiden of the Sciences (Mathematics).
E. T. Bell, 216 pages, Williams and Wilkins, 1937.

Men of Mathematics.
E. T. Bell, 592 pages, Simon and Schuster, 1937; English Edition, 653 pages, Victor Gollance, Ltd., London, 1937.

Hydraulics (fourth edition, completely rewritten).
R. L. Daugherty, 458 pages, McGraw-Hill Book Company, Inc., 1937.

The Early Stuarts, 1603-1660.
Godfrey Davies, 452 pages, Oxford, 1937.

Genetics and the Origin of Species.
Th. Dobzhansky, 364 pages, Columbia University Press, 1937.

L'Effet de Position et la Théorie de l'Hérédité.
Th. Dobzhansky, 39 pages, Herman et Cie, Paris, 1936.

Writing From Experience.
Harvey Eagleson (with Murray G. Hill), 389 pages, F. S. Crofts, 1937.

Textbook of Thermodynamics.
Paul S. Epstein, 406 pages, John Wiley and Sons, 1937.

Economics in a Changing World.
Graham A. Laing, Social Studies Series, 82 pages, American Association of University Women, Washington, D. C., 1936.

Mechanics, Molecular Physics, Heat and Sound.
Robert Andrews Millikan, Duane Roller, and Earnest Charles Watson, 498 pages, Ginn and Company, 1937.

Major Changes in the Governments of Europe Since 1930 (1937 Supplement to *The Governments of Europe*, revised edition).
William B. Munro, 77 pages, The Macmillan Company, 1937.

Three Typical Beliefs.
Theodore Gerald Soares, 113 pages, The University of Chicago Press, 1937.

Problemes Génétiques.
A. H. Sturtevant, 20 pages, Herman et Cie, Paris, 1936.

The Social Security Act and Its Influence on Security Values.
R. E. Untereiner, 20 pages. Privately printed and distributed by Banks, Huntley & Co., Los Angeles, and Brush Slocumb & Co., San Francisco (1937).

Phytohormones.
F. W. Went and Kenneth V. Thimann, 294 pages, The Macmillan Company, 1937.

Scientific and Literary Articles

NORMAN BRIDGE LABORATORY OF PHYSICS

Models to Illustrate Gyromagnetic and Electron-Inertia Effects.
S. J. Barnett, *Am. Phys. Teacher*, 5, 1-6 (1937).

An Amplifier for the Coincidences of Proportional Wire Counters.
G. Bernadini, D. Bociarelli and F. Oppenheimer, *R. S. I.*, 7, 382-383 (1936).

Ionization of Air by β-Rays as a Function of Pressure and Collecting Field II.
I. S. Bowen and Everett F. Cox, *Phys. Rev.*, 51, 232-234 (1937).

The Influence of the Earth's Magnetic Field on Cosmic-Ray Intensities Up to the Top of the Atmosphere.
I. S. Bowen, R. A. Millikan and H. V. Neher, *Phys. Rev.*, 52, 80-88 (1937).

Measurement of the Nuclear Absorption of Electrons by the Atmosphere Up to About 10^{10} Electron-Volts.
I. S. Bowen, R. A. Millikan, H. V. Neher, *Nature*, 23, 3531 (1937).

Latitude Effect in Cosmic Rays at Altitudes Up to 29,000 Feet.
I. S. Bowen, R. A. Millikan, S. A. Korff and H. V. Neher, *Phys. Rev.*, 50, 579-581 (1936).

***A Method for Sealing β-Magnesia Windows Into Steel Spectroscopic Absorption Furnaces and a Needle Valve for Controlling the Evacuation of Such Furnaces.**
R. T. Brice, *R. S. I.*, 8, 209-212 (1937).

A Determination of h/e from the Short Wave-Length Limit of the Continuous X-Ray Spectrum.
Jesse DuMond and Vernon Bollman, *Phys. Rev.*, 51, 400-429 (1937).

A Direct Spectrum of the Structure and Shift of the Compton Line With Helium Gas as the Scatterer.
Jesse W. M. DuMond and Harry A. Kirkpatrick, *Phys. Rev.*, 52, 419-436 (1937).

A Precision Two Crystal X-Ray Spectrometer of Wide Applicability With Worm Wheel Drive; an Improved Precise Method of Equalizing the Spacing of Worm Wheel Teeth.
Jesse W. M. DuMond and Douglas Marlow, *R. S. I.*, 8, 112-121 (1937).

The Thirty Kilowatt Continuous Imput X-Ray Equipment and High Constant Voltage Generating Plant of the Watters Memorial Research Laboratory at the California Institute of Technology.
Jesse W. M. DuMond and J. Paul Youtz, *R. S. I.*, 8, 291-307 (1937).

***A Determination of e/m for an Electron by a New Deflection Method, II.**
Frank G. Dunnington, *Phys. Rev.*, 52, 475-501 (1937).

***Self-Consistent Field and Bohr's Nuclear Model.**
W. M. Elsasser, *Phys. Rev.*, 51, 55 (1937).

On the Equation of Diffusion.
Paul S. Epstein, *Proc. Nat. Acad. Sci.*, 23, 94-98 (1937).

Physics and Metaphysics.
Paul S. Epstein, *Sci. Monthly*, 45, 49-54 (1937).

Application of Gibbs' Methods to Modern Problems of Thermodynamics.
Paul S. Epstein, *Commentary on the Scientific Writings of J. W. Gibbs*, II, 59-112 (1936).

Critical Appreciation of Gibbs' Statistical Mechanics.
Paul S. Epstein, *Commentary on the Scientific Writings of J. W. Gibbs*, II, 461-520 (1936).

Gibbs' Methods in Quantum Statistics.
Paul S. Epstein, *Commentary on the Scientific Writings of J. W. Gibbs*, II, 521-584 (1936).

---

*Not available for distribution.

Discussion to the Article: The Nonexistence of a Regular Secondary Structure.
A. Goetz, *Zs. f. Krist. A.*, 93, 167 (1936).

***Discussion to the Article: Hot Working, Cold Working, and Recrystallization Structure.**
A. Goetz, *Trans. A. S. M.*, 1037, December (1936).

Intensities of X-Ray Reflections From Bismuth Crystals Between 25° and 530° Abs.
Alexander Goetz and Robert B. Jacobs, *Phys. Rev.*, 51, 151-159 (1937).

The Radioactive Isotope of Rubidium.
A. Hemmendinger and W. R. Smythe, *Phys. Rev.*, 51, 1052-1053 (1937).

The Shape of the Compton Line for Helium and Molecular Hydrogen.
Bruce Hicks, *Phys. Rev.*, 52, 436-442 (1937).

***A Note on Abstract Polynomials in Complex Spaces.**
Ivar E. Highberg, *Journal de Mathematiques Pures et Appliquées*, 60, 307-314 (1937).

Higher Education in Science and Engineering.
W. V. Houston, *Journal of Proceedings and Addresses of the Association of American Universities*, pp. 75-78, November, 1936.

A New Method of Analysis of the Structure of H and D.
W. V. Houston, *Phys. Rev.*, 51, 446-449 (1937).

Physical Content of Quantum Mechanics.
W. V. Houston, *Am. Phys. Teacher*, 5, 49-55 (1937).

The Philosophy of Physics.
W. V. Houston, *Science*, 85, 413-419 (1937).

Thermal Expansion of the Bi Lattice Between 25° and 530° Abs.
Robert B. Jacobs and Alexander Goetz, *Phys. Rev.*, 51, 159-164 (1937).

Dipolverluste und Molekülstruktur.
E. Keutner and G. Potapenko, *Physikalische Zeits.*, 38, 635-636 (1937).

On the Dispersion and Absorption of Ultra-Short Electric Waves.
E. Keutner and G. Potapenko, *Proc. Intern. Congress for Short Waves*, Vienna, 135 (1937).

Anharmonicity Constants of the Potential Function of the Water Molecule.
G. W. King, *Jour. Chem. Physics*, 5, 413-415 (1937).

The Potential Function of the Water Molecule.
G. W. King, *Jour. Chem. Physics*, 5, 405-412 (1937).

***Solvent Refining, a Study of Its Molecular Physics I.**
S. Kyropoulos, *Refiner and Nat. Gas. Mfgr.*, 16, 131 (1937).

***Solvent Refining, a Study of Its Molecular Physics II.**
S. Kyropoulos, *Refiner and Nat. Gas Mfgr.*, 16, 188 (1937).

***A Method of Measuring the Nonviscous Coefficient of Friction of Lubricants.**
S. Kyropoulos and E. I. Shobert, *Instruments*, 10, 185 (1937).

***A Simple Method for Measuring the Coefficient of Nonviscous Friction of Thin Lubricating Layers.**
S. Kyropoulos and E. I. Shobert, *R. S. I.*, 8, 151-158 (1937).

Recent Observations of Cosmic Radiations.
R. M. Langer, *A. S. P.*, leaflet, 104, 1-8, October, 1937.

On the Generation of the Shortest Electric Waves.
C. Y. Meng and G. Potapenko, *Proc. Intern. Congress for Short Waves*, Vienna, 109-111 (1937).

Albert Abraham Michelson.
Robert A. Millikan, *Proc. Am. Acad. Arts and Sciences*, 71, 531-532 (1937).

Award of the Nobel Prize in Physics to Victor F. Hess and Carl D. Anderson.
Robert A. Millikan, *Sci. Monthly*, 44, 94-97 (1937).

*Not available for distribution.

Exploring the Stratosphere for New Electrical Effects.
Robert A. Millikan, *Jour. Franklin Institute*, 224, 145-152 (1937).

***I Believe in God.**
Robert A. Millikan, *Commentator*, 1, 3-5 (1937).

Recent Findings in Cosmic-Ray Researches.
Robert Andrews Millikan, *Sci. Monthly*, 43, 396-401 (1936).

Studies of Cosmic Rays.
Robert A. Millikan, *Carnegie Institution Year Book for 1935-36, No. 35*, 349-352 (1936).

***Vernon Lyman Kellogg.**
Robert A. Millikan, *Science*, 86, 214-215 (1937).

***Precision Cosmic-Ray Measurements Up to Within a Per Cent or Two of the Top of the Atmosphere.**
R. A. Millikan, H. V. Neher and S. K. Haynes, *Phys. Rev.*, 50, 992-998 (1936).

***Erratum: Precision Cosmic-Ray Measurements Up to Within a Per Cent or Two of the Top of the Atmosphere.**
R. A. Millikan, H. V. Neher and S. K. Haynes, *Phys. Rev.*, 50, 1191 (1936).

Note on the Nature of Cosmic-Ray Particles.
Seth H. Neddermeyer and Carl D. Anderson, *Phys. Rev.*, 51, 884-886 (1937).

Note on the Nature of Cosmic-Ray Particles.
J. R. Oppenheimer and R. Serber, *Phys. Rev.*, 51, 1113 (1937).

Secondary Particles From the Penetrating Component of the Cosmic Radiation.
William H. Pickering, *Phys. Rev.*, 51, 628-629 (1937).

***Ein neues Messverfahren zur Bestimmung der ferromagnetischen Eigenschaften von Metallen im Gebiet sehr hober Frequenzen.**
G. Potapenko and R. Sänger, *Zeits. für Physik*, 104, 779-803 (1937).

On the Measurement of the Dispersion and Absorption of Ultra-Short Electric Waves in Dielectrics.
G. Potapenko, *Proc. Intern. Congress for Short Waves*, Vienna, 133-134 (1937).

An Adjustable Vacuum Leak.
W. R. Smythe, *R. S. I.*, 7, 435 (1936).

Radioactive Isotope of Potassium.
W. R. Smythe and A. Hemmendinger, *Phys. Rev.*, 51, 178-182 (1937).

The Present Status of Cosmology.
Richard C. Tolman, *Scientific Monthly*, Dec., 1936, and Jan., 1937.

The Ionization of Neon, Krypton and Xenon by Bombardment With Accelerated Neutral Argon Atoms.
Harold Wayland, *Phys. Rev.*, 51, 31-37 (1937).

***Cooperative Phenomena.**
F. Zwicky, pages 293-307, in "Introduction to Ferromagnetism," by Francis Bitter. McGraw-Hill Publishing Company, 1937.

***Intrinsic Properties of Light and Corpuscles from Distant Sources.**
F. Zwicky, *Proc. Nat. Acad. Sci.*, 23, 106-110 (1937).

Nebulæ as Gravitational Lenses.
F. Zwicky, *Phys. Rev.*, 51, 290 (1937).

***On the Probability of Detecting Nebulæ Which Act as Gravitational Lenses.**
F. Zwicky, *Phys., Rev.*, 51, 679 (1937).

---

*Not available for distribution.

Astrophysical Laboratory

Optical Shop Structural Features.
Byron Hill, *Architectural Concrete*, 2, No. 4, 11-13 (1936).

***As the 200-Inch Telescope Develops.**
C. S. McDowell, Captain, U. S. N., Retired, *Scientific American*, 155, 252-257 (1936).

Medicine in Education.
Max Mason, *Journ. Am. Med. Assn.*, 108, 1455-1457 (1937).

***Some Magnitudes of Nova 618. 1936 Aquilae (I).**
C. F. J. Overhage and F. Zwicky, *Pubs. A. S. P.*, 48, 321-323 (1936).

***Illustrations for "As the 200-Inch Telescope Develops," by C. S. McDowell, Captain U.S.N., Retired.**
Russell W. Porter, *Scientific American*, 155, 252-257 (1936).

What Aluminum Has Done for the Reflecting Telescope.
John Strong, *A. S. P.*, leaflet, No. 96, 4 pages (1937).

***On a New Cluster of Nebulæ in Pisces.**
F. Zwicky, *Proc. Nat. Acad. Sci.*, 23, 251-256 (1937).

***A Super-Nova in NGC 4157.**
F. Zwicky, *A. S. P.*, 49, 204-206 (1937).

W. K. Kellogg Laboratory of Radiation

Disintegration of Nitrogen by Fast Neutrons.
T. W. Bonner and W. M. Brubaker, *Phys. Rev.*, 50, 781 (1937).

The Energy and Absorption of the Gamma-Radiation From Lithium Bombarded by Protons.
L. A. Delsasso, W. A. Fowler and C. C. Lauritsen, *Phys. Rev.*, 51, 143 (A), (1937).

Energy and Absorption of the Gamma-Radiation From $Li^7 + H^1$.
L. A. Delsasso, W. A. Fowler and C. C. Lauritsen, *Phys. Rev.*, 51, 391 (L), (1937).

Gamma-Radiation From Fluorine Bombarded With Protons.
L. A. Delsasso, W. A. Fowler and C. C. Lauritsen, *Phys. Rev.*, 51, 527 (L), (1937).

Radioactive Alpha-Particles From $Li^7 — H^2$.
W. A. Fowler and C. C. Lauritsen, *Phys. Rev.*, 51, 1103 (L), (1937).

Disintegration of Boron by Deuterons.
W. E. Stephens and T. W. Bonner, *Phys. Rev.*, 52, 527 (L), (1937).

Mathematics

Associated Airy Functions in Elasticity and Hydrodynamics.
H. Bateman, *Congres International des Mathematiciens*, Oslo (1936).

The Polynomial Fn (x) and Its Relation to Other Functions.
H. Bateman, *Ann. of Math.*, 38, 303-310 (1937).

Progressive Waves of Finite Amplitude and Some Steady Motions of An Elastic Fluid.
H. Bateman, *Proc. Nat. Acad. Sci.*, 22, 607-619 (1936).

The Arithmetical Function M (n, f, g) and Its Associates Connected With Elliptic Power Series.
E. T. Bell, *Am. Jour. Math.*, 58, 759-768 (1936).

Certain Ternary Cubic Arithmetical Forms.
E. T. Bell, *Duke Math. Jour.*, 3, 289-293 (1937).

An Elementary Device in Diphantine Analysis.
E. T. Bell, *Am. Math. Monthly*, 44, 364-366 (1937).

---

*Not available for distribution.

General Theorems on Numerical Functions.
E. T. Bell, *Journal de Mathematiques Pures et Appliquées*, New Series, 16, 151-154 (1937).

Note on an Easier Waring Problem.
E. T. Bell, *Jour. London Math. Soc.*, 11, 277-278 (1936).

Note on an Inversion Formula.
E. T. Bell, *Am. Math. Monthly*, 43, 464-465 (1936).

The Reciprocal of a Numerical Function.
E. T. Bell, *Tôhoku Math. Jour.*, 43, 77-8 (1937).

Representations in Certain Pure Forms of Degrees Higher Than the Second.
E. T. Bell, *Am. Jour. Math.*, 59, 585-598 (1937).

An Algebraic Identity.
Newman A. Hall, *Jour. London Math. Soc.*, 11, 276 (1936).

Binary Quadratic Discriminants with a Single Class of Reduced Forms in Each Genus.
Newman A. Hall, *Proc. Nat. Acad. Sci.*, 23, 414-415 (1937).

A New Class of Functions of Two Variables Involving Bessel Functions of Half an Odd Integer.
Newman A. Hall, *Bull. Am. Math. Soc.*, 42, 695-698 (1936).

On the Laplacian of a Vector Point Function.
Newman A. Hall and Francis Clauser, *Phil. Mag.*, 22, 967-970 (1936).

***An Independent Set of Postulates for Abstract Linear Spaces.**
I. E. Highberg and A. E. Taylor, *Comptes Rendus Soc. Sci. Varsovie*, 28, 136-142 (1936).

***Functional Equations in Linear Topological Spaces.**
Donald H. Hyers, *Proc. Nat. Acad. Sci.*, 23, 496-499 (1937).

Abstract Covariant Vector Fields in a General Absolute Calculus.
A. D. Michal, *Am. Jour. Math.*, 59, 306-314 (1937).

General Tensor Analysis.
A. D. Michal, *Bull. Am. Math. Soc.*, 43, 394-401 (1937).

Postulates for Linear Connections in Abstract Vector Spaces.
A. D. Michal, *Annali di Matematica Pura ed Applicata*, 197-220 (1936).

Completely Integrable Differential Equations in Abstract Spaces.
A. D. Michal and V. Elconin, *Acta Mathematica*, 68, 71-107 (1937).

Differential Properties of Abstract Transformation Groups with Abstract Parameters.
A. D. Michal and V. Elconin, *Am. Jour. Math.*, 59, 129-143 (1937).

Abstract Euclidean Spaces with Independently Postulated Analytical and Geometrical Metrics.
A. D. Michal, I. E. Highberg, A. E. Taylor, *Annali della R. Scuola Normale Superiore di Pisa (Scienze Fisiche e Matematiche)*, Serie II, Vol. VI, 117-149 (1937).

The Differential in Abstract Linear Spaces with a Topology.
A. D. Michal and E. W. Paxson, *Comptes Rendus des Séances de la Societe des Sciences et des Lettres de Varsovie*, XXIX, 15 pages (1936).

On the Mean Value of r^s for Keplerian Systems.
Simon Pasternack, *Proc. Nat. Acad. Sci.*, 23, 91-94 (1937).

***Sur la Theorie des Fonctions Analytiques dans les Espaces Abstraits.**
A. E. Taylor, *Comptes Rendus of Paris Academy*, 203, 1228-1230 (1936).

A Theory of Integral Invariants.
A. E. Taylor, *Journal de Mathematiques Pures et Appliquées*, XVI, 1 (1937).

***On Postulate Systems for Normed Vector Spaces.**
A. E. Taylor and I. E. Highberg, *Comptes Rendus Soc. Sci. Varsovie*, 28, 142-153 (1936).

*Not available for distribution.

Arithmetic Functions on Rings.
Morgan Ward, *Ann. of Math.*, 38, 725-732 (1937).

Linear Divisibility Sequences.
Morgan Ward, *Trans. Am. Math. Soc.*, 41, 276-286 (1937).

Note on Divisibility Sequences.
Morgan Ward, *Bull. Am. Math. Soc.*, 42, 843-845 (1936).

GATES AND CRELLIN LABORATORIES OF CHEMISTRY

548. The Extraction of Ferric Chloride From Hydrochloric Acid Solutions by Isopropyl Ether.
Gerard J. Forney, Richard W. Dodson, and Ernest H. Swift, *J. Am. Chem. Soc.*, 58, 2573-2577 (1936).

553. Phase Equilibria in Hydrocarbon Systems. XVII. The Ethane Crystal Oil System.
B. H. Sage, J. A. Davies, J. E. Sherborne, and W. N. Lacey, *Ind. Eng. Chem.*, 28, 1328-1333 (1936).

554. The Isomeric 2-Pentenes.
H. J. Lucas and Arthur N. Prater, *J. Am. Chem. Soc.*, 59, 1682-1686 (1937).

555. The Diamagnetic Anisotropy of Aromatic Molecules.
Linus Pauling, *Jour. Chem. Phys.*, 4, 673-677 (1936).

556. The Crystal Structure of the Low Temperature Modification of Thallous Iodide.
Lindsay Helmholz, *Zeit. f. Krist.*, 95, 129-137 (1936).

557. Stereochemical Relationships of the Isomeric 2, 3-Butanediols and Related Compounds; Evidence of Walden Inversion.
Howard J. Lucas and Chester E. Wilson, *J. Am. Chem. Soc.*, 58, 2396-2402 (1936).

558. The Molecular Structures of the Methyl Derivatives of Silicon, Germanium, Tin, Lead, Nitrogen, Sulfur, and Mercury, and the Covalent Radii of the Non-Metallic Elements.
L. O. Brockway and H. O. Jenkins, *J. Am. Chem. Soc.*, 58, 2036-2044 (1936).

559. The Crystal Structure of Aluminum Metaphosphate.
Linus Pauling and J. Sherman, *Zeitschrift für Kristallographie*, 96, 481-487 (1937).

561. The X-Ray Analysis of Crystals.
Linus Pauling, *Current Science*, Special Number, pp. 20-22, January, 1937.

562. The Raman Spectra of Boron Trifluoride, Trichloride, and Tribromide. The Effect of the Boron Isotopes.
T. H. Anderson, Edwin N. Lassettre, and Don M. Yost, *J. of Chem. Phys.*, 4, No. 11, 703-707 (1936).

563. Formation Volumes and Energy Characteristics of Gas Cap Material From Kettleman Hills Field.
B. H. Sage and W. N. Lacey, *A. P. I. Drilling and Production Practice*, 1936; *Oil and Gas Journal*, 35, No. 26, 176-182 (Nov. 12, 1936).

565. On the Application of the Raman-Krishnan Theory to Dipole Moment Measurements by the Dilute Solution Method.
H. O. Jenkins and S. H. Bauer, *J. Am. Chem. Soc.*, 58, 2435-2438 (1936).

566. The Structure of Pentaborane, B_5H_9.
S. H. Bauer and Linus Pauling, *J. Am. Chem. Soc.*, 58, 2403-2407 (1936).

567. The Molecular Structures of the 2-Butenes and the 2, 3-Epoxybutanes.
L. O. Brockway and Paul C. Cross, *J. Am. Chem. Soc.*, 58, 2407-2409 (1936).

568. The CN Bond in Methyl Cyanide and Methyl Isocyanide.
L. O. Brockway, *J. Am. Chem. Soc.*, 58, 2516-2518 (1936).

569. The Hydration of Unsaturated Compounds IV. The Rate of Hydration of Isobutene in the Presence of Silver Ion. The Nature of the Isobutene-Silver Complex.
W. F. Eberz, Henry Welge, Don M. Yost, and H. J. Lucas, *J. Am. Chem. Soc.*, *59*, 45-49 (1937).

570. The Photodecomposition of Ammonia.
Henry J. Welge and Arnold O. Beckman, *J. Am. Chem. Soc.*, *58*, 2462-2467 (1936).

571. The Hydration of Unsaturated Compounds. V. The Rate of Hydration of Acetylene in Aqueous Solution of Sulfuric Acid and Mercuric Sulfate.
R. H. Frieman, E. R. Kennedy, and H. J. Lucas, *J. Am. Chem. Soc.*, *59*, 722-726 (1937).

572. The Adjacent Charge Rule and the Structure of Methyl Azide, Methyl Nitrate, and Fluorine Nitrate.
Linus Pauling and L. O. Brockway, *J. Am. Chem. Soc.*, *59*, 13-20 (1937).

573. The Structures of the Fluorochloromethanes and the Effect of the Bond Type on Chemical Reactivity.
L. O. Brockway, *J. Phys. Chem.*, 41, 185-195 (1937).

574. The Analysis of the Raman Spectra of $Si_2Cl_6(l)$ and of $Si_2H_6(g)$.
Fred Stitt and Don M. Yost, *J. Chem. Phys.*, *5*, 90-96 (1937).

575. Absorption Spectra of the Vapors of Twelve Alcohols and of Nitric Acid in the Region of the O-H Harmonic Band at $\lambda 9500$.
Richard M. Badger and Simon H. Bauer, *J. Chem. Phys.*, *4*, No. 11, 711-715 (1936).

576. Phase Equilibria in Hydrocarbon Systems. XVIII. Thermodynamic Properties of Ethane.
B. H. Sage, D. C. Webster, and W. N. Lacey, *Ind. and Eng. Chem.*, *29*, 658-666 (1937).

577. The Kinetics of the Thermal Isomerization of Cinnamic Acid Catalyzed by Iodine.
Roscoe G. Dickinson and H. Lotzkar, *J. Am. Chem. Soc.*, *59*, 472-475 (1937).

578. The Electron Diffraction Investigation of the Fluorochloromethanes.
L. O. Brockway, *J. Phys. Chem.*, 41, 747-762 (1937).

579. Remarks on the Spectra of Methyl Cyanide and Methyl Isocyanide.
Richard M. Badger and Simon H. Bauer, *J. Am. Chem. Soc.*, *59*, 303-305 (1937).

580. The Magnetic Properties and Structure of Ferrihemoglobin (Methemoglobin) and Some of Its Compounds.
Charles D. Coryell, Fred Stitt, and Linus Pauling, *J. Am. Chem. Soc.*, *59*, 633-642 (1937).

581. The Formula of Ammonium Paramolybdate.
J. H. Sturdivant, *J. Am. Chem. Soc.*, *59*, 630-631 (1937).

582. Note on the Spectra of the Disubstituted Acetylenes and of the Mustard Oils.
Richard M. Badger, *J. Chem. Phys.*, *5*, 178-180 (1937).

***583. The Interpretation of Freezing Point Lowering Data in Terms of Polymerization.**
Edwin N. Lassettre, *J. Am. Chem. Soc.*, *59*, 1383-1387 (1937).

584. The Crystal Structure of Selenium Dioxide.
J. D. MacCullough, *J. Am. Chem. Soc.*, *59*, 789-794 (1937).

***585. The Relation of the Hydrogen Bond to Abnormalities in Molecular Weights of Substances in Solution.**
Edwin N. Lassettre, *Chemical Reviews*, 20, 259-303 (1937).

586. The Structure of the α and β Band Systems of SiF.
Eugene H. Eyster, *Physical Review*, 51, No. 12, 1078-1086 (1937).

587. The Structure of Diborane.
Simon H. Bauer, *J. Am. Chem. Soc.*, *59*, 1096-1103 (1937).

*Not available for distribution.

*589. **The Spectrum Characteristic of Hydrogen Bonds (Letter to the Editor).**
R. M. Badger and S. H. Bauer, *J. Chem. Phys.*, 5, 369 (1937).

591. **The Molecular Structures of the 2, 3-Epoxybutanes: A Correction.**
L. O. Brockway and Paul C. Cross, *J. Am. Chem. Soc.*, 59, 1147-1148 (1937).

592. **Measurement of a Reaction Rate at Equilibrium by Means of a Radioactive Indicator. The Reaction Between Arsenic Acid and Iodide.**
J. Norton Wilson and Roscoe G. Dickinson, *J. Am. Chem. Soc.*, 59, 1358-1361 (1937).

593. **Spectroscopic Studies of the Hydrogen Bond. I. A Photometric Investigation of the Association Equilibrium in the Vapor of Acetic Acid.**
Richard M. Badger and Simon H. Bauer, *J. Chem. Phys.*, 5, 605-608 (1937).

594. **Carbon-Carbon Bond Distances. The Electron Diffraction Investigation of Ethane, Propane, Isobutane, Neopentane, Cyclopropane, Cyclopentane, Cyclohexane, Allene, Ethylene, Isobutene, Tetramethylethylene, Mesitylene, and Hexamethylbenzene. Revised Values of Covalent Radii.**
Linus Pauling and L. O. Brockway, *J. Am. Chem. Soc.*, 59, 1223-1236 (1937).

595. **Argentic Salts in Acid Solution. IV. The Kinetics of Reduction by Water and Formation by Ozone of Argentic Silver in Nitric Acid Solution.**
Arthur A. Noyes, Charles D. Coryell, Fred Stitt, and Alexander Kossiakoff, *J. Am. Chem. Soc.*, 59, 1316-1325 (1937).

596. **Argentic Salts in Acid Solution. V. Oxidation Potentials, Equilibria with Higher Silver Oxides, and Formation of Nitrate Complexes.**
Arthur A. Noyes, Don DeVault, Charles D. Coryell, and Thomas J. Deahl, *J. Am. Chem. Soc.*, 59, 1326-1337 (1937).

597. **Strong Oxidizing Agents in Nitric Acid Solution. III. Oxidation Potential of Cobaltous-Cobaltic Salts, with a Note on the Kinetics of the Reduction of Cobaltic Salts by Water.**
Arthur A. Noyes and Thomas J. Deahl, *J. Am. Chem. Soc.*, 59, 1337-1344 (1937).

598. **The Molecular Structures of Iron Nitrosocarbonyl $Fe(NO)_2(CO)_2$ and Cobalt Nitrosocarbonyl $Co(NO)(CO)_3$.**
L. O. Brockway and J. S. Anderson, *Transactions of the Faraday Society*, 33, 1233-1239 (1937).

599. **The Hydration of Unsaturated Compounds. VI. The Rate of Hydration of *Trans*-Crotonaldehyde. The Equilibrium Between *Trans*-Crotonaldehyde and Aldol in Dilute Aqueous Solution.**
Saul Winstein and Howard J. Lucas, *J. Am. Chem. Soc.*, 59, 1461-1465 (1937).

600. **The Infrared Spectrum and Internuclear Distances of Methyl Acetylene (Letter to the Editor).**
Richard M. Badger and Simon H. Bauer, *J. Chem. Phys.*, 5, 509 (1937).

601. **A Redetermination of the Carbon-Oxygen Distance in Calcite and the Nitrogen-Oxygen Distance in Sodium Nitrate.**
Norman Elliott, *J. Am. Chem. Soc.*, 59, 1380-1382 (1937).

603. **A Quantitative Discussion of Bond Orbitals.**
Linus Pauling and J. Sherman, *J. Am. Chem. Soc.*, 59, 1450-1456 (1937).

604. **An Extension of the Analytic Method of Analysis of Electron Diffraction Photographs of Gases (Letter to the Editor).**
Simon Bauer, *J. Chem. Phys.*, 5, 368 (1937).

610. **The Molecular Structure of the Bromomethanes.**
L. O. Brockway and Henri Lévy, *J. Am. Chem. Soc.*, 59, 1662-1665 (1937).

621. **Viscosity of Hydrocarbon Solutions. Methane-Propane-Crystal Oil System.**
B. H. Sage, B. N. Inman, and W. N. Lacey, *Ind. Eng. Chem.*, 29, 888-892 (1937).

*Not available for distribution.

Balch Graduate School of the Geological Sciences

Granitization, Albitization, and Related Phenomena in the Northern Inyo Range of California-Nevada.
George H. Anderson, *Bull. Geol. Soc. Amer.*, 48, 1-74 (1937).

Types of Pegmatites in Archean Rocks at Grand Canyon, Arizona.
Ian Campbell, *Amer. Mineralogist*, 22, 436-445 (1937).

Geologic Studies of the Archean Rocks at Grand Canyon.
Ian Campbell and John H. Maxson, *Carn. Inst. of Washington, Year Book 35*, 329-331 (1936).

Mechanics of the Lone Mountain Landslides, San Francisco, California.
W. M. Cogen, *Calif. Jour. of Mines and Geology, Report 32 of the State Mineralogist*, 459-474 (1936).

Mutual Interference in the Microchemical Determination of Ore Minerals.
H. J. Fraser and R. M. Dreyer, *Amer. Mineralogist*, 22, 949-976 (1937).

Geophysics as a Science.
B. Gutenberg, *Geophysics*, 2, 185-187 (1937).

The Structure of the Earth's Crust and the Spreading of the Continents.
B. Gutenberg, *Bull. Geol. Soc. Amer.*, 47, 1587-1610 (1936).

Données Relatives à l'étude des Tremblements de Terre à Foyer Profond.
B. Gutenberg and C. F. Richter (translated by E. Rothé). Publications du Bureau central seismologique international, Serie A, Fasc. 15, 3-69 (1937).

Materials for the Study of Deep-Focus Earthquakes.
B. Gutenberg and C. F. Richter, *Bull. Seis. Soc. Amer.*, 26, 341-390 (1936).

Materials for the Study of Deep-Focus Earthquakes, 2nd Paper.
B. Gutenberg and C. F. Richter, *Bull. Seis. Soc. Amer.*, 27, 157-183 (1937).

A Method for Estimating the Finishing Birefringence Color of a Crystal of Random Orientation in a Thin Section.
R. von Huene, *Amer. Mineralogist*, 22, 926-928 (1937).

A Fast and Thorough Method for Impregnating Porous Rocks.
R. von Huene, *Econ. Geol.*, 32, 387-388 (1937).

Notes on the Mineralization of Crestmore.
V. C. Kelley, *Amer. Mineralogist*, 22, 140-141 (1937).

Upper Cretaceous Mollusca from Southern California.
W. P. Popenoe, *Jour. Paleontology*, 11, 379-402 (1937).

Needless Photographic Failures.
John L. Ridgway, *The Condor*, 39, 10-12 (1937).

A Late Cenozoic Vertebrate Fauna from the Coso Mountains, Inyo County, California.
John R. Schultz, *Carn. Inst. Wash. Publ.*, 487, 75-109 (1937).

California Buffalo of Long Ago.
Chester Stock, *Westways*, 29, No. 2, 29 (1937).

An Eocene Titanothere from San Diego County with Remarks on the Age of the Poway Conglomerate.
Chester Stock, *Proc. Natl. Acad. Sci.*, 23, 48-53 (1937).

Mojave's Petrified Forest.
Chester Stock, *Westways*, 28, No. 12, 24-25 (1936).

A New Mountain Goat from the Quaternary of Smith Creek Cave, Nevada.
Chester Stock, *Bull. So. Cal. Acad. Sci.*, 25, 149-153 (1936).

A Peccary Skull from the Barstow Miocene, California.
Chester Stock, *Proc. Natl. Acad. Sci.*, 23, 398-404 (1937).

Tar Babies.
Chester Stock, *Westways*, 29, No. 9, 26-27 (1937).

Titanotheres from the Titus Canyon Formation, California.
Chester Stock, *Proc. Natl. Acad. Sci.*, 22, 656-661 (1936).

To the Sea in Fragments.
Chester Stock, *Westways*, 29, No. 6, 30-31 (1937).

Ursus or the Past of the California Bears.
Chester Stock, *Westways*, 28, No. 11, 30 (1936).

Observed and Calculated Values of the Magnetic Intensity over a Major Geologic Structure.
L. F. Uhrig and Signey Schafer, *Gerlands Beiträge zur Geophysik*, 49, 129-139 (1937).

Paleontology of the Pleistocene of Point Loma, San Diego County, California.
Robert W. Webb, *San Diego Soc. Natl. Hist.*, 8, 337-348 (1937).

Heavy Accessory Minerals of the Val Verde Tonalite.
Robert W. Wilson, *Amer. Mineralogist*, 22, 122-132 (1937).

A New Pleistocene Deer-Mouse from Santa Rosa Island, California.
Robert W. Wilson, *Jour. Mammalogy*, 17, 408-410 (1936).

New Middle Pliocene Rodent and Lagomorph Faunas from Oregon and California.
Robert W. Wilson, *Carn. Inst. Wash. Publ.*, 487, 1-19 (1937).

Pliocene Rodents of Western North America.
Robert W. Wilson, *Carn. Inst. Wash. Publ.*, 487, 21-73 (1937).

William G. Kerckhoff Laboratories of the Biological Sciences

Induced Chromosomal Alterations in Maize.
E. G. Anderson, *Biological Effects of Radiation*, 1297-1310 (1936).

The Chemistry and Physiology of the Pectins.
James Bonner, *Botanical Review*, 10, 475-497 (1936).

The Growth and Respiration of the Avena Coleoptile.
James Bonner, *J. Gen. Phys.*, 20, 1-11 (1936).

Vitamin B_1 a Growth Factor for Higher Plants.
James Bonner, *Science*, 85, 183-4 (1937).

The Growth of Plant Embryos in Vitro. Preliminary Experiments on the Role of Accessory Substances.
James Bonner and Grice Axtman, *Proc. Nat. Acad. Sci.*, 23, 453-457 (1937).

The Oxidation of Ascorbic Acid and Its Reduction in Vitro and in Vivo.
Henry Borsook, Horace W. Davenport, Cecil E. P. Jeffreys, and Robert C. Warner, *J. Biol. Chem.*, 117, 237-279 (1937).

***Sulfhydryl Oxidation-Reduction Potentials Derived from Thermal Data.**
Henry Borsook, Emory L. Ellis and Hugh M. Huffman, *J. Bio. Chem.*, 117, 281-308 (1937).

Genes and Chromosomes.
Calvin B. Bridges, *The Teaching Biologist*, 17-23 (Nov., 1936).

***Microscope Illumination Systems.**
C. B. Bridges, *The Collecting Net*, 11, 208 (1936).

The Mutants and Linkage Data of Chromosome Four of Drosophila Melanogaster.
Calvin B. Bridges, *J. Biol.*, 4, 401-420 (1935).

An Oil-Retaining Beveled Face for High-Aperture Condensers.
Calvin B. Bridges, *Science*, 84, 335-336 (1936).

---

*Not available for distribution.

***Progress in Cytogenetics.**
C. B. Bridges, *The Collecting Net,* 11, 244-245 (1936).

The Vapor Method of Changing Reagents and of Dehydration.
Calvin B. Bridges, *Stain Technology,* 12, 51-52 (1937).

***Semi-Homologous Inversions in Drosophila Melanogaster.**
C. B. Bridges and J. C. Li, *Genetics,* 22, 186 (1937).

Genetical and Cytological Studies in a Deficiency (notopleural) in the Second Chromosome of Drosophila Melanogaster.
C. B. Bridges, Eleanor Nichols Skoog, and Ju-Chi Li, *Genetics,* 21, 788-795 (1936).

***Flashing of Fireflies in Jamaica.**
John B. Buck, *Nature,* 139, 801 (1937).

***Electrical Polarity and Auxin Transport.**
W. G. Clark, *Plant Phys.,* 12, 409-440 (1937).

***Transport of Root-Forming Hormone in Woody Cuttings.**
William C. Cooper, *Plant Phys.,* 11, 779-793 (1936).

Further Data on Drosophila Miranda and Its Hybrids with Drosophila Pseudoobscura.
Th. Dobzhansky, *J. Genetics,* 34, 135-151 (1937).

Further Data on the Variation of the Y Chromosome in Drosophila Pseudoobscura.
Th. Dobzhansky, *Genetics,* 22, 340-346 (1937).

Genetic Nature of Species Differences.
Th. Dobzhansky, *American Naturalist,* 71, 404-420 (1937).

What is a Species?
Th. Dobzhansky, *Scientia,* May, 280-286 (1937).

Studies on Hybrid Sterility III. A Comparison of the Gene Arrangement in Two Species, Drosophila Pseudoobscura and Drosophila Miranda.
Th. Dobzhansky and C. C. Tan, *Zeit. f. ind. Abst.-u. Vererbgsl.,* 72, 88-114 (1936).

Studies on Hybrid Sterility IV. Transplanted Testes in Drosophila Pseudoobscura.
Th. Dobzhansky and G. W. Beadle, *Genetics,* 21, 832-840 (1936).

Electronarcosis with Alternating Current in Fish.
A. van Harreveld, *Neer. Phys. de l'Homme et des Animaux,* 22, 84-92 (1937).

A Physiological Solution for Freshwater Crustaceans.
A. van Harreveld, *Proc. Soc. Exp. Biol. and Med.,* 34, 428-432 (1936).

The Double Motor Innervation of the Adductor Muscle in the Claw of the Crayfish.
A. van Harreveld and C. A. G. Wiersma, *Jour. Phys.,* 88, 78-99 (1936).

The Triple Innervation of the Crayfish Muscle.
A. van Harreveld and C. A. G. Wiersma, *Proc. Nat. Acad. Sci.,* 22, p. 667 (1936).

Thermal Data. VI. The Heats of Combustion and Free Energies of Seven Organic Compounds Containing Nitrogen.
Hugh M. Huffman, Emory L. Ellis, and Sidney W. Fox, *J. Am. Chem. Soc.,* 58, 1728-1733 (1936).

Haploid Ovarian Tissue in Drosophila.
R. H. MacKnight, *Proc. Nat. Acad. Sci.,* 23, 440-443 (1937).

The Behaviour of the Maturation Spindles in Polar Fragments of Eggs of Ilyanassa Obtained by Centrifuging.
T. H. Morgan, *Biol. Bull.,* 72, 88-89 (1937).

Constitution of the Germinal Material in Relation to Heredity.
T. H. Morgan, C. B. Bridges, and Jack Schultz, *Carn. Inst. Wash. Year Book No. 35,* 289-297 (1936).

*Not available for distribution.

An Effect of the Y Chromosome on the Sex-Ratio of Interracial Hybrids of Drosophila Pseudoobscura.
A. H. Sturtevant, *Proc. Nat. Acad. Sci.*, 23, 360-362 (1937).

The Relations of Inversions in the X Chromosome of Drosophila Melanogaster to Crossing Over and Disjunction.
A. H. Sturtevant and G. W. Beadle, *Genetics*, 21, 554-604 (1936).

Observations on the Species Related to Drosophila Affinis, with Descriptions of Seven New Forms.
A. H. Sturtevant and Th. Dobzhansky, *American Naturalist*, 70, 574-584 (1936).

The Comparative Genetics of Drosophila Pseudoobscura and D. Melanogaster.
A. H. Sturtevant and C. C. Tan, *J. Genetics*, 34, 415-432 (1937).

***The Development of the Theory of the Gene (printed in Chinese).**
C. C. Tan, *Wuhang University Science Bulletin*, 6, 306-328 (1936).

***Genetic Maps of the Autosomes in Drosophila Pseudoobscura.**
C. C. Tan, *Genetics*, 21, 796-807 (1936).

***The Behaviour of Vermilion and Orange Eye Colours in Transplantation in Drosophila Pseudoobscura.**
C. C. Tan and D. F. Poulson, *J. Genetics*, 34, 433-435 (1937).

On the Energetics of Differentiation III. Comparison of the Temperature Coefficients for Cleavage and Later Stages in the Development of the Eggs of Some Marine Animals.
Albert Tyler, *Biol. Bull.*, 71, 59-81 (1936).

On the Energetics of Differentiation IV. Comparison on the Rates of Oxygen Consumption and of Development at Different Temperatures of Eggs of Some Marine Animals.
Albert Tyler, *Biol. Bull.*, 71, 82-100 (1936).

On the Energetics of Differentiation V. Comparison of the Rates of Development and of Oxygen Consumption of Tight Membranes and Normal Echinoderm Eggs.
Albert Tyler, *J. Exp. Zool.*, 76, 395-406 (1937).

Influence of Temperature and Other Agents on the Respiration and Development of Marine Eggs.
Albert Tyler, *The Collecting Net*, 12 (1937).

Polar Body Extrusion and Cleavage in Artificially Activated Eggs of Urechis Caupo.
Albert Tyler and Hans Bauer, *Biol. Bull.*, 73, 164-180 (1937).

The Action of Certain Substituted Phenols on Marine Eggs in Relation to Their Dissociation.
Albert Tyler and Norman H. Horowitz, *Proc. Nat. Acad. Sci.*, 23, 369-374 (1937).

Glycylglycine as a Sea Water Buffer.
Albert Tyler and Norman H. Horowitz, *Science*, 86, 85-86 (1937).

Inhibition of Fertilization in Eggs of Marine Animals by Means of Acid.
Albert Tyler and Bradley Titus Scheer, *J. Exp. Zool.*, 75, 179-197 (1937).

Effect of the Roots on the Production of Auxin by the Coleoptile.
J. van Overbeek, *Proc. Nat. Acad. Sci.*, 23, 272-276 (1937).

Growth Substance Curvatures of Avena in Light and Dark.
J. van Overbeek, *Jour. Gen. Phys.*, 20, 283-309 (1936).

Allgemeine Betrachtungen über das Auxin-Problem.
F. W. Went, *Biologischen Zentralblatt*, 56, 449-463 (1936).

---

*Not available for distribution.

Salt Accumulation and Polar Transport of Plant Hormones.
F. W. Went, *Science*, 86, 127-128 (1937).

Die Doppelte Motorische Innervation des Scherenschliegers von Astacus Fluviatilis.
C. A. G. Wiersma, *Zeit. f. vergl. Phys.*, 24, 381-386 (1937).

On the Mechanism of Inhibition of Crayfish Muscle.
C. A. G. Wiersma and George Marmont, *Proc. Nat. Acad. Sci.*, 22, 502-504 (1936).

The Double Motor Innervation of a Crayfish Muscle.
C. A. G. Wiersma and A. van Harreveld, *Proc. Nat. Acad. Sci.*, 22, 190-191 (1936).

Effect of Auxin on Chlorella Vulgaris.
H. C. Yin, *Proc. Nat. Acad. Sci.*, 23, 174-176 (1937).

***Growth Hormone of Plants (printed in Chinese).**
H. C. Yin, *Wu-Han Science Journal*, 6, 157-173 (1936).

VERTEBRATE ZOOLOGY

New Races of the Genus Otus from Northwestern Mexico.
Robert T. Moore, *Proc. Biol. Soc. Washington*, 50, 63-68 (1937).

Four New Birds from Northwestern Mexico.
Robert T. Moore, *Proc. Biol. Soc. Washington*, 50, 95-102 (1937).

Two New Owls from Sinaloa, Mexico.
Robert T. Moore, *Proc. Biol. Soc. Washington*, 50, 103-106 (1937).

New Race of Chubbia jamesoni from Colombia.
Robert T. Moore, *Proc. Biol. Soc. Washington*, 50, 151-152 (1937).

Description of a New Race of Carpodacus mexicanus.
Robert T. Moore, *Condor*, 37, 203-208 (1936).

A New House Finch from Central Mexico.
Robert T. Moore, *Condor*, 39, 204-206 (1937).

†New Birds from Northwestern Mexico.
Robert T. Moore, *Proc. Biol. Soc. Washington*, 48, 111-114 (1935).

†A New Jay of the Genus Cyanocorax from Sinaloa, Mexico.
Robert T. Moore, *Auk*, 52, 274-277 (1935).

†The Protection and Conservation of the Zoological Life of the Galapagos Archipelago.
Robert T. Moore, *Science*, 82, 2135 (1935).

A Review of the Races of the Mountain Quail.
A. J. van Rossem, *Condor*, 39, 20-24 (1937).

Concerning the Name of the Sonora House Finch.
A. J. van Rossem, *Condor*, 39, 38 (1937).

A Race of the Derby Flycatcher from Northwestern Mexico.
A. J. van Rossem, *Proc. Biol. Soc. Wash.*, 50, 25-26 (1937).

The Ferruginous Pigmy Owl of Northwestern Mexico and Arizona.
A. J. van Rossem, *Proc. Biol. Soc. Wash.*, 50, 27-28 (1937).

The Type of Falco cooperii.
A. J. van Rossem, *Auk*, 54, 203 (1937).

A Further Report on Birds from Sonora, Mexico, with Descriptions of Two New Races.
A. J. van Rossem and the Marquess Hachisuka, *Trans. San Diego Soc. Nat. Hist.*, 8, 323-334, (1937).

---

*Not available for distribution.
†Not previously reported.

A Northwestern Race of the Mexican Black Hawk.
A. J. van Rossem and the Marquess Hachisuka, *Trans. San Diego Soc. Nat. Hist.*, 8, 361-362, (1937).

A New Bat Falcon from Sonora.
A. J. van Rossem and the Marquess Hachisuka, *Proc. Biol. Soc. Wash.*, 50, 107-108 (1937).

The Blue-Gray Gnatcatcher of Southern Sonora.
A. J. van Rossem and the Marquess Hachisuka, *Proc. Biol. Soc. Wash.*, 50, 109-110 (1937).

The Yellow-Green Vireo of Northwestern Mexico.
A. J. van Rossem and the Marquess Hachisuka, *Proc. Biol. Soc. Wash.*, 50, 159-160 (1937).

The Tiger-Bittern of Northwestern Mexico.
A. J. van Rossem and the Marquess Hachisuka, *Proc. Biol. Soc. Wash.*, 50, 161-162 (1937).

GUGGENHEIM AERONAUTICAL LABORATORY

76. Charts for Calculating the Performance of Airplanes Having Constant-Speed Propellers.
Roland J. White and Victor J. Martin, *N. A. C. A. Tech. Note*, 579 (1936).

77. Transfer of Stress From Main Beams to Intermediate Stiffeners in Metal Sheet Covered Box Beams.
B. B. C. Lovett and W. F. Rodee, *Jour. Aero. Sci.*, 3, 426-430 (1936).

78. Effect of Rivet Spacing on Stiffened Thin Sheet under Compression.
W. Lavern Howland, *Jour. Aero. Sci.*, 3, 434-438 (1936).

79. Uber Aerodynamische Forschungsergebnisse und Ihre Auswertung für den Flugzeugbau.
Clark B. Millikan, *Luftwissen*, 3, 277-287 (1936).

***80. Progressive Waves of Finite Amplitude and Some Steady Motions of an Elastic Fluid.**
H. Bateman, *Proc. Nat. Acad. Sci.*, 22, 607-619 (1936).

81. On the Results of Aerodynamic Research and Their Application to Aircraft Construction.
Clark B. Millikan, *Jour. Aero. Sci.*, 4, 43-53 (1936).

82. The Physicist Gets Air Minded.
Clark B. Millikan, *Jour. App. Phys.*, 8, 107-116 (1937).

83. On the Statistical Theory of Turbulence.
Th. von Kármán, *Proc. Nat. Acad. Sci.*, 23, 98-105 (1937).

84. The Fundamentals of the Statistical Theory of Turbulence.
Th. von Kármán, *Jour. Aero. Sci.*, 4, 131-138 (1937).

85. Le Transport Aérien à Haute Altitude.
W. C. Rockefeller and Norton B. Moore, *Jour. Tech. Intern. l'Aero.*, 336-350 (1936).

86. A Theory for Rectangular Wings of Small Aspect Ratio.
William Bollay, *Jour. Aero. Sci.*, 4, 294-296 (1937).

87. Stress Distribution in Stiffened Panels under Compression.
E. E. Sechler, *Jour. Aero. Sci.*, 4, 320-323 (1937).

88M. Forecasting the Dissipation of Fog and Stratus Clouds.
Irving Krick, *Jour. Aero. Sci.*, 4, 366-371 (1937).

89M. The Technique of Weather Forecasting.
Irving Krick, *Mech. Eng.*, 59, 579-582 (1937).

90M. The Galcit Radio-Meteorograph.
O. C. Maier and L. E. Wood, *Jour. Aero. Sci.*, 4, 417-422 (1937).

---

*Not available for distribution.

91. Effect of Slipstream on the Longitudinal Stability of a Low Wing Monoplane.
C. M. Bolster, *Jour. Aero. Sci.*, 4, 411-416 (1937).

92. The Effect of Curvature on the Transition from Laminar to Turbulent Boundary Layer.
Milton Clauser and Francis Clauser, *N. A. C. A. Tech. Note*, 613 (1937).

***I Fondamenti della Teoria Statistica della Turbolenza.**
Th. von Kármán, *l'Aerotecnica*, 17, 643-654 (1937).

†*Il Problema della Resistenza Nei Fluidi Compressibilie.
Th. von Kármán, *l'Aerotecnica*, 16, 575-616 (1936).

†*Turbolenza e Attrito Superficiale.
Th. von Kármán, *l'Aerotecnica*, 14, 1156-1185 (1934).

***Review of Progress in Aerodynamics for 1935.**
A. L. Klein, *Mech. Eng.*, 58, 432-433 (1936).

***Applying Modern Methods of Weather Analysis and Forecasting to Citrus.**
Irving Krick, *California Citrograph*, 22, 3 (1936).

***A Telethermoscope for Use in Citrus Groves.**
Irving Krick and L. E. Wood, *California Citrograph*, 22, 120-122 (1937).

***Underlying Principles of Frost Protection.**
Irving Krick, *California Cultivator*, LXXXIV, 649 (1937).

†*The Use of Animated Pictures for Weather Studies.
Irving Krick, *Jour. Aero. Sci.*, 2, 77 (1935).

†*Air Mass Symbols for Use on Synoptic Charts.
Irving Krick, *Jour. Aero. Sci.*, 2, 55 (1935).

ENGINEERING

Experimental Determinations of the Flow Characteristics in the Volutes of Centrifugal Pumps.
R. C. Binder and R. T. Knapp, *A. S. M. E. Trans.*, 649-661, Nov., 1936.

***Discussion to the Article: Physical Properties of Axle Steels.**
Wm. Howard Clapp, *Trans. Am. Soc. of Metals*, 292-293, Mar., 1937.

A Chart for the Rapid Determination of Commercial Gear Sizes.
Wm. Howard Clapp, *Product Engineering*, 401-402, Oct., 1936.

Materials Testing and Steel Performance.
Wm. Howard Clapp, *Trans. Am. Petrol. Inst.—Drilling and Production Practice*, 310-321 (1936); reprints in *Petroleum Engineering*, Jan., 1937; *Steel*, Feb., 1937; *Heat Treating and Forging*, Mar., 1937.

A New Test for Relative Sliding Wear.
D. S. Clark and R. B. Freeman, *Metal Progress*, 31, 399-402 (1937).

The Relative Wear of Some Hard Metals.
R. B. Freeman, *Metal Progress*, 31, 281-285 (1937).

The Hydraulic-Machinery Laboratory at the California Institute of Technology.
R. T. Knapp, *A. S. M. E. Trans.*, 663-676, Nov., 1936.

Earthquake Damage to Type III Buildings in Long Beach.
R. R. Martel, *U. S. Coast and Geodetic Survey, Special Publ.*, 201, 143-162 (1936).

Modern Conceptions of the Mechanics of Fluid Turbulence.
Hunter Rouse, *Trans. A. S. C. E.*, 102, 463-543 (1937).

Nomogram for the Settling Velocity of Spheres.
Hunter Rouse, *Annual Report, Committee on Sedimentation*, National Research Council, 57-64 (1937).

†Not previously reported.
*Not available for distribution.

HUMANITIES

Japanese Prints.
Harvey Eagleson, *California Arts and Architecture,* 24, 48, Dec., 1936.

***Whither Taxation?**
Philip S. Fogg, *The Tax Digest,* 257-259, 271-273, Aug., 1937.

***The U. S. and the War Debts.**
Philip S. Fogg, *Commercial and Financial Digest,* 3, 4, Dec., 1936.

***Financial Problems of the Federal Government.**
Philip S. Fogg, *Commercial and Financial Digest,* 10, 12, Nov., 1936.

†***Three Evil Fates.**
Philip S. Fogg, *The Tax Digest,* 122, 123, 129-132, Apr., 1936.

Case 54.
H. N. Gilbert, *Agricultural Industries,* Vol. II, Harvard Graduate School of Business Administration (1936).

Economic Basis of Europe's War Problem.
H. N. Gilbert, *Proc. Inst. of World Affairs,* 14, 139-141 (1937).

The High Cost of Labor.
H. N. Gilbert, *Barron's Financial Weekly,* 16, 43, p. 6 (1936).

The California Institute of Technology.
William Huse, *Jewish Community Press,* 84-86, Sept. 3, 1937.

What the Adult Should Know About Economics.
Graham A. Laing, *California Review of Adult Education,* 197-201, Dec., 1936.

Child Wonders in El Dorado.
George R. MacMinn, *Frontier and Midland,* December, 1936.

***Collective Security in the Pacific Area.**
William B. Munro, *Proc. Inst. of World Affairs,* 14, 119-125 (1937).

The Social Security Act.
R. E. Untereiner, published serially in *Investment Dealers' Digest:* June 3, 3, 4, 5, 30; June 10, 10, 11, 12, 13, 30; June 17, 8, 30; June 24, 8, 9, 30 (1937).

The Purposeful Reading of Our Colonial Ancestors.
Louis B. Wright, *E. L. H. A Journal of English Literary History,* 4, 85-111 (June, 1937).

---

*Not available for distribution.
†Not previously reported.

INFORMATION AND REGULATIONS FOR THE GUIDANCE OF GRADUATE STUDENTS

A. GENERAL REGULATIONS

I. REQUIREMENTS FOR ADMISSION TO GRADUATE STANDING

1. The Institute offers graduate work leading to two higher degrees, the degree of Master of Science,* and the degree of Doctor of Philosophy. To be admitted to graduate standing at the Institute an applicant must in general have received a bachelor's degree representing the completion of an undergraduate course in science or engineering substantially equivalent to one of those courses offered by the Institute. He must, moreover, have attained such a scholastic record and, if from another institution, must present such recommendations as to indicate that he is fitted to pursue with distinction advanced study and research.

2. Application for admission to graduate standing at the Institute for work toward either the master's or the doctor's degree should be made upon a form which can be obtained from the Dean of the Graduate School. The applicant should state the degree for which he wishes to work. If the applicant's preliminary training in science, mathematics, and engineering has not been substantially that given by the four-year undergraduate courses at the Institute, he must pursue such undergraduate subjects as may be assigned. Since admission to graduate work will be granted to only a limited number of students of superior ability, applications should be made as long as possible before the opening of the school year, preferably by the first of May. Admission may have to be refused to students who apply at a later date, solely on the basis of limited facilities in the department in which they wish to work. Students applying for assistantships or fellowships need not make separate application for admission

*In addition the Institute offers the higher degrees of Bachelor of Science in Aeronautics and in Meteorology for a fifth year of work in those departments (see pages 176-177) under the conditions applying in general to the degree of Master of Science.

to graduate standing, but should make application for appointment by February 15. See Section DI.

3. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy.

II. TUITION FEES

The tuition fee for graduate students pursuing courses of more than 32 units will be $300 a year, payable in three equal installments of $100 at the beginning of each term. Graduate students who continue their researches during the summer are not required to pay tuition fees therefor.

An annual fee of $3 to assist in the defraying of expenses in cases of emergency requiring hospitalization is required.* No other fees are required of graduate students; but charges may be made for breakage and supplies. Students working in the chemical laboratories are required to make a deposit of $15 at the beginning of the school year to cover these charges. No degrees are awarded until all bills due the Institute have been paid.

In regard to *fellowships and assistantships,* see pages 153-157 of this catalogue. In addition, to students with high scholastic attainments there may be awarded *graduate scholarships* covering one-half or the whole of the tuition fee. For such students *loans* also may be arranged, for which application should be made to the Student-Aid Committee.

B. REGULATIONS AND REQUIREMENTS CONCERNING WORK FOR THE DEGREE OF MASTER OF SCIENCE

I. GENERAL REQUIREMENTS

To receive the degree of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of one of the fifth-year courses, as well as in the schedule of the Four-

*See page 72.

Year Course in Science or in Engineering (see pages 162-179), except that, in the case of students transferring from other institutions, equivalents will be accepted in subjects in which the student shows by examination or otherwise that he is proficient, and except in so far as substitutions may be approved by special vote of the Committee in charge.

Senior students at the Institute desiring to return for a fifth year should consult with the representative of the department in which they expect to do their major work, and make application for admission to work towards the master's degree on a form which can be obtained from the Dean of the Graduate School. Such students will be expected to present satisfactory scholarship qualifications, and to have demonstrated a capacity for doing advanced work.

All programs of study, and applications for candidacy for the degree of Master of Science, shall be in charge of the Committee on Courses in Science (in case the advanced work is to be in Physics, Chemistry, Chemical Engineering, Mathematics, Geology, Paleontology, or Biology), or of the Committee on Courses in Engineering (in case the work is to be in Civil, Mechanical or Electrical Engineering, Aeronautics or Meteorology); and recommendations to the Faculty for the award of that degree shall be made by one of these Committees, all such actions being taken in general after consideration and recommendation by the department concerned.

A student before entering upon work for the degree of Master of Science should, after consultation with the department concerned, submit a plan of study (together with his previous record if he transfers from another institution), and make application to the Committee in charge for acceptance as a candidate for that degree. Application forms for admission to candidacy for the degree of Master of Science may be obtained from the Registrar, and must be submitted not later than the end of the first week of the first term of the year in which the degree is to be granted.

II. REGISTRATION

1. The regulations governing registration and student responsibilities as given for undergraduate students on page 89 of the catalogue apply also to fifth-year students.

2. Before registering, the graduate student should consult with members of the department in which he is taking his work to determine the studies which he can pursue to the best advantage.

3. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office.

4. Applications for registration in excess of the prescribed number of units must be approved by the Committee on Courses in Science or by the Committee on Courses in Engineering and will be conditioned upon the quality of work done in the preceding term.

III. SCHOLASTIC REQUIREMENTS

1. Scholastic requirements given on pages 91-92 of the catalogue for undergraduate students also apply to fifth-year students.

2. In the case of a student registered for a master's degree and holding a position as Assistant or Teaching Fellow, the actual number of hours per week required by the teaching shall be deducted from the total number of units for which the student may register.

IV. THESIS

Two final copies of theses must be filed with the Division concerned ten days before the degree is to be conferred. In the Division of the Geological Sciences and in the department of Mathematics, a complete first draft of theses presented in partial fulfillment of the requirements for the degree of Master of Science must be submitted to the supervising instructor by the first of May.

C. REGULATIONS CONCERNING WORK FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

I. GENERAL REGULATIONS

The degree of Doctor of Philosophy is conferred by the Institute in recognition of breadth of scientific attainment and of power to investigate scientific problems independently and efficiently, rather than for the completion of definite courses of study through a stated term of residence. The work for the degree must consist of scientific research and the preparation of a thesis describing it, and of systematic studies of an advanced character in science or engineering. In addition, the candidate must have acquired the power of expressing himself clearly and forcefully both orally and in written language, and he must have a good reading knowledge of French and German.

Subject to the general supervision of the Committee on Graduate Study, the student's work for the degree of Doctor of Philosophy is specifically directed by the department in which he has chosen his major subject. Each student should consult his department concerning special divisional and departmental requirements. See Section VI for special requirements for the doctor's degree in Mathematics, Physics and Electrical Engineering, Section VII for special requirements in Chemistry, Section VIII for special requirements in Aeronautics, Civil and Mechanical Engineering and Meteorology, and Section IX for special requirements in Geology and Paleontology.

With the approval of the Committee on Graduate Study, any student studying for the doctor's degree whose work is not satisfactory may be refused registration at the beginning of any term by the department in which the student is doing his major work.

II. REQUIREMENTS FOR ADMISSION TO WORK FOR THE DOCTOR'S DEGREE

With the approval of the Committee on Graduate Study, students are admitted to graduate standing by the department in which they choose their major work toward the doctor's degree. In the case of insufficient preparation, applicants for the doctor's degree may be

required to register for the master's degree first. The master's degree, however, is in no sense a prerequisite for the doctor's degree. Students who have received the master's degree and wish to pursue further studies leading towards the doctor's degree must file a new application for admission to graduate standing to work towards that degree.

III. REGISTRATION

1. Students are required to register and file a program card in the Registrar's office at the beginning of each term of residence, whether they are attending regular courses of study, or only carrying on research or independent reading, or writing a thesis or other dissertation.

2. Before registering, the student should consult with members of the department in which he is taking his major work to determine the studies which he can pursue to the best advantage.

3. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office. *The student himself is charged with the responsibility of making certain that all grades to which he is entitled have been recorded.*

4. One term of residence shall consist of one term's work of not less than 45 units of advanced work in which a passing grade is recorded. If less than 45 units are successfully carried the residence will be regarded as shortened in the same ratio, but the completion of a larger number of units in any one term will not be regarded as increasing the residence. Students who are permitted to carry on research during the summer will be allowed credit, but in order to obtain such credit they must register therefor in advance.

5. The number of units allowed for a course of study or for research is figured on the basis that one unit corresponds roughly to one hour a week of work throughout the term, for a student of superior ability.

6. In registering for research, students should indicate on their program card the name of the instructor in charge, and should consult with him to determine the number of units to which the proposed work corresponds. At the end of the term the instructor in charge shall decrease the number of units for which credit is given, in case he feels that the progress of the research does not justify the full number originally registered.

7. Graduate students studying for the doctor's degree who are devoting their whole time to their studies will be allowed to register for not more than 60 units in any one term. Students on part time teaching appointments will not be allowed to register for so many units. Teaching Fellows and Assistants will be allowed to register for not more than 45 units.

IV. GRADES IN GRADUATE COURSES

1. Term examinations are held in all graduate courses unless the instructor shall, after consultation with the chairman of the division, arrange otherwise. No student taking a course for credit shall be exempt from these examinations when held.

2. Grades for all graduate work are reported to the Registrar's office at the close of each term.

3. The following system of grades is used to indicate class standing in graduate courses: 4 denotes marked distinction, 3 denotes above average, 2 denotes average, 1 denotes below average, C denotes conditioned, F denotes failed. In addition to these grades, which are to be interpreted as having the same significance as for undergraduate courses, the grade P, which denotes passed, may be used at the discretion of the instructor, in the case of seminar, research, or other work which does not lend itself to more specific grading.

V. REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

1. *Major and Minor Subjects:* The work for the doctor's degree must consist of scientific research and advanced studies in some branch of science or engineering, which will be termed the "major

subject" of the candidate. In addition, as "minor subject" (or subjects), studies which will give a fundamental knowledge and research point of view must be pursued in at least one other branch of science or engineering.

The choice and scope of the minor subject must be approved by the departments in charge both of the major and of minor subjects, and must involve not less than 45 units of advanced study in each minor subject. Such advanced study must consist of courses which are listed as graduate courses.[1]

2. *Residence:* At least three years of work in residence subsequent to a baccalaureate degree equivalent to that given by the Institute are required for the doctor's degree. Of this at least one year must be in residence at the Institute. It should be understood that these are minimum requirements, and students must usually count on spending a somewhat longer time in residence.

Graduate students are encouraged to continue their research during the whole or a part of the summer, but in order that such work may count in fulfillment of the residence requirements, the student must comply with the above regulations and file a registration card for such summer work in the office of the Registrar.

A graduate student who, by special arrangement, is permitted to conduct a portion of his research in the field, in government laboratories, or elsewhere off the campus, must file a registration card for this work in the office of the Registrar, in order that it may count in fulfillment of residence requirements. The number of units to be credited for such work shall be determined by the Dean of the Graduate School in consultation with the Chairman of the Division in which the student is carrying his major work; and a recommendation as to the proportion of the full tuition to be paid for such work shall be made by the Dean to the Executive Council.

A student whose undergraduate work has been insufficient in amount or too narrowly specialized, or whose preparation in his

[1] For a minor in Mathematics the candidate must offer at least 45 units in those subjects of the Mathematics department numbered 100 and above.

special field is inadequate, must count upon spending increased time in work for the degree.

3. *Admission to Candidacy:* Any student admitted to work for the doctor's degree who has been in residence one term or more, who has satisfied the several departments concerned by written or oral examination or otherwise that he has a comprehensive grasp of his major and minor subjects as well as of subjects fundamental to them, who has satisfied the department of modern languages that he can read scientific German and French with reasonable facility, who has shown ability in carrying on research and whose research subject has been approved by the Chairman of the Division concerned, and whose program of study has been approved by both his major and minor departments may, on recommendation of the Chairman of the Division in which he is working, be admitted by the Committee on Graduate Study to candidacy for the degree of Doctor of Philosophy. Members of the permanent Institute staff of rank higher than that of Assistant Professor are not admitted to candidacy for a higher degree.

A regular form, to be obtained from the Dean of the Graduate School, is provided for making application for admission to candidacy. Such admission to candidacy must be obtained before the close of the first term of the year in which the degree is to be conferred, and must be followed by two terms of further residence before the degree is conferred. *The student himself is responsible for seeing that admission is secured at the proper time.*

4. *Examinations:* The French and German examinations, prerequisite to admission to candidacy for the degree of Doctor of Philosophy, will be given in September on the afternoon of the date set for the removal of conditions, and on the afternoons of the first Fridays of December and of March. Candidates may, in place of the above, take the advanced undergraduate examinations offered at the end of each term. Students who have credit for courses in languages taken at the Institute and who have a grade above average

may be exempted from further requirement after consultation with the language department.

Graduate students are permitted to audit all courses in the department of languages. In general, however, it is desirable for students without previous language study to take the class work in French and German for at least the first term rather than to depend upon studying it by themselves. Students expecting to file application for candidacy in December are advised to take the September examination, so that, if their preparation is inadequate, they may enroll for the fall term in one of the language courses. No fee is charged for these examinations.

Special examinations, or the final examinations in specified courses, are required by certain departments for admission to candidacy for the doctor's degree. (See Sections VI, VII, VIII and IX.)

Final examinations in their major and minor subjects are required of all candidates for the doctor's degree. These examinations, subject to the approval of the Committee on Graduate Study, may be taken at such time after admission to candidacy as the candidate is prepared, except that they must take place at least two weeks before the degree is to be conferred. The examinations may be written or oral, or both, and may be divided into parts or given all at one time at the discretion of the departments concerned. The student must petition for these examinations on a form obtained from the Dean of the Graduate School after consultation with the Chairman of the Division.

5. *Thesis:* The candidate is required to submit to the Dean of the Graduate School two weeks before the degree is to be conferred two copies of a satisfactory thesis describing his research, including a one-page digest or summary of the main results obtained.

With the approval of the department concerned, a portion of the thesis may consist of one or more articles published jointly by the candidate and members of the Institute staff or others. In any case,

however, a substantial portion of the thesis must be the candidate's own exposition of his work.

The thesis must be typewritten on paper of good quality, 8½ by 11 inches, leaving a margin for binding of not less than one inch, or may consist in part of pages taken from a published article and pasted on paper of the above size. It should be preceded by a title page containing the following items: Title, Thesis by (*name of candidate*), In Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, California Institute of Technology, Pasadena, California, Date (*year only*).

Before submitting his thesis to the Dean of the Graduate School, the candidate must obtain approval of it by the Chairman of his Division, and the members of his examining committee. This approval must be obtained in writing on a form which will be furnished at the office of the Dean. *The candidate himself is responsible for allowing sufficient time for the members of his committee to examine his thesis.*

6. *Grades on Degree:* The doctor's degree is awarded with the designations "*summa cum laude*," "*magna cum laude*," "*cum laude*," or without designation.

VI. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN MATHEMATICS, PHYSICS, AND ELECTRICAL ENGINEERING

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of Mathematics, Physics and Electrical Engineering has adopted the following supplementary regulations:

1, a. To be recommended for candidacy for the doctor's degree in *Mathematics* the applicant must pass the following courses with a grade of 2 or better:

Ma. 101 a b c	Modern Algebra (including Galois Theory)
Ma. 201	Modern Analysis
Ma. 256	Modern Differential Geometry
Ma. 102	Introduction to Higher Geometry

and any *one* of the courses, other than the purely mathematical, listed under requirements for admission to candidacy in Physics, preferably one of the following:

Ph. 101 a b c	Electricity and Magnetism
Ph. 103 a b c	Analytical Mechanics

and a course in the mathematical quantum theory (to be selected from those offered from year to year).

1, b. To be recommended for candidacy for the doctor's degree in *Physics* the applicant must pass the following courses with a grade of 2 or better:

Ph. 101 a b	Electricity and Magnetism
Ph. 103 a b	Analytical Mechanics
Ph. 105 a b	Optics
Ph. 107 a b c	Atomic Physics

and any two of the following courses:

Ph. 101 c	Electricity and Magnetism
Ph. 103 c	Analytical Mechanics
Ph. 114	Principles of Quantum Mechanics
Ph. 115	Applications of Quantum Mechanics

and, in case the applicant's minor is in Mathematics, one of the following courses:

Ma. 8 a b c	Advanced Calculus
Ma. 10 a b c	Differential Equations
Ma. 114 a b c	Mathematical Analysis

and, in case the applicant's minor is in Chemistry, one of the following courses:

Ch. 21 a b c	Chemical Principles
Ch. 21 a	Chemical Principles
together with	
Ch. 23 a b	Chemical Principles

1, c. To be recommended for candidacy for the doctor's degree in *Electrical Engineering* the applicant must pass the following courses with a grade of 2 or better:

Ph. 101 a b c	Electricity and Magnetism

and one of the following courses:

Ph. 103 a b c	Analytical Mechanics
AM. 1 a b	Applied Mechanics
together with	
AM. 1 c	Strength of Materials

and one of the following courses:

Ma. 8 a b c	Advanced Calculus
Ph. 5 a b c	Introduction to Mathematical Physics
Ma. 8 a b	Advanced Calculus
together with	
Ma. 11	Differential Equations.

and the following courses or their equivalents:

EE. 120	Alternating Current Analysis
EE. 122	Advanced Alternating Current Machinery
EE. 144	Transmission Lines
EE. 152	Dielectrics
EE. 162	Vacuum Tubes

2. An applicant may also satisfy the requirements described above by taking an examination in the subject with the instructor in charge.

Students are advised to satisfy the conditions for admission to candidacy in their respective departments as rapidly as possible.

Students who fail to meet at least one-half of these requirements by the end of their first year of graduate study will not be allowed to register for further work except when special permission is obtained from the department.

3. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy.

4. A candidate for the degree of Doctor of Philosophy with a major in Mathematics must deliver a typewritten or printed copy of his completed thesis, in final form, to the professor in charge on or before May 1 of the year in which the degree is to be conferred.

5. A student in Electrical Engineering will, in general, be expected to have had six months or more of practical work in manufacturing, operating, or engineering research, in addition to the time required for college residence.

VII. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN CHEMISTRY

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of Chemistry and Chemical Engineering has adopted the following supplementary regulations:

1. To be recommended for candidacy for the doctor's degree the applicant must give satisfactory evidence of proficiency by means of the following:

a. Candidacy examination in physical chemistry,
b. Candidacy examination in inorganic chemistry,
c. Candidacy examination in organic chemistry,
d. Candidacy examination in colloid and surface chemistry,
e. Written report on the progress of research.

The examinations will be mainly written but will be partly oral. They will cover their respective subjects substantially to the extent

that these are treated in the undergraduate chemistry option; the proficiency expected is not less than that acquired by the abler undergraduates. A detailed informational knowledge is not so much desired as an understanding of general principles and a power to apply these to concrete problems.

The written report must be a satisfactory description of the applicant's research up to the date of his application. By this report and his laboratory work the applicant must have given evidence of his industry and ability in research, and of his power to present his results in clear, forceful language and with discrimination as to what is essential in scientific papers.

2. It is expected that the applicant shall have studied mathematics and physics substantially to the extent that these subjects are covered in the first two years of the Institute undergraduate courses. In cases where the applicant's training is less extensive than this, the Division of Chemistry and Chemical Engineering may prescribe additional work in these subjects prior to recommending him as candidate.

3. After admission to candidacy students must in general pursue advanced study and research for not less than 5 terms (counting equivalent summer work) before they will be recommended by the Division of Chemistry and Chemical Engineering for the final examination for the doctor's degree.

4. The final examination will consist in part of the candidate's oral presentation of a brief résumé of his research and its defense against attack, and in part of the defense of a set of propositions prepared by the candidate. The candidate may also expect questions not immediately related to his research or propositions.

The propositions should be about twelve in number, of which about three should relate to the minor subject, three (or more) to general branches of chemistry, and about six to the branch of chemistry of major interest to the candidate, including his research. The candidate may also include propositions not relating to his major and minor fields. The propositions, prepared by the candidate himself, should display his originality, breadth of interest, and soundness of training;

the candidate will be judged on his selection and formulation of the propositions as well as on his defence of them.

A copy of the set of propositions must be submitted to the Division of Chemistry and Chemical Engineering at least two weeks before the date set for the examination. A copy of the set of propositions must be submitted to the Dean of the Graduate School with each of the two copies of the thesis.

5. The doctor's degree is not awarded in Chemical Engineering at the present time, but students interested in this field may offer a minor in Chemical Engineering in connection with a major in Chemistry or in Mechanical Engineering.

VIII. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN AERONAUTICS, CIVIL AND MECHANICAL ENGINEERING AND METEOROLOGY

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as stated in Section V, the Division of Civil and Mechanical Engineering has adopted the following supplementary regulations:

1, a. To be recommended for candidacy for the doctor's degree in *Aeronautics* the applicant must pass the following courses with a grade of 2 or better:

Ma. 14	Vector Analysis
AE. 251 a b c	Aerodynamics of the Airplane
AE. 266 a b	Theoretical Aerodynamics I

and one of the following:

Ma. 114 a b	Mathematical Analysis
EE. 226 a b	Engineering Mathematical Physics

and also one of the following:

AE. 252 a b c	Airplane Design
Ph. 103 a b c	Analytical Mechanics
AE. 270 a b c	Elasticity Applied to Aeronautics

If any of the above subjects were taken elsewhere than at the Institute, the candidate will be required to pass special examinations indicating an equivalent knowledge of the subject.

1, b. To be recommended for candidacy for the doctor's degree in *Civil Engineering* the applicant must pass the courses prescribed

and elected for the fifth year, or equivalent substitutions satisfactory to the department, and such other advanced courses as the department may require, and must pass special comprehensive oral or written examinations in the fields covered by these courses.

1, c. To be recommended for candidacy for the doctor's degree in *Mechanical Engineering* the applicant must pass the following courses with a grade of 2 or better:

Ma. 11	Differential Equations

and one of the following:

EE. 226 a b	Engineering Mathematical Physics
Ma. 8 a b c	Advanced Calculus
Ma. 15 a b c	Higher Mathematics for Engineers and Physicists

and any one of the following three groups:

ME. 101 a b	Advanced Machine Design
ME. 110 a b c	Science of Metals
ME. 111 a b c	Metallography Laboratory
AE. 270 a	Elasticity Applied to Aeronautics
ME. 120, 121, 122	Heat Engines
Ph. 211	Thermodynamics
Hy. 100	Applied Hydrodynamics
Hy. 101	Hydraulic Machinery
AE. 266 a b and 267	Theoretical Aerodynamics

and also special comprehensive oral or written examinations in the fields covered by these courses.

1, d. To be recommended for candidacy for the doctor's degree in *Meteorology* the applicant must pass the following courses with a grade of 2 or better:

Ma. 14	Vector Analysis
AE. 266 a b	Theoretical Aerodynamics I
Ph. 211	Thermodynamics

and one of the following courses:

Ma. 109 a b	Introduction to Mathematical Analysis
EE. 226 a b	Engineering Mathematical Physics
AE. 265 a b	Mathematical Methods Applied in Aeronautics

2. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy, and will be expected to have had six months or more of practical work.

IX. SPECIAL REGULATIONS RELATING TO REQUIREMENTS FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN THE DIVISION OF THE GEOLOGICAL SCIENCES

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of the Geological Sciences has adopted the following supplementary regulations:

1. To be admitted to candidacy for the doctor's degree in the Division of the Geological Sciences the applicant must have shown more than average ability in mastering the previous geological, paleontological, and geophysical subjects.

2. The applicant for admission to candidacy may be required to take a qualifying examination which may be oral, or written, or both.

3. After admission to candidacy, students must in general pursue advanced study and research for a minimum of six terms, or approximately two years (counting each summer of field work as a term).

4. Candidates are required to take two oral examinations after admission to candidacy. The first, termed the general examination, tests knowledge in a specified number, but not all, of the various branches of geology and paleontology, and may be taken at any convenient time after admission to candidacy. The second, or final examination, is principally, but not entirely, a defense of the Ph.D. thesis and a test of the candidate's knowledge in the specialized fields of his major and minor subjects.

5. A first draft of the Ph.D. thesis with data, maps, and illustrations complete must be submitted to the professor in charge not later than February 1. Two copies of the final, revised thesis must be filed by April 20 with the professor in charge and circulated among the members of the examining committee. Likewise on this date, the candidate must file and circulate a paper, prepared for publication in form acceptable to his examining committee, embodying the results of his research in whole or in part.

D. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

1. FELLOWSHIPS AND ASSISTANTSHIPS

The Institute offers in each of its divisions a number of Fellowships and Graduate Assistantships. These usually carry, as stipends, tuition ($300) with or without an additional grant.

Most of the major grants consist in providing, for a continuous period of ten months, board in the Athenæum (see pages 66 and 157) and lodging in the Athenæum loggia, the Dormitory, or the Student Houses. The purpose of this plan is to enable the Fellows and Assistants of the various divisions to live together under attractive and healthful conditions, and thus secure the great educational and social advantages that result from intimate contacts with one another, with members of the professorial staff of the Institute, and with others using the Athenæum.

In the award of graduate scholarships and fellowships preferred consideration will be given to students who have been accepted as candidates for the degree of Doctor of Philosophy.

Teaching Fellows and Graduate Assistants devote during the school year not more than fifteen hours a week to teaching or laboratory assistance of a character that affords them useful experience. This time includes that required in preparation and in marking note-books and papers, as well as that spent in classroom and laboratory. Of the remaining time at least one-half must be devoted to research, unless otherwise arranged by the division concerned; and the obligation to prosecute the research earnestly is regarded as no less binding than that of showing proper interest in the teaching and in the advanced study, which is also pursued so far as time permits. The appointments are for a period of ten months; and it is understood that the research work will be continued in the summer, at least until this period is completed.

Forms for making application for fellowships or assistantships may be obtained on request from the Dean of the Graduate School. When possible, these applications should reach the Institute by February 15,

and notices of awards will be mailed to successful applicants on March 20. Appointments to fellowships and assistantships are for one year only; and a new application must be filed before February 15 of each year by all who desire appointments for the following year, regardless of whether they are already holders of such appointments or not.

II. RESEARCH FELLOWSHIPS AND SCHOLARSHIPS

1. **Institute Research Fellowships:** The Institute each year appoints as Research Fellows a number of men holding the degree of Doctor of Philosophy who desire to pursue additional research work.

2. **National Research Fellowships:** These fellowships, established by the Rockefeller Foundation, are awarded by the National Research Council to men who have their doctor's degree. Fellows may choose the institution in which they desire to pursue research. Applications should be made to the National Research Council, Washington, D. C.

3. **Drake Fellowships and Scholarships:** The income from the Drake Fund, provided by the late Mr. and Mrs. Alexander M. Drake, is used to maintain fellowships and scholarships in such numbers and amounts as the Board of Trustees determine. The recipients are designated as Drake Fellows and Drake Scholars.

4. **Blacker Fellowships:** The Robert Roe Blacker and Nellie Canfield Blacker Scholarship Endowment Fund, established by the late Mr. R. R. Blacker and Mrs. Blacker, provides in part for the support of graduate men engaged in research work. The recipients are designated as Blacker Fellows.

5. **Henry Laws Fellowships:** The income from a fund given by the late Mr. Henry Laws is used to provide fellowships for research in pure science, preferably in physics, chemistry, and mathematics. The recipients are designated as Henry Laws Fellows.

6. **Caroline W. Dobbins Fellowships:** The income from the Caroline W. Dobbins Fellowships and Scholarships Fund, provided by the late Mrs. Caroline W. Dobbins, is used to maintain fellowships

and scholarships at the Institute. The recipients are designated as Caroline W. Dobbins Fellows or Caroline W. Dobbins Scholars.

7. **Elizabeth Thompson Stone Scholarship:** A fund provided by the late Miss Elizabeth Thompson Stone is used to maintain at the Institute the Elizabeth Thompson Stone Scholarship.

8. **Bridge Fellowship:** The late Dr. Norman Bridge provided a fund, the income of which is used to support a research fellowship. The recipient is designated as the Bridge Fellow.

9. **George Ellery Hale Research Fellowships in Radiation Chemistry:** Dr. Arthur Amos Noyes, for many years Professor of Chemistry and Director of the Gates and Crellin Laboratories of Chemistry, by his will, gave to the Institute a fund to provide for certain research fellowships to be known as the "George Ellery Hale Research Fellowships in Radiation Chemistry," these fellowships to be available to competent young investigators who have received the degree of Doctor of Philosophy or have had a corresponding research training, and who will pursue, at the Institute, investigations in radiation chemistry (broadly interpreted to include the study of molecule structure by the methods of modern physics). These fellowships are to carry stipends, obligations and privileges similar to those of the National Research Fellowships.

10. **Noyes Fellowships:** Dr. Noyes further left his entire estate, after providing for certain specific bequests and annuities, to the Institute to constitute a fund to be known as the "Noyes Chemical Research Fund." The purpose of this fund, as stated in his will, is to provide for the payment of salaries or grants to competent persons to enable them to carry on scientific investigations in the field of chemistry at the Institute. Such persons shall have the status of members of the staff of the Institute, and shall devote their time and attention mainly to the execution at the Institute of experimental and theoretical researches upon the problems of pure science (as distinct from those of applied science) in the field of chemistry. Dr. Noyes further provided that "no portion of the income of the said fund shall be used

for the payment of tuition fees, nor for scholarships or fellowship grants to persons still registered as students, or in general for the education of persons as to existing knowledge; but on the contrary the whole thereof shall be used for promoting, in the manner aforesaid in the field aforesaid, the search for new or more exact knowledge by persons who have completed their period of formal study and are devoting at least one-half of their working time to scientific investigations."

Special Fellowship Funds

A considerable group of governmental and industrial organizations and private individuals have contributed funds for the support of Fellows engaged in fundamental researches related to their interests and activities. These include the United States Navy Department, the United States Soil Conservation Service, the United States Reclamation Service, the Metropolitan Water Board, Los Angeles County Flood Control District, Los Angeles County Seismological interests, Los Angeles County Harbor Board, Standard Oil Company of California, Union Oil Company, Shell Oil Company, Sunshine Mining Company, Agfa-Ansco Corporation, Geo-Frequenta Corporation, Hughes Tool Company, General Petroleum Corporation, Arnold Pfau, Caterpillar Tractor Company, William M. White, Allis-Chalmers Manufacturing Company, Lane Wells Company, National Supply Company of Delaware, A. O. Smith Corporation, Research Corporation of New York, Douglas Aircraft Co., Inc.; Boeing Airplane Company; Northrop Corporation; Lockheed Aircraft Corporation; Hughes Aircraft Company; Goodyear-Zeppelin Corporation; Curtiss-Wright Airplane Co.; Consolidated Aircraft Corp.; North American Aviation; Vultee Aircraft Division of Aviation Mfg. Corp., and the Mudd and Kellogg funds for researches on cancer and carcinogenic substances.

The Rockefeller Bio-Organic Fund: This fund is contributed by the Rockefeller Foundation for the support of a group of post-doctorate men who are working on the problem of the molecular structure of organic substances.

The Carnegie Corporation Cosmic Ray Fund: This fund is given by the Carnegie Corporation and administered by the Carnegie Institution of Washington, D. C., for cosmic-ray researches carried on by a group of five or six men.

The Earhart Foundation has contributed funds for the whole program of meteorological research at the Institute, including the development and use of the radiometeorograph.

III. INSTITUTE GUESTS

Members of the faculties of other educational institutions and Research Fellows who have already received their doctor's degree and desire to carry on special investigations may be granted the privileges of the facilities of the Institute, without payment of fees. Arrangement should be made in advance with the chairman of the division of the Institute concerned. Such guests are requested to file a card in the Registrar's office at the beginning of their work, giving Institute and home address, degrees, nature of work planned, etc.

IV. GRADUATE LIFE

The Athenæum (see page 66) affords opportunity for contact between the Associates of the Institute, distinguished foreign visitors, and members of the staffs and graduate students at the three adjacent institutions, the Mount Wilson Observatory, the Huntington Library, and the California Institute. It also provides living quarters for a limited number of men associated with the foregoing institutions, including specially economical sleeping quarters for about eighteen graduate students.

DESCRIPTION OF THE UNDERGRADUATE AND FIFTH-YEAR COURSES

THE COURSES IN ENGINEERING

The five-year plan of engineering instruction is based on recognition of the fact that a four-year period of study is inadequate to give satisfactorily the combination of cultural, basic scientific, and engineering studies essential to the highest type of engineer, and to afford at the same time leisure for the development of the physical well-being and human interests of the students. The four-year course trains, more broadly and fundamentally than the engineering courses now given at most institutions, the large proportion of students who study engineering not to make themselves engineering experts in a specialized sense, but to fit themselves to fill satisfactorily administrative positions in the utilities and manufacturing industries, and to serve as operating and constructing engineers in such industries. The fifth-year courses, based on this broad fundamental preparation, and co-ordinated with it so as to constitute a harmonious, unified, five-year period of study, with no sharp breaks between the undergraduate and graduate periods, will afford the more intensive training required by the engineer who is to do creative work in his field.

The four-year course in Engineering includes an unusually thorough training in physics and mathematics, and instruction in chemistry and geology; also extended courses, continuing throughout the four years, in humanistic studies, including English writing and speaking, literature, evolutionary science, history of civilization, current social and political problems, and economics; and, finally, those engineering subjects common to all branches of engineering, such as surveying, mechanism, descriptive geometry, machine drawing, applied mechanics, engineering materials, hydraulics, and preliminary courses in Civil, Mechanical, and Electrical Engineering.

Laboratory facilities are available for experimental work in hydraulics, thermodynamics, metallography, materials of construction, soil

mechanics, and electricity, including a high-voltage laboratory with a maximum rating of one million volts.

The fifth-year courses in Civil, Mechanical, and Electrical Engineering, and Aeronautics consist mainly of the engineering subjects that are fundamental in these separate branches of engineering. Thus the Civil Engineering Course deals largely with the analysis, design and construction of water systems, sanitation works and structures; the Mechanical Engineering Course, with machine design, steam and gas engineering, and power-plant design and operation; the Electrical Engineering Course with the generation, transmission and utilization of electric power and the communication of intelligence by electrical means; and the Aeronautics Course with the principles of aerodynamics, the design and construction of airplanes, their engines and instruments. Of all these courses, engineering research or design forms an important part.

THE COURSES IN SCIENCE

The courses in science prepare for those scientific and engineering professions in which an extensive training in the basic sciences and in research is of more importance than a knowledge of the principles and practice of engineering. Accordingly, the four-year course in science, while including the same historical, literary and economic subjects as the course in engineering, requires much more extended study of the three sciences of chemistry, physics, and mathematics; also two years' study of scientific German and French. In its junior and senior years there are offered a series of options which, when supplemented by the corresponding fifth-year courses, afford definite preparation for various scientific professions, as outlined in the following statement.

The Option in Chemistry and the Option in Physics and the fifth-year courses in Chemistry and Physics prepare students, on the chemical and physical sides respectively, for research and teaching in universities, colleges, and high schools, and for research positions in governmental laboratories and especially in the research and develop-

ment departments of the larger chemical, metallurgical, and electrical companies.

The Option in Applied Chemistry and the fifth-year courses in Chemical Engineering differ from those in Chemistry in that they include, in place of some of the science work, general subjects in mechanical and electrical engineering, and (in the fifth year) an extended treatment of chemical engineering itself. This course is designed to fit men for the installation, operation, and the research development of industrial chemical processes.

The Geology Option and the Graduate Course in Geology and Paleontology prepare for teaching and research positions in colleges and universities, for government posts in connection with geological and mining surveys, for places as directors and field explorers of museums and, above all, for expert work in geology in the oil and mining industries.

The Biology Option and the Graduate Course in Biology prepare for teaching and research in colleges and universities, for government service in agriculture and public health, and for field studies and laboratory research in connection with museums. The option of the undergraduate course affords a preliminary training, with emphasis on the fundamental sciences, for those who desire to pursue graduate studies in medicine, sanitation, and the public health.

SCHEDULES OF THE UNDERGRADUATE COURSES

The school year is divided into three terms. The number of units assigned in any term to any subject is the total number of hours per week devoted to that subject, including class work, laboratory work, and the estimated time for outside preparation. Laboratory assignments include drawing exercises and field work.

Besides the subjects shown in the course schedules, students are required to take Assembly and Physical Education in each term of each of the four school years. Students who continue their undergraduate work beyond four years continue to take Physical Education throughout their undergraduate course. Freshmen attend in the second and third terms, in addition to the general assemblies, six orientation assemblies.

The subject numbers correspond to those given in the description of subjects on pages 180-244. The abbreviations denote the various branches of instruction as follows:

Aeronautics	AE
Applied Chemistry	A Ch
Applied Mechanics	AM
Applied Physics	A Ph
Assembly	As
Astronomy	Ay
Biology	Bi
Chemistry	Ch
Civil Engineering	CE
Drawing	D
Economics	Ec
Electrical Engineering	EE
English	En
Geology	Ge
History and Government	H
Hydraulics	Hy
Languages	L
Mathematics	Ma
Mechanical Engineering	ME
Meteorology	My
Philosophy	Pl
Physical Education	PE
Physics	Ph
Thesis	Th

BOTH COURSES

ENGINEERING AND SCIENCE COURSES

FIRST YEAR, ALL THREE TERMS

		Units per Term
En 1 abc	English* (3-0-3)**	6
Ph 1 abc	Physics* (3-3-6)	12
Ch 1 abc	Chemistry* (3-6-3)	12
Ma 1 abc	Mathematics* (4-0-8)	12
H 1 abc	History (3-0-2)	5
D 1, 3 ab	Drawing*** (0-3-0)	3

*Students are required to pass, at the end of the sophomore year, comprehensive examinations in English and History, in Physics, and in Mathematics. Students taking the Options in Chemistry or Applied Chemistry are required to pass also a comprehensive examination in Chemistry.

**Number of hours devoted to class, laboratory, and preparation.

***D 1 is taken by all freshmen the first term, and D 3a, b, the second and third terms, respectively.

COURSE IN ENGINEERING

FOR STUDENTS PREPARING FOR CIVIL, MECHANICAL, AND ELECTRICAL ENGINEERING, AND AERONAUTICS

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

SECOND YEAR

		Units per Term 1st	2nd	3rd
Ma 2 abc	Mathematics*† (4-0-8)**	12	12	8*
Ph 2 abc	Physics*† (3-3-6)	12	12	8*
Ma 2 d	Mathematics Review† (4-0-8)	..	..	4*
Ph 2 d	Physics Review† (3-3-6)	..	..	4*
H 2 abc	History*** (2-0-4)	6	6	6
CE 1	Surveying (3-4-4)	..	11 or	11
ME 1	Mechanism (3-3-3)	9 or	9 or	9
ME 3	Materials and Processes (3-3-5)	..	11 or	11
Ge 1a	Geology (3-3-3)	9	..	..
D 3c	Descriptive Geometry (0-3-0)	3 or	3	..
D 3d	Descriptive Geometry (0-3-0)	..	3 or	3
D 6a	Engineering Drawing (0-6-0)	6 or	6	..
D 6b	Engineering Drawing (0-6-0)	..	6 or	6

*Students in the first honor section complete the regular work in Mathematics and in Physics during the first two terms and take in the third term Vector Analysis (Ma 14) and Modern Physics (Ph 3). Such students do not take Physics Review (Ph 2d) and Mathematics Review (Ma 2d).

†Students not in the first honor section take in the first 7 weeks of the third term Physics Ph 2c (8 units) and Mathematics Ma 2c (8 units), and in the last three weeks Physics Review Ph 2d (4 units) and Mathematics Review Ma 2d (4 units). A condition in either of these review subjects, unless made up in September, excludes the student from all third-year subjects for which these are prerequisite. To assist students in making up such conditions, and to aid students transferring from other colleges who may not have had such intensive courses as those of the Institute, each of these subjects will be offered as a summer course (with a fee of $20 each) during the three weeks preceding the opening of the fall term, provided not less than six students apply for it.

**Number of hours devoted to class, laboratory, and preparation.

***All students are required to pass a comprehensive examination in English and History at the end of the sophomore year.

COURSE IN ENGINEERING
ELECTRICAL ENGINEERING OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Ch 6	Engineering Chemistry (3-0-6)	9	..	..
Ec 17	Accounting (3-0-6)	9	..	..
EE 2	Direct Currents (3-0-6)	..	9	..
EE 3	Direct Current Laboratory (0-3-3)	..	6	..
EE 4	Alternating Currents (3-0-6)	..	..	9
EE 5	Alternating Current Laboratory (0-3-3)	..	..	6
A: Ma 11	Differential Equations (3-0-6)	9	..	..
ME 15	Heat Engineering (3-3-6)	..	12	..
Hy 1	Hydraulics (3-3-6)	..	..	12
B: Ph 5 abc	Mathematical Physics (4-0-8)	12	12	12

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
Ec 25	Business Law (3-0-3)	6	..	..
EE 6 ab	Electrical Machinery (2-0-4) (3-0-6)	..	6	9
EE 7	Electrical Engineering Laboratory (0-3-6)	..	..	9
EE 12	Electric Circuits (3-0-9)	12	..	..
EE 70 abc	Engineering Conferences	2	2	2
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
A†: EE 162	Vacuum Tubes (4-0-8)	..	12	..
ME 27	Mechanical Laboratory (0-3-6)	9	..	..
ME 18	Heat Engineering (3-0-7)	..	10	..
B†: EE 162	Vacuum Tubes (4-0-8)	..	12	..
ME 15	Heat Engineering (3-3-6)	..	12	..
Hy 1	Hydraulics (3-3-6)	12	..	..

*Humanities Electives

Pl 1	Philosophy (Soares)	En 10	Modern Drama (Stanton, Huse)
Pl 4	Ethics (Soares)	En 11	Literature of the Bible (MacMinn)
En 8	Contemporary Literature (Eagleson, Judy)	L 40	German Literature (Macarthur)
En 9	American Literature (MacMinn)	Pl 5	Sociology (Laing)

Students are required to take one term of Philosophy or Ethics, and choose two terms from the other electives. The assignment to each subject is 9 units (3-0-6).

†Options A and B in the fourth year are dependent upon the third year options, except for third term, when ME 18 or EE 162 may be substituted by students in either group.

COURSE IN ENGINEERING
CIVIL ENGINEERING OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
CE 2	Advanced Surveying (3-6-3)	12	..	..
Ch 6	Engineering Chemistry (3-0-6)	9	..	..
Ec 25	Business Law (3-0-3)	6	..	..
Hy 1 ab	Hydraulics (3-3-6) (3-0-6)	..	12	9
Ec 17	Accounting (3-0-6)	..	9	..
CE 4	Highway Engineering (3-0-3)	..	6	..
ME 20	Heat Engineering (2-3-4)	..	..	9
Ec 2	Economics (4-0-6)	..	..	10

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
CE 14 abc	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	..	6	..
CE 8 abc	Railway Engineering	6	6	6
CE 10 abc	Theory of Structures	12	12	9
CE 12	Reinforced Concrete (3-3-6)	..	..	12
EE 8	Direct Currents (3-0-4)	7	..	..
EE 9	Direct Current Laboratory (0-3-2)	5	..	..
Hy 2	Hydraulics Laboratory (0-6-0)	..	..	6
EE 10	Alternating Currents (3-0-4)	..	7	..
EE 11	Alternating Currents Laboratory (0-3-2)	..	5	..
Ge 10	Engineering Geology** (2-2-5)	..	..	9

*See first footnote on page 164.

**Men anticipating fifth year may elect Ma. 11 (9 units) as an alternate.

COURSE IN ENGINEERING
MECHANICAL ENGINEERING OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

	THIRD YEAR	Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Hy 1 a	Hydraulics (3-3-6)	12	..	..
Hy 1 b	Hydraulics (3-0-6)	..	9	..
Ch 6	Engineering Chemistry (3-0-6)	9	..	..
Ec 25	Business Law (3-0-3)	6	..	..
ME 15	Heat Engineering (3-3-6)	..	12	..
Hy 2	Hydraulics Laboratory (0-3-3)	..	6	..
ME 16	Heat Engineering (4-0-8)	..	..	12
Ec 17	Accounting (3-0-6)	..	..	9
ME 25	Mechanical Laboratory (0-3-3)	..	..	6
	FOURTH YEAR			
	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
ME 50	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	..	..	6
CE 9	Structures (3-3-6)	..	12	..
ME 5a	Machine Design (2-3-4)	9	..	..
ME 5b	Machine Design (2-3-4)	..	9	..
ME 5c	Machine Design (0-9-0)	..	..	9
ME 10	Metallurgy (2-0-4)	6	..	..
ME 17	Heat Engineering (3-0-6)	9	..	..
ME 26	Mechanical Laboratory (0-3-3)	..	6	..
EE 8	Direct Currents (3-0-4)	7	..	..
EE 9	Direct Currents Laboratory (0-3-2)	5	..	..
Ec 2	Economics (4-0-6)	..	10	..
EE 10	Alternating Currents (3-0-4)	..	..	7
EE 11	Alternating Currents Laboratory (0-3-2)	..	..	5
	Elective†	..	..	9

Men who intend to enter the graduate school of aeronautics must substitute Ma 11 (9 units) for ME 16 in the third term of the third year and in the fourth year must substitute:

Ma 8 abc	Advanced Calculus (4-0-8)	12	12	12
ME 8	Machine Design (3-3-6)	12	..	..
AE 2 ab	Aircraft Structures	..	12	12
AM 3	Testing Materials Laboratory (0-3-3)	..	6	..

for ME 5 abc, 17, 26, 50; CE 9; AM 3; and elective 9 units.

*See first footnote on page 164.

†Ma 11, Differential Equations, advised for all who expect to take fifth year.

COURSE IN SCIENCE

FOR STUDENTS PREPARING FOR CHEMISTRY, APPLIED CHEMISTRY, PHYSICS, APPLIED PHYSICS, MATHEMATICS, GEOLOGY, PALEONTOLOGY, BIOLOGY, ASTRONOMY AND MEDICINE

(For First Year, see page 162)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

SECOND YEAR

		Units per Term 1st	2nd	3rd
Ma 2 abc	Mathematics*† (4-0-8)	12	12	8*
Ph 2 abc	Physics*† (3-3-6)	12	12	8*
Ma 2d	Mathematics Review (4-0-8)	..	..	4*
Ph 2d	Physics Review (3-3-6)	..	..	4*
H 2 abc	History (2-0-4)	6	6	6
Ch 12 ab	Chemistry (2-6-2) (Except Ph., Ap.Ph. and Ma.)	10	10	..
Ge 1a	Geology (3-3-3)	9	..	..
Bi 1	Biology (3-3-3)	..	9	..
Ge 1b	Paleontology (4-1-4) or			
Bi 2	Biology (3-4-2) or	..	..	9
Ay 1	Astronomy (3-1-5)			
	Options as below	..	..	10

OPTIONS

PHYSICS, APPLIED PHYSICS, AND MATHEMATICS
(Students in these options do not take Ch 12 ab)

Ma 3	Theory of Equations (3-0-7)	10	..	..
Ma 14	Vector Analysis (3-0-7)	..	10	..
Ch 11	Analytical Chemistry (2-6-2)	..	..	10

CHEMISTRY AND APPLIED CHEMISTRY

Ch 12c	Analytical Chem. and Chem. Review** (2-6-2)	..	..	10

BIOLOGY

Bi 4	Invertebrate Zoology (2-6-2)	..	..	10

GEOLOGY**

CE 1	Surveying (3-4-4)	..	..	11
D 5	Descriptive Geometry (0-3-0)	..	..	3
Ge 1c	Historical Geology (3-0-6)	..	..	9

*Students in the first honor section complete the regular work in Mathematics and in Physics during the first two terms, and take in the third term Vector Analysis (Ma 14) and Modern Physics (Ph 3). Students in the first honor honor section do not take Mathematics Review (Ma 2d) and Physics Review (Ph 2d).

†Students not in the first honor section take in the first 7 weeks of the third term Physics Ph 2c (8 units) and Mathematics Ma 2c (8 units), and in the last 3 weeks Physics Review Ph 2d (4 units) and Mathematics Review Ma 2d (4 units). A condition in either of these review subjects, unless made up in September, excludes the student from all third-year subjects for which these are prerequisite. To assist students in making up conditions, and to aid students transferring from other colleges who may not have had such intensive courses as those of the Institute, each of these subjects will be offered as a summer course (with a fee of $20) during the 3 weeks preceding the opening of the fall term, provided not less than six students apply for it.

**Students in Geology do not take Mathematics the third term.

COURSE IN SCIENCE
PHYSICS OR ASTRONOMY OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a Ch 23 ab	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	..	10
L 35 a	German (4-0-6 or 3-0-3)	10	6**	6**
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 118 ab	Introduction to Statistics (3-0-6)	9	9	..

PHYSICS OPTION

An average grade of 2 or better in Ph 5 abc is required for admission to Ph 101 abc

Ph 101 abc	Electricity and Magnetism (3-0-6)	9	9	9
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

*See first footnote on page 164.

**Students may, with the approval of the language department and the Registrar, substitute French (L 1 a, b), 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE
APPLIED PHYSICS OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a Ch 23 ab	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ma 11	Differential Equations (3-0-6)	..	..	9
AM 1 abc	Applied Mechanics (4-3-7 or 4-1-7)	14	12***	12***
EE 8, 9	Direct Currents (3-3-6)	12	..	..
EE 10, 11	Alternating Currents (3-3-6)	..	12	..
ME 15 EE 162	Heat Engineering (3-3-6), or Vacuum Tubes (4-0-8)	..	..	12

*See first footnote on page 164.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b), 10 units, for German (L 35 b, c) in the second and third terms.

***Students in this option, with the approval of the applied mechanics department and of the Registrar, may register for the two additional hours of computing normally taken.

COURSE IN SCIENCE
MATHEMATICS OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a	Chemical Principles (4-0-6)	10	..	..
Ma 4 ab	Analytic Geometry (3-0-7)	..	10	10
Ma 8 abc	Advanced Calculus (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ma 106 abc	Introduction to Theory of Functions of Real Variables	5	5	5
Ma 107	Conformal Representation	..	..	9
Ma 101 abc	Modern Algebra (3 lectures a week)	6	6	6
Ma 102 ab	Higher Geometry (3-0-6)**	9	9	..
Ma 201 a	Modern Analysis	15	..	..

*See first footnote on page 164.
**See note on Ma 102, page 187.

COURSE IN SCIENCE
CHEMISTRY OPTION

(For First and Second Years, see pages 162 and 163)

Students of the Chemistry or Applied Chemistry Option whose average grade (credits divided by units) in the required chemistry subjects of the sophomore or junior year is less than 1.9 will be admitted to the required chemistry subjects of the following year only with the special permission of the Division of Chemistry and Chemical Engineering.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6)	10	10	10
Ch 26 ab	Physico-Chemical Laboratory (0-6-2 or 0-3-1)	..	8	4
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-12-0; 0-6-0)	12	6	..
Ch 13 a	Inorganic Chemistry (2-0-2)	..	..	4
Ch 14 a	Inorganic Chemistry Lab. (0-8-0)	..	..	8

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 22 ab	Thermodynamic Chemistry (2-0-4)	6	6	..
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
Ch 16	Instrumental Analysis (0-6-2)	8	..	..
Ch 70-73	Chemical Research (0-5-0 or 0-19-0)	..	5	19
Ch 29	Colloid and Surface Chemistry (3-0-5)	..	..	8
A: Ch 13 b	Inorganic Chemistry (2-0-2)	4	..	..
Ch 14 bc	Inorganic Chemistry Lab. (0-5-0 or 0-8-0)	5	8	..
B: Ph 5 ab	Introduction to Math. Physics (4-0-8)	12	12	..

*See first footnote on page 164.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE
APPLIED CHEMISTRY OPTION

(For First and Second Years, see pages 162 and 163)

Students of the Chemistry or Applied Chemistry Option whose average grade (credits divided by units) in the required chemistry subjects of the sophomore or junior year is less than 1.9 will be admitted to the required chemistry subjects of the following year only with the special permission of the Division of Chemistry and Chemical Engineering.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6)	10	10	10
AM 2 ab	Applied Mechanics (4-0-8)	12	12	..
Ch 63 ab	Chem. Eng. Thermodynamics (2-0-4)	..	6	6
Ec 2	Economics (4-0-6)	..	..	10
Ch 26 ab	Physical Chemistry Laboratory (0-3-1)	..	4	4
Ch 16	Instrumental Analysis (0-6-2)	8	..	..

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-9-0)	9	9	..
Ch 29	Colloid and Surface Chemistry (3-0-5)	..	..	8
Ch 22a	Thermodynamic Chemistry (2-0-4)	6	..	..
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
EE 8, 9	Direct Currents (3-3-6)	..	12	..
EE 10, 11	Alternating Currents (3-3-6)	..	..	12

*See first footnote on page 164.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE
GEOLOGICAL SCIENCES OPTION*

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a Ch 23 a	Chemical Principles (4-0-6)	10	10	..
CE 3	Plane Table Surveying (1-6-1)	..	..	8
Ge 3 abc	Mineralogy	12	12	12
Ge 14	Geologic Illustration	10	..	..
Ge 121 ab	Field Geology	..	10	10

FOURTH YEAR

	Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (3-0-3 or 2-0-4)	..	..	10
L 35 abc	German (4-0-6 or 3-0-3)	10	6***	6***
Ge 109	Structural Geology (4-0-6)	10	..	..
Ge 111 ab	Invertebrate Paleontology#	8	10	..
Ge 112 ab	Vertebrate Paleontology (2-6-2)#	..	10	10
Ge 105	Optical Mineralogy (2-6-2)#	10	..	..
Ge 106 ab	Petrography#	..	10	10
Ge 100	Geology-Paleontology Club	1	1	1
Ge 21, 22	Thesis#	..	..	..

*Summer Field Geology required after both Junior and Senior Years.

**See first footnote on page 164.

***Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

#Students desiring to specialize in physical geology may take Ge 105 and Ge 106 in conjunction with one paleontology course. Those desiring to specialize in paleontology may take both Ge 111 and Ge 112, omitting Ge 105 and Ge 106. In either case the course not taken in the fourth year is to be taken in the fifth. Thesis units, Ge 21 or 22, arranged to bring total units per term to 50.

COURSE IN SCIENCE
BIOLOGY OPTION

(For First and Second Years, see pages 162 and 163)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 92.

THIRD YEAR*

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ec 2	Economics (4-0-6)	..	10	..
Ch 41 ac	Organic Chemistry (3-0-5, 2-0-4)	8	..	6
Ch 21 a	Chemical Principles (4-0-6)	10	..	..
Ch 23 ab	Chemical Principles (4-0-6)	..	10	10
Bi 11	Entomology (2-3-3)	..	..	8
A: Courses offered in 1938-39 and every second year:				
Bi 3	Botany (2-9-3)	14	..	..
Bi 5 ab	Plant Physiology (3-6-3 and 2-4-2)	..	12	8
B: Courses offered in 1937-8 and every second year:				
Bi 12	Histology (1-6-2)	9	..	..
Bi 13	Mammalian Anatomy (1-2-2)	5	..	..
Bi 6	Embryology (2-8-2)	..	12	..
Bi 8	Advanced Genetics (2-3-3)	..	..	8

FOURTH YEAR

	Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Bi 16 ab	Animal Physiology (3-2-5)	10	10	..
Bi 7 ab	Biochemistry (2-4-4)	..	10	10
Bi 20	Biological Literature (0-0-4)	4	..	..
Bi 22	Research	..	..	10
	And one of the following:			
A: Courses offered in 1938-39, same as in third year		14	12	8
B: Courses offered in 1937-8, same as in third year		14	12	8

*Students taking the Biology Option are urged to take Bi 17 (Vertebrate Anatomy, 10 units), at Corona del Mar in the summer between their second and third years.

**See first footnote on page 164.

SCHEDULES OF COURSES FOR THE DEGREE OF MASTER OF SCIENCE

SUBJECTS COMMON TO ALL COURSES

		Units per Term 1st	2nd	3rd
H 100	Seminar in American History and Government			
En 100	or English Literature	9	9	9
Pl 100	or Philosophy			
Ec 100 abc	or Business Economics	12	12	12
	Engineering or Research Seminars	2	2	2
	Professional Subjects	42	42	42

ELECTRICAL ENGINEERING

	Subjects common to all courses	11	11	11
EE 120	Alternating Current Analysis	12	..	..
EE 122	Advanced Alternating Current Machinery	..	12	..
EE 144	Transmission Lines	..	..	12
EE 121 abc	Alternating Current Laboratory	6	6	6
EE 148	Specifications and Design	6	..	..
EE 160	Electric Transients	..	6	..
EE 152	Dielectrics	..	..	6
	Research or Thesis	12	12	12
	Electives, as below	6	6	6

ELECTIVES

EE 162	Vacuum Tubes	..	..	12
EE 128	Electric Traction	..	9	..
EE 156	Electrical Communication	6	..	..
EE 130	Light and Power Distribution	..	..	6
Ph 5 abc	Introduction to Mathematical Physics	12	12	12

CIVIL ENGINEERING

	Subjects common to all courses	11	11	11
CE 23	Statically Indeterminate Structures	12	..	..
CE 16	Masonry Structures	..	..	9
Ma 15 abc	Higher Mathematics for Engineers	9	9	9
CE 15	Irrigation and Water Supply	..	12	..
CE 21 abc	Structural and Civil Engineering Design	12	9	9
CE 17	Sewerage	..	..	9
AM 105	Soil Mechanics	6	..	..
CE 115	Foundations	..	6	..
	Research or Other Thesis	3	6	6

SUPPLEMENTARY SUBJECTS

CE 101 ab	Water Power Plant Design	10	10	..
CE 105 bc	Statically Indeterminate Structures	..	..	..
CE 107 abc	Geodesy and Precise Surveying	6	6	6
CE 108	Highway Problems	..	..	..
CE 110 bc	Sewage Treatment Plant Design	..	10	10
CE 114	Earthquake Effects upon Structures	..	..	..
Ge 10	Engineering Geology	..	..	9
AE 270	Elasticity	12	6	6
AE 273 abc	Synoptic Meteorology	12	12	12
Hy 100	Applied Hydrodynamics	..	12	..

MECHANICAL ENGINEERING

		Units per Term 1st	2nd	3rd
	Subjects common to all courses (page 175)	11	11	11
ME 110a	Science of Metals	6	..	..
ME 111a	Metallography Laboratory	6	..	..
ME 120	Heat Engineering	12	..	..
Ma 15 or Ma 8	Higher Mathematics for Engineers or Advanced Calculus	9	9	9
	Electives, as below	9*	36	36

ELECTIVES*

ME 101 ab	Advanced Machine Design	..	12	12
ME 110 bc	Science of Metals	..	6	6
ME 111 bc	Metallography Laboratory	..	6	6
ME 121, 122	Heat Engineering	..	12	12
Hy 100	Applied Hydrodynamics	..	12	..
Hy 101	Hydraulic Machinery	..	..	12
	Research or Thesis, as arranged			

AERONAUTICS

FIFTH YEAR

	Subjects common to all courses (page 175)	11	11	11
AE 251 abc	Aerodynamics of the Airplane	9	9	9
AE 252 abc	Airplane Design	12	12	12
AE 253 abc	Airplane Design and Testing Procedure	6	6	6
EE 226 ab or MA 114 ab	Engineering Mathematical Physics or Mathematical Analysis	15 12	15 12	.. ..
MA 14	Vector Analysis	..	..	12
AE 290 abc	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	..	..	..
	*Electives	..	..	..

SIXTH YEAR

AE 254 abc	Advanced Problems in Airplane Design	9	9	9
AE 266 ab	Theoretical Aerodynamics I	12	9	..
AE 267	Theoretical Aerodynamics II	..	..	12
AE 270	Elasticity Applied to Aeronautics	12	6	6
AE 290	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	..	..	..
	Electives	..	..	..

*Ma 11 Differential Equations must be taken in the first term unless the student has already passed the course in the fourth year.

METEOROLOGY

FIFTH YEAR

		Units per Term 1st	2nd	3rd
	Subjects common to all courses (page 175)	11	11	11
AE 273 abc	Synoptic Meteorology	12	12	12
AE 274 abc	Meteorological Laboratory	15	15	15
AE 276	Meteorological Instruments	6	..	..
AE 280	Research	..	..	..
AE 291 abc	Meteorological Seminar	2	2	2
Ph 91 abc	Introduction to Mathematical Physics	8	8	8

SIXTH YEAR

*AE 272 abc	Dynamic Meteorology	9	9	9
AE 274 abc	Meteorological Laboratory	15	15	15
AE 275	Structure of the Atmosphere	..	..	3
AE 280	Research	..	..	..
AE 291 abc	Meteorological Seminar	2	2	2
Ma 118 abc	Introduction to Statistics	9	9	9
	Electives	..	..	..

PHYSICS OR APPLIED PHYSICS

	Subjects common to all courses (page 175)	11	11	11

ELECTIVES

Ph 110 ab	Kinetic Theory	9	9	..
Ph 107 abc	Atomic Physics	9	9	9
Ph 108	Spectroscopy Laboratory	..	3	..
Ph 103 abc	Analytical Mechanics	12	12	12
Ph 105 ab	Optics	9	9	..
Ph 106 ab	Optics Laboratory	3	3	..
EE 162	Vacuum Tubes	..	..	12
Ma. 114	Mathematical Analysis	12	12	12
Ph 114	Principles of Quantum Mechanics	..	..	9
Ph 115	Applications of Quantum Mechanics	9	..	
	Research	15	15	15

MATHEMATICS

	Subjects common to all courses (page 175)	11	11	11
	Courses open to graduates in Mathematics Curriculum, 45 units during the year.			
	Research	6	6	6
	Subjects in fifth-year Physics Course			

*AE 272 abc will replace Ph 91 abc on fifth year students' curricula when a one-year course is pursued.

CHEMISTRY OR CHEMICAL ENGINEERING

		Units per Term 1st	2nd	3rd
	Subjects common to all courses (page 175)	11	11	11

ELECTIVES

Ch 153	Thermodynamic Chemistry	6	6	..
Ch 155 abc	Nature of Chemical Bond	6	6	6
Ch 156 abc	Introduction to Wave Mechanics	9	9	9
Ch 157 abc	Structure of Crystals	6	6	6
Ch 158	Photochemistry	6	..	..
Ch 159a	Kinetics of Homogeneous Reactions	6	..	..
Ch 159b	Kinetics of Heterogeneous Reactions	..	6	..
Ch 161	Organic Chemical Analysis	9	..	..
Ch 162 abc	Organic Chemistry (special topics)	6	6	6
Ch 163	Introduction to the Spectra of Molecules	6	..	..
Ch 166 abc	Chemical Engineering*	12	12	12
Ch 167	Phase Equilibria in Applied Chemistry	6	..	..
Ch 168	Thermodynamics of Multi-component Systems	..	8	8
Ch 169	Research Manipulations	3	..	..
ME 25	Mechanical Laboratory	6 or	6 or	6
	Research	12-18	12-18	12-18

*Candidates for the master's degree in Chemical Engineering are required to take the subject Chemical Engineering. They must also have taken or take in this year the engineering subjects included in the Applied Chemistry Option of the Four-Year Course in Science. Their research must be in the fields of Applied Chemistry or Chemical Engineering.

GEOLOGICAL SCIENCES

		Units per Term 1st	2nd	3rd
	Subjects common to all courses	11	11	11
	Subjects chosen from the following electives to constitute a program of study approved by a Division representative	39	39	39
Ge 100	Geology-Paleontology Club	1	1	1
Ge 105	Optical Mineralogy**	10	..	..
Ge 106 ab	Petrography**	..	10	10
Ge 109	Structural Geology	10	..	..
Ge 110	Engineering Geology	..	..	9
Ge 111 ab	Invertebrate Paleontology**	8	10	..
Ge 112 ab	Vertebrate Paleontology**	..	10	10
Ge 121 ab	Field Geology	..	10	10
Ge 122	Spring Field Trip	..	..	1
Ge 123	Summer Field Geology	..	..	12
Ge 175	Elementary Geophysics	..	..	5‡
Ge 176	Elementary Seismology	..	..	5†
Ge 187	Research	..	..	..
Ge 200	Mineragraphy	8	..	..
Ge 201	Introduction to Economic Geology	5	..	..
Ge 202	Metalliferous Deposits	..	10	..
Ge 210	Advanced Petrology	..	8	..
Ge 211	Petrology (Seminar)	..	..	5
Ge 212	Non-Metalliferous Ore Deposits	..	..	10
Ge 213	Advanced Economic Geology (Seminar)	..	5‡	..
Ge 214	Advanced Economic Geology (Seminar)	..	5†	..
Ge 215	Mineralogy (Seminar)	5	..	..
Ge 216	Advanced Study	..	..	..
Ge 220	History of Geology	..	5†	..
Ge 225	Geology of the Pacific Coast Region	..	..	6†
Ge 226	Geomorphology	10‡	..	..
Ge 289a	Structural Geology (Seminar)	5	..	..
Ge 289b	Physical Geology (Seminar)	..	..	5
Ge 290 ab	Vertebrate Paleontology (Seminar)	..	5	5
Ge 291 ab	Invertebrate Paleontology (Seminar)	5	5	..
Ge 261	Theoretical Seismology	6‡	..	..
Ge 262	Interpretation of Seismograms of Teleseisms	..	5‡	..
Ge 263	Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes	..	..	5‡
Ge 265	Introduction to General Geophysics	..	6‡	..
Ge 270	Seismic Instruments	9	..	..
Ge 273	Applied Geophysics I	..	5†	..
Ge 274	Applied Geophysics II	..	6†	..
Ge 275	Applied Geophysics III	..	..	6†
Ge 278	Interpretation of Field Seismograms	..	..	5†
Ge 282	Geophysics (Seminar)	..	..	3
Ge 283	Geophysical Instruments (Seminar)	..	3	..
Ge 295 abc	Geophysics Research Conference	2	2	2

**The starred course not completed during the senior year is to be taken.

Symbols:

No symbol; course given every year.

†Course given in 1937-1938.

‡Course given in 1938-1939.

SUBJECTS OF INSTRUCTION

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, HARRY BATEMAN, IRA S. BOWEN, PAUL S. EPSTEIN, WILLIAM V. HOUSTON, CHARLES C. LAURITSEN, J. ROBERT OPPENHEIMER, RICHARD C. TOLMAN, EARNEST C. WATSON

ASSOCIATE PROFESSORS: CARL D. ANDERSON, ALEXANDER GOETZ, S. STUART MACKEOWN, GENNADY W. POTAPENKO, WILLIAM R. SMYTHE, FRITZ ZWICKY

ASSISTANT PROFESSOR: H. VICTOR NEHER

SENIOR FELLOW IN RESEARCH: JOHN D. STRONG

RESEARCH FELLOWS: JOSEF F. JOHNSON, SETH H. NEDDERMEYER, WILLIAM H. PICKERING

UNDERGRADUATE SUBJECTS

Ph. 1 a, b, c. Mechanics, Molecular Physics, Heat, and Sound. 12 units (3-3-6); first, second and third terms.

Prerequisites: A high school course, or its equivalent, and trigonometry.

The first year of a general college course in physics extending through two years. It is a thorough analytical course, in which the laboratory carries the thread of the work, and the problem method is largely used. A bi-weekly demonstration lecture, participated in by all members of the department, adds the inspirational and informational element, and serves for the development of breadth of view.

Text: *Mechanics, Molecular Physics, Heat, and Sound,* Millikan, Roller and Watson.

Instructors: Watson, Neher, Strong and Teaching Fellows.

Ph. 2 a, b, c. Electricity, Sound, and Light. 12 units (3-3-6), first and second terms; 8 units, third term.

Prerequisites: A high school course, or its equivalent, and trigonometry.

Continuation of Ph. 1 a, b, c, to form a well-rounded two-year course in general physics.

Text: *Electricity, Sound, and Light,* Millikan and Mills.

Instructors: Anderson, Lauritsen, Neddermeyer, Pickering and Teaching Fellows.

Ph. 2 d. Physics Review. 4 units; last three weeks of sophomore year.

The last three weeks of the sophomore year are devoted to a comprehensive review and examination covering the whole of the two years' work (Ph. 1 a, b, c, and 2 a, b, c).

Ph. 3. Modern Physics. 12 units (2-6-4); third term.

Prerequisites: Ph. 1 a, b, c, 2 a, b; Ma. 2 a, b.

A brief survey of recent developments in electron theory, quantum theory, radioactivity, and atomic structure. Experiments to determine e, e/m, h, and other

fundamental constants will be performed. Open only to students on honor standing, sophomore year.

Instructor: Anderson.

Ph. 5 a, b, c. Introduction to Mathematical Physics. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

An introduction to the application of mathematics to physics, and practice in the solution of problems.

Instructor: Houston.

Ph. 7 a, b, c. Electricity and Magnetism. 6 units (2-0-4); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A course in theoretical electricity and magnetism, primarily for electrical engineering students Ph. 9 a, b (Electrical Measurements) must accompany this course.

Text: *Principles of Electricity,* Page and Adams.

Instructor: Mackeown.

Ph. 9 a, b, c. Electrical Measurements. 4 units (0-3-1); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A laboratory course in advanced electrical measurements.

Text: *Advanced Electrical Measurements,* Smythe and Michels.

Instructors: Smythe and Assistants.

Astronomy 1. Introduction Course in Astronomy. 9 units (3-1-5); third term.

This course is intended to give the student sufficient familiarity with general astronomy to enable him to read with ease most of the semi-popular books dealing with various phases of the subject.

Text: *Astronomy,* Moulton.

Instructor: Johnson.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ph. 91 a, b, c. Introduction to Mathematical Physics. 8 units; first, second and third terms.

This course is the same as Ph. 5 a, b, c but with reduced credit for graduate students.

Instructor: Houston.

Ph. 101 a, b, c. Electricity and Magnetism. 9 units (3-0-6); first, second and third terms.

Prerequisites: Ma. 8 a, b, c, or 10 a, b, c, and an average grade of 2 in Ph. 5 a, b, c.

A problem course in the mathematical theory of electricity and magnetism, intended primarily as a preparation for graduate work in science. Ph. 9 a, b, c (Electrical Measurements) should accompany or precede this course.

Text: *Static and Dynamic Electricity,* Smythe.

Instructor: Smythe.

Ph. 103 a, b, c. Analytical Mechanics. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A study of the fundamental principles of theoretical mechanics; force and the laws of motion; statics of systems of particles; the principle of virtual work, potential energy, stable and unstable equilibrium; motion of particles, systems of particles and rigid bodies; generalized coordinates, Hamilton's principle and the principle of least action; elementary hydrodynamics and elasticity.

Text: *Dynamics,* Webster.

Instructor: Zwicky.

Ph. 105 a, b. Optics. 9 units (3-0-6); first and second terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A problem course dealing with the fundamental principles of geometrical optics, of diffraction, interference, the electromagnetic theory of light, etc., and their experimental verification. Ph. 106 a, b (Optics Laboratory), should accompany this course.

Text: *Theory of Optics,* Drude.

Instructor: Bowen.

Ph. 106 a, b. Optics Laboratory. 3 units (0-3-0); first and second terms.

Advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization, spectrophotometry.

Text: *Manual of Advanced Optics,* Taylor.

Instructor: Bowen.

Ph. 107 a, b, c. Atomic Physics. 9 units; first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

An outline of the experimental and theoretical basis of modern atomic physics, which covers electron theory, spectroscopy and nuclear physics.

Instructors: Millikan, Bowen, Anderson.

Ph. 108. Spectroscopy Laboratory. 3 units; second term.

A laboratory course in the measurement and classification of spectral lines to accompany Ph. 107 b.

Instructor: Bowen.

Ph. 110 a, b. Kinetic Theory of Matter. 9 units; first and second terms.

Prerequisites: Ph. 1 a, b, c, d; Ma. 2 a, b, c, d.

During the first term, the fundamentals of the kinetic theory of gases are treated from both the theoretical and the experimental viewpoint (Clausius, Maxwell, Boltzmann, van der Waals, Knudsen equations). During the second term more advanced problems of the constitution of matter are discussed in the form of a seminar (liquefaction of gases, low temperature phenomena, specific heats, thermal expansion, crystallization, plasticity).

(Not given in 1937-1938.)

Instructor: Goetz.

Ph. 114. Principles of Quantum Mechanics. 9 units; third term.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

An outline, developed by means of problems, of the experimental and theoretical basis of quantum mechanics, including the idea of states, principle of indetermination, the Schroedinger equation, methods of approximate solution, electron spin, and Pauli principle.

Instructor: Houston.

Ph. 115. Applications of Quantum Mechanics. 9 units; first term.
Prerequisite: Ph. 114.
The application of non-relativistic quantum mechanics to problems in various fields of physics. The subjects treated will be determined partly by the interests of the class.
Instructor: Houston.

Ph. 142. Research in Physics. Units in accordance with the work accomplished. Approval of the department must be obtained before registering.

GRADUATE SUBJECTS

Ph. 211. Thermodynamics. 12 units; first term.
Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.
The two fundamental laws of thermodynamics. Entropy and the thermodynamical potentials. Equations of reciprocity. Application to gases, perfect and imperfect, and to dilute solutions. Phase rule and chemical equilibrium. Nernst's theorem.
Instructor: Epstein.

Ph. 221. Potential Theory. 15 units; third term.
Prerequisites: Ma. 8 a, b, c, 10 a, b, c.
An exposition of the properties of the potential functions occurring in the theories of gravitation, electricity and magnetism, hydrodynamics, conduction of heat, and the theory of elasticity. Solution of special problems.
Instructor: Bateman.

Ph. 222. Theory of Electricity and Magnetism. 12 units; first term.
Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.
Electrostatics, magnetostatics, ferromagnetism, electromagnetic field of stationary currents, electromagnetic induction, phenomena in moving bodies, Maxwell's equations, ponderomotive forces of an electromagnetic field, introduction to the theory of electrons.
(Not given in 1937-1938.)
Instructor: Epstein.

Ph. 223. Theory of Electromagnetic Waves. 12 units; second term.
Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.
Mathematical study of Maxwell's equations, propagation of waves, absorption and reflection, approximate and rigorous treatment of diffraction, theory of dispersion, electro- and magneto-optics.
(Not given in 1937-1938.)
Instructor: Epstein.

Ph. 224. Theory of Sound. 9 units; second term.
Prerequisites: Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.
Vibrations of strings, rods, plates and of the larynx. Resonators, horns and musical instruments. Theories of hearing. The acoustics of an auditorium. The propagation of sound. Reflection, refraction and absorption of sound.
Instructor: Bateman.

Ph. 225. Theory of Electrons. 12 units; second term.
Prerequisites: Ph. 101 a, b, c, 222; Ma. 8 a, b, c, 10 a, b, c.
Retarded potentials. Radiation of a point charge. Theory of dielectrics. Electron

theory of dia-, para- and ferro-magnetism. Phenomena in moving bodies and experimental foundations of the theory of relativity.

(Not given in 1937-1938.)

Instructor: Epstein.

Ph. 226. Heat Radiation and Quantum Theory. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 211; Ma. 8 a, b, c, 10 a, b, c.

Historical treatment of the development of the mathematical theory of heat radiation and of the application of the theory of quanta to the phenomena of specific heats of solid and gaseous bodies, photoelectricity, photochemistry, chemical constants, etc.

Instructor: Epstein.

Ph. 228. Modern Aspects of the Quantum Theory. 12 units; third term.

Prerequisites: Ph. 103 a, b, c, 107 a, b, c, 229; Ma. 8 a, b, c, 10 a, b, c.

The course is devoted to a review of recent developments in the quantum theory, especially in the fields of the theory of radiation and of the electron theory of metals. The subject matter varies from year to year.

Instructor: Epstein.

Ph. 232. Physics of Ultra-Short Electromagnetic Waves. 6 units (2-0-4); first and second terms.

Propagation of waves. Maxwell's dispersion and absorption in semi-conductors and metals. Electronic and dipolar dispersion and absorption in dielectrics. Dispersion and absorption in electrolytes. Waves along wires and dispersion in magnetic substances.

Experimental results on dispersion and absorption of ultra-short waves in dielectrics, electrolytes and magnetic substances.

Instructor: Potapenko.

Ph. 234. Topics in Theoretical Physics. 9 units (3-0-6); third term.

The subject of this course will vary from year to year. Typical topics: Theory of atomic collisions; relativistic quantum theory; theory of radiation; statistical mechanics. In 1936-37 the course dealt with recent contributions to the theory of atomic nuclei; the problem of nuclear stability; nuclear collisions and transmutations; the interaction of neutrons with nuclei; nuclear radiative processes; and the phenomenological theory of beta-ray decay.

Instructor: Oppenheimer.

Ph. 236 a, b, c. Introduction to the Theory of Relativity. 6 units; first, second and third terms.

The special theory of the relativity of motion in free space, with applications to mechanical and electromagnetic problems. Use of four dimensional language for expressing the results of relativity. Introduction to tensor analysis. The general theory of relativity and the theory of gravitation. Applications to thermodynamics and cosmology.

Text: *Relativity, Thermodynamics and Cosmology*, Tolman.

Instructor: Tolman.

Ph. 237. Astrophysics. 6 units (2-0-4); first and second terms.

Prerequisites: The fundamental courses in physics.

Mechanics and thermodynamics of stellar bodies, constitution of stars, stellar atmospheres and their spectra, evolution of the planetary system and of stellar

systems, time scales, characteristics of extragalactic nebulæ and their apparent velocities of recession, evolution of the universe, etc.

(Not given in 1937-1938.)

Instructor: Zwicky.

Ph. 238. Seminar on Theoretical Physics. 4 units; first, second and third terms.

Recent developments in theoretical physics for specialists in mathematical physics.

In charge: Epstein.

Ph. 239. Research Conference on the Physics of Solids. 2 units; first, second and third terms.

Recent developments in the field of the solid state, crystallization, physics of colloids, low temperature.

In charge: Goetz.

Ph. 240. Seminar on X-Radiation. 4 units; first, second and third terms.

Meets once a week for reports and discussions of problems in X-Radiations. Standard texts on X-rays are followed in the first term as an outline only; the reports being amplifications and additions to the material of the text as drawn from the original papers of workers in the field. During the second and third terms advanced reports are made on current problems and on fundamental classical work.

In charge: DuMond.

Ph. 241. Research Conferences in Physics. 4 units; first, second and third terms.

Meets twice a week for a report and discussion of the work appearing in the literature and that in progress in the laboratory. Advanced students in physics and members of the physics staff take part.

In charge: Millikan and Houston.

Ph. 242. Research in Physics. Units in accordance with the work accomplished. Opportunities for research are offered to graduate students in all the main branches of physics. See "Publications of the Staff," pages 119-122, for a survey of researches actually in progress. The student should consult the department and have a definite program of research outlined before registering.

Ph. 245. Seminar on Ultra-Short Electromagnetic Waves. 4 units (2-0-2); first and second terms.

Recent developments in methods of generation of ultra-short waves. Modern methods of physical measurements in high frequencies.

In charge: Potapenko.

Astronomy and Physics Club.

The club, consisting of physicists and astronomers of the Institute and of the Mount Wilson Observatory, meets on the first Friday in each month either at the Institute or the Observatory Laboratory for the discussion of researches carried on by its members as well as those appearing in the journals.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, HARRY C. VAN BUSKIRK
RESEARCH ASSOCIATE: DINSMORE ALTER, Statistics
ASSOCIATE PROFESSORS: ARISTOTLE D. MICHAL, MORGAN WARD, LUTHER E. WEAR
ASSISTANT PROFESSOR: WILLIAM N. BIRCHBY.

UNDERGRADUATE SUBJECTS

NOTE: Students intending to take the mathematics option must indicate their choice by the end of the second term of their sophomore year.

Ma. 1 a, b, c. Freshman Mathematics. 12 units (4-0-8); first, second and third terms.

Including the fundamentals of analytical geometry, certain topics in college algebra, and some of the principles of the differential and integral calculus.

Texts: *Differential and Integral Calculus,* Cohen; *Analytical Geometry,* Young, Fort and Morgan.

Ma. 2 a, b, c. Sophomore Mathematics. 12 units (4-0-8); first and second terms; 8 units third term.

Prerequisite: Ma. 1 a, b, c.

Includes additional topics in analytical geometry, and completes the usual subjects of the calculus, begun in the freshman year.

Texts: *Analytical Geometry,* Nowlan; *Differential and Integral Calculus,* Cohen.

Ma. 2 d. Mathematics Review. 4 units (4-0-8).

A comprehensive review of freshman and sophomore mathematics during the last three weeks of the sophomore year.

Courses Ma. 1 a, b, c, and 2 a, b, c, d, form a continuous two-year course in analytical geometry, college algebra, and the differential and integral calculus.

Ma. 3. Theory of Equations. 10 units (3-0-7); first term.

Includes the elementary theorems in the roots of an equation, solution of numerical equations, determinants, symmetric functions, resultants and discriminants.

Instructors: Wear, Dilworth.

Ma. 4 a, b. Analytic Geometry. 10 units (3-0-7); second and third terms.

Prerequisites: Ma. 1 and 2.

Aims to acquaint the student majoring in mathematics with the basic ideas and methods of Higher Geometry. Subjects treated include: Homogeneous coordinates, line coordinates, cross-ratio, projective coordinates, point curves and line curves, projective and metric properties of conics, correlations.

Text: *Higher Geometry,* Graustein.

Instructor: Wear.

Ma. 8 a, b, c. Advanced Calculus. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ma. 1, Ma. 2.

Planned to extend the knowledge gained from the previous studies in calculus and analytic geometry and to lay a better foundation for advanced work in mathematics and science.

Text: *Advanced Calculus,* Woods and Osgood.

Instructors: Birchby, Michal, Arnold.

Ma. 10 a, b, c. Differential Equations. 9 units (3-0-6); first, second and third terms.

Prerequisite: Ma. 2 a, b, c, d.

An introductory course in differential equations, designed to be helpful both to the student of mathematics and the student of science or engineering.

Text: *Differential Equations,* Ford.

Instructor: Wear.

Ma. 11. Differential Equations. 9 units (3-0-6); first or third terms.

Prerequisite: Ma. 2 a, b, c, d.

An abridged course in Differential Equations for students in Electrical Engineering.

Text: *Differential Equations,* 2nd edition, Cohen.

Instructor: Wear.

Ma. 12. Probability and Least Squares. 6 units (2-0-4); first term.

Prerequisites: Ma. 1, Ma. 2.

A study of the fundamental principles of probability and their application to statistical data, adjustment of observations, and precision of measurements.

Text: *Theory of Errors and Least Squares,* Bartlett.

Instructor: Alter.

Ma. 14. Vector Analysis. 12 units (4-0-8); second or third term.

Prerequisites: Ma. 2 a, b, c, d.

Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated.

Instructors: Ward, Sears.

Ma. 15 a, b, c. Higher Mathematics for Engineers and Physicists. 9 units; first, second and third terms.

Prerequisites: Ma. 1, Ma. 2.

An alternative course to Ma. 8, Advanced Calculus, covering about the same range of subjects. Intended primarily for Engineers and Applied Physicists who do not expect to use advanced theory.

Text: *Higher Mathematics for Engineers and Physicists,* Sokolnikoff.

Instructors: Birchby, Hall.

UNDERGRADUATE OR GRADUATE SUBJECTS

NOTE: Those of the following courses for which there is a demand will be given periodically.

Ma. 101 a, b, c. Modern Algebra. 6 or 9 units; first, second and third terms.

Prerequisite: Ma. 8, reading knowledge of German.

Instructor: Bell.

Ma. 102 a, b, c. Introduction to Higher Geometry. 9 units; first, second and third terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d, 4 a, b.

A course in the modern methods of analytic geometry.

NOTE: If all three terms are not included in the undergraduate course, graduate students in mathematics must complete this subject in the fifth year.

Instructor: Wear:

Ma. 106 a, b, c. Introduction to Theory of Functions of Real Variables. 5 units; first, second and third terms. Required for graduation (B.S.) in mathematics.

Prerequisite: Ma. 8 a, b, c.

Postulational treatment of real number system, descriptive properties of point sets, continuous and discontinuous functions, derivatives and differentials. Riemann integration, functions of several real variables, implicit functions.

Instructors: Michal, Ward.

Ma. 107. Conformal Representation. 9 units (3-0-6); second term.

Prerequisites: Ma. 8, 10.

Riemann's problem, work of Schwarz and Christoffel. Applications to physical problems. Associated variation problems.

Instructor: Ward.

Ma. 110 a, b, c. Introduction to Theory of Numbers. 6 units; first, second and third terms.

Prerequisite (third term): Reading knowledge of German.

This course will cover selected topics in elementary number theory.

Texts: *Introduction to Theory of Numbers,* Dickson; *Vorlesungen,* Landau.

Instructor: Ward.

Ma. 111. Elementary Theory of Tensors. 9 units.

Prerequisites: Ma. 8, 10.

Fundamental properties of tensors, differential forms, covariant differentiation, geodesic coordinates, Riemannian differential geometries.

Instructor: Michal.

Ma. 113 a, b, c. Geometry. 12 units; first, second and third terms.

Prerequisite: Ma. 2 a, b, c, d.

Algebraic geometry; projective geometry; differential geometry; tensor analysis and its applications to numerous geometrical problems; non-Euclidean geometry; Riemannian differential geometry; geometry of dynamics; hyperspace; elementary group theory and its geometrical applications.

Texts: *Applications of the Absolute Differential Calculus,* McConnell; *Riemannian Geometry,* Eisenhart; collateral reading.

Instructor: Michal.

Ma. 114. Mathematical Analysis. 12 units; first, second and third terms.

This course will be offered every alternate year, and covers essentially the same topics as Ma. 201.

Prerequisites: Ma. 8, 10, and reading knowledge of German.

Instructor: Ward.

Ma. 118 a, b, c. Introduction to Statistics. 9 units; first, second and third terms.

Prerequisites: At least a year of calculus, and a laboratory course in some science.

First term: Curve fitting by moments, correction for lack of high contact and for histogram group, introduction to the Pearson family of frequency curves, including the "normal" curve. Second term: Continuation of frequency curves, coefficients of relationships, including multiple correlation. Third term: Tests of goodness of fit, cycle analysis.

Instructor: Alter.

GRADUATE SUBJECTS

NOTE: For all courses numbered above 200, except 201a, a reading knowledge of French and German is required.

Ma. 201 a, b, c. Modern Analysis. 15 units; first, second and third terms. Prerequisites: Ma. 8, 10.

Theory of convergence, integration and residues, expansions of functions in infinite series, asymptotic and divergent series. Fourier series. Differential equations and function theory, integral equations, the gamma function and the zeta function, the hypergeometric function and related functions of mathematical physics, elliptic functions, ellipsoidal harmonics.

NOTE: The first term will satisfy the requirement in Complex Variable for those taking a minor in mathematics.

Instructor: Bateman.

Ma. 202 a, b, c. Modern Theory of Differential Equations. 12 units; first, second and third terms.

Prerequisites: Ma. 10, 107, and reading knowledge of German.

Expansion of functions in series, asymptotic expansions. Linear differential equations in complex domain. Elementary methods of integration. General theory of linear differential equations and their solution by definite integrals and contour integrals. Classification of linear differential equations of the second order.

Instructor: Ward.

Ma. 204 a, b, c. Geometrical Transformations and Invariants. 15 units; first, second and third terms.

Prerequisite: Graduate standing.

Linear and bilinear transformations of one variable. Simple algebraic invariants. General theory of linear transformations and their invariants. Conformal transformations. Birational transformations. Contact transformations.

Instructor: Bateman.

Ma. 205 a, b, c. Theory of Functions. 15 units; first, second and third terms.

Theory of convergence and infinite processes, properties of continuous and discontinuous functions, functions of limited variation, selected topics on analytic functions, point sets, measure of point sets, Stieltjes integrals, Lebesgue integrals, Fourier series and integrals, orthogonal functions, convergence in the mean, geometry of Hilbert space.

Text: *The Theory of Functions,* Titchmarsh.

Instructor: Michal.

Ma. 209 a, b, c. Functionals and Functional Equations. 15 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Analysis.

Functional operations; permutable functions, functions of composition; integral equations, integro-differential equations; differentials of functionals, functional equations with functional derivatives; infinite matrices; Stieltjes and Lebesgue integrals; abstract spaces.

Instructor: Michal.

Ma. 251 a. Seminar (I) in Algebra and the Theory of Numbers. 9 units; third term.

Prerequisite: Graduate standing.

In charge: Bell.

Ma. 251 b. Theory of Algebraic Numbers. 9 units; third term. Alternates with Ma. 251 a.

Prerequisite: Graduate standing.

Instructor: Bell.

Ma. 251 c, d. Mathematical Logic. 15 units; first and second terms.

Instructor: Bell.

Ma. 252 a, b, c. Seminar in Continuous Groups. 9 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics.

Lie's theory of r-parameter groups; differential geometry of the group manifold. Groups of functional transformations; invariant functionals; differential geometries of function spaces.

In charge: Michal.

Ma. 254 a, b, c. Seminar in Modern Theories of Integration. 6 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Function Theory.

Stieltjes and Lebesgue integrals with applications to the algebra and geometry of functionals.

In charge: Michal.

Ma. 255 a, b, c. Methods of Mathematical Physics. 15 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Integral equations in which the kernel is a Green's function, Fourier series and integrals, Sturm-Liouville functions. Methods of Volterra, Fredholm and Hilbert for dealing with integral equations. Laplace's type of equation and the Heaviside calculus, calculus of variations, matrices and bilinear forms. Partial differential equations and the related simple solutions. Expansions in series of orthogonal functions.

Instructor: Bateman or Ward.

Ma. 256 a, b, c. Modern Differential Geometry. 9 units; first, second and third terms.

Prerequisite: Graduate standing.

Riemannian and Non-Riemannian geometries. Theory of parallel displacement of tensors. Affine differential geometry. Projective differential geometry. Continuous groups and their applications to geometry. Contemporary researches in differential geometry.

Instructor: Michal.

Ma. 257 a, b, c. Seminar in Abstract Spaces. 6 units; first, second and third terms.

Prerequisite: Graduate standing.

Metric spaces, linear vector spaces; topological spaces; abstract polynomials; general function theories; analysis and geometry in abstract spaces; connections

with abstract algebra and the theory of functionals; analysis of selected papers of Frechet, Riesz and Banach; contemporary researches; applications to mathematical problems in modern theoretical physics.

In charge: Michal.

Ma. 258 a, b, c. Partial Differential Equations of Mathematical Physics. 12 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Illustration of general methods by consideration of ordinary linear equations. The simple wave-equation, the potential equation. Applications of the integral theorems of Stokes and Green. Reduction to variation problems and the solution of such problems by direct methods. Use of difference equations to obtain approximate solutions. Use of simple solutions expressed as products. Properties of the special functions introduced in this way. Solution of initial and boundary problems by various methods.

Instructor: Bateman.

Ma. 260. Reading.

Occasionally advanced work is given by a reading course under the direction of an instructor. Hours and units by arrangement.

Ma. 261. Research.

By arrangement with members of the staff, properly qualified graduate students are directed in research. Hours and units by arrangement.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN
ASSOCIATE PROFESSORS: FREDERICK C. LINDVALL, S. STUART MACKEOWN
ASSISTANT PROFESSOR: FRANCIS W. MAXSTADT

UNDERGRADUATE SUBJECTS

EE. 2. Direct Currents. 9 units (3-0-6); second term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.
Theory and practice of direct current motors and generators. Fundamental to courses in operation and design of electrical apparatus. Numerous problems are solved.
Text: *Principles of Direct Current Machines*, Langsdorf.
Instructors: Maxstadt, Harrison.

EE. 3. Direct Current Laboratory. 6 units (0-3-3); second term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; and registration for EE. 2.
Uses of measuring instruments, operation of direct current motors and generators, and determination of their characteristics.
Text: Laboratory notes.
Instructors: Maxstadt, McLeish, McMaster.

EE. 4. Alternating Currents. 9 units (3-0-6); third term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2.
Elementary study of alternating currents by analytical and graphical methods; alternating current machinery. The effect of inductance, capacitance, and resistance loads. Numerous problems are worked dealing with reactive circuits; resonance; coils in series and multiple; single and polyphase alternators; single and polyphase systems; synchronous motors; transformers; induction and single phase motors.
Text: *Alternating Currents*, Magnusson.
Instructors: Maxstadt, Doll.

EE. 5. Alternating Current Laboratory. 6 units (0-3-3); third term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2, 3, and registration for EE. 4.
Uses of alternating current indicating instruments and oscillograph operation of alternators, induction and synchronous motors and transformers; determination of characteristics of these machines.
Text: Laboratory notes.
Instructors: Maxstadt, Gates, Baldwin.

EE. 6 a, b. Electrical Machinery. 6 units (2-0-4) second term; 9 units (3-0-6); third term.
Prerequisites: EE. 2, 3, 4, and 5.
Further study of direct current and alternating current machinery with particular emphasis on application; short transmission lines; short circuit currents; protective devices.
Texts: *Principles of Direct Current Machines*, Langsdorf; *Alternating Currents*, Magnusson; *Problems in Electrical Engineering*, Lyon.
Instructor: Lindvall.

EE. 7. Electrical Laboratory. 9 units (0-3-6); third term.
Prerequisites: EE. 2, 3, 4, 5, 6; Ph. 7.
A continuation of EE. 3 and 5. Efficiency tests of alternating current machinery. Graphic analysis of alternator performance; operation of transformers, alternators and direct current machines in parallel; communication circuit testing; use of electronic devices; writing of engineering reports.
Text: Laboratory notes.
Instructors: Maxstadt, McMaster.

EE. 8. Direct Currents. 7 units (3-0-4); first or second term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.
An abridged course in direct currents and direct current machinery designed to acquaint in an objective manner students, not majoring in electrical engineering, with electrical theory through its practical applications to circuits and machines.
Text: *Principles of Electrical Engineering*, Blalock.
Instructors: Maxstadt, Doll, Oliver.

EE. 9. Direct Current Laboratory. 5 units (0-3-2); first or second term.
An abridged course for other than Electrical Engineering students.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; registration for EE. 8.
Text: Laboratory notes.
Instructors: Maxstadt, Baldwin, Gates, McLeish, McMaster.

EE. 10. Alternating Currents. 7 units (3-0-4); second or third term.
Prerequisites: EE. 8 and 9.
An abridged course in alternating currents and alternating current machinery similar to EE. 8.
Text: *Principles of Electrical Engineering*, Blalock.
Instructors: Maxstadt, Doll, Harrison.

EE. 11. Alternating Current Laboratory. 5 units (0-3-2); second or third term.
Prerequisites: EE. 8 and 9 and registration for EE. 10.
An abridged course for other than Electrical Engineering students.
Text: Laboratory notes.
Instructors: Maxstadt, Baldwin, Gates, McLeish, McMaster.

EE. 12. Electric Circuits. 12 units (3-0-9); first term.
Prerequisites: EE. 2, 3, 4, 5.
A course of study involving the calculation of voltage, current, and power in electrical circuits by the symbolic or complex method.
Texts: *Principles of Alternating Currents*, Lawrence; *Problems in Alternating Currents*, Lyon.
Instructors: Sorensen, McCann.

EE. 70 a, b, c. Engineering Conference. 2 units (1-0-1); first, second and third terms.
Prerequisites: EE. 2, 3, 4, 5.
Presentation and discussion of new developments in the industry. Review of current literature.
Instructors: Sorensen, Lindvall, Mackeown, Maxstadt.

FIFTH-YEAR SUBJECTS

EE. 120. Alternating Current Analysis. 12 units (4-0-8); first term.

Prerequisites: EE. 7 and preceding courses.

Advanced study of magnetic and electric circuits. Solution of problems involving the symbolic method and complex notation; symmetrical components; analysis of electromotive force and current, nonsinusoidal wave forms; analysis of oscillograms.

Texts: *Alternating Current Phenomena,* Steinmetz; *Problems in Electrical Engineering,* Lyon; *Applications of the Method of Symmetrical Components,* Lyon.

Instructor: Sorensen.

EE. 121 a, b, c. Alternating Current Laboratory. 6 units (0-3-3); first, second and third terms.

Prerequisites: EE. 7 and preceding courses.

Complete tests of the induction motor; the operation of transformers in parallel; study of polyphase connections; photometric measurements; use of the oscillograph; calibration of watt-hour meters and relays; high voltage tests of insulation.

Text: Advanced laboratory notes.

Instructors: Maxstadt, Harrison.

EE. 122. Advanced Alternating Current Machinery. 12 units (4-0-8); second term.

Prerequisites: EE. 120 and preceding courses.

An advanced study of the alternator, the induction motor and the stationary transformer, with particular emphasis on problems involving polyphase polarity, together with single and polyphase multiple circuit.

Texts: *Principles of Alternating Current Machinery,* Lawrence; *Problems in Alternating Current Machinery,* Lyon.

Instructor: Sorensen.

EE. 128. Electric Traction. 9 units (3-0-6); second term.

Prerequisites: EE. 2, 4, 6.

Modern electric and oil-electric railways, studies of the motive power, train requirements, frictional and other resistances, schedules, acceleration and braking; the portable power plant vs. substations and contact conductor. Safe speeds and riding qualities are studied.

Text: *Transit Engineering,* Tuthill.

Instructors: Lindvall, Maxstadt.

EE. 130. Electric Lighting and Power Distribution. 6 units (2-0-4); third term.

Prerequisites: EE. 2, 4, 6.

Electric distribution and wiring; calculation of simple alternating current circuits; installation and operation costs and selling price of electric power.

Text: *Electrical Distribution Engineering,* Seelye.

Instructor: Maxstadt.

EE. 144. Transmission Lines. 12 units (4-0-8); third term.

Prerequisites: EE. 122 and preceding courses.

Line performance and protection; elementary transient phenomena; use of hyperbolic functions in line calculations; generalized system constants.

Instructor: Lindvall.

EE. 148. Specifications and Design of Electrical Machinery. 6 units (4-0-2); first term.

Prerequisites: EE. 7 and preceding courses.

Preparation of specifications and design calculations for alternating and direct current machinery.

Text: *Electrical Machine Design,* Gray.

Instructor: Sorensen.

EE. 152. Dielectrics. 6 units (2-0-4); third term.

Prerequisites: EE. 122 and preceding courses.

A study of electric fields in insulations, particularly air, and the effects on sparking voltage of the sparking distance, atmospheric pressure and humidity; corona phenomena; high frequency voltages; characteristics of commercial insulations.

Text: *Dielectric Phenomena in High Voltage Engineering,* Peek.

Instructors: Sorensen, McCann.

EE. 156. Electrical Communication. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 3, 4, 5.

A study of modern means of communication with special emphasis on recent developments.

Instructor: Mackeown.

EE. 160. Electric Transients. 6 units (2-0-4); second term.

Prerequisites: EE. 120 and preceding courses.

A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors; with special emphasis on the use of differential equations for solving circuit problems.

Instructor: Mackeown.

EE. 162. Vacuum Tubes. 12 units (4-0-8); second term.

Prerequisites: EE. 6 and preceding courses.

Fundamental theory, and uses as detectors, amplifiers, and oscillators. Special uses of vacuum tubes in both radio and line communication.

Instructor: Mackeown.

EE. 163. Radio. 9 units (3-0-6); first term.

Prerequisite: EE. 162.

Elementary course dealing with fundamentals of Radio Transmission.

Text: *Radio Engineering,* Terman.

Instructor: Mackeown.

ADVANCED SUBJECTS

EE. 200. Advanced Work in Electrical Engineering.

Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of Professors R. W. Sorensen and F. C. Lindvall; Electrical Engineering Problems using vacuum tubes under the direction of Professor S. S. Mackeown; Electrical Engineering Problems relating to the distribution and uses of electric power for lighting and industrial uses under the direction of Professor F. W. Maxstadt.

EE. 220. Research Seminar in Electrical Engineering. 2 units required; additional units based on work done. First, second and third terms.

Meets once a week for discussion of work appearing in the literature and in progress at the Institute, or for presentation of technical developments in the industry. All advanced students in Electrical Engineering and members of the Electrical Engineering staff are expected to take part.

In charge: Sorensen, Mackeown, Maxstadt, and Lindvall.

EE. 221. Transmission Line Problems. 15 units.

A study of transmission line transient problems, inductive interference, power limit analysis, etc.

Instructor: Sorensen.

EE. 223 a, b. Electric Strength of Dielectrics. 15 units; second and third terms.

A study of the effect of high potentials applied to dielectrics.

Text: *Theory of Dielectrics,* Schwagen-Sorensen.

Instructors: Sorensen, McCann.

EE. 224 a, b, c. Vacuum Tube and Radio Frequency Circuits. Units to be based on work done; first, second and third terms.

A study of the literature on vacuum tube circuits. Experimental work with oscillators, transmitters, and receivers.

Instructor: Mackeown.

EE. 225. Principles of Electrical Design. 15 units; first term.

A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.

Instructors: Sorensen, Maxstadt.

EE. 226 a, b, c. Engineering Mathematical Physics. 15 units (3-0-12); first, second and third terms.

Prerequisites: B.S. in Engineering; Differential Equations, Ma. 10 or Ma. 11.

This course is designed to develop the correlation of mathematics and physics with problems in engineering design and application. The following subjects will be treated in detail: mechanical vibrations, oscillations in electro-mechanical systems, short circuit forces, power system transients, electric motors applied to variable or pulsating loads, heat transfer and transient heat flow. The principle of constant flux linkage in electrical transient analysis; solution of mechanical problems by electrical methods; application of Heaviside operational calculus to mechanical and thermal problems.

Instructor: Lindvall.

EE. 227. Operational Circuit Analysis. 6 units (2-0-4); third term.

An introduction to the solution of circuit problems by the operational method.

Instructor: Mackeown.

EE. 228. Conduction of Electricity in Gases. Units to be arranged; first, second and third terms.

Selected topics in glow, arcs, and spark discharges.

Instructor: Mackeown.

EE. 229. Advanced Circuit Analysis. 12 units (3-0-9); first, second and third terms in alternate years.

Development of circuit equations from Maxwell's equations; application of Maxwell's equations to circuits at high frequency, filter circuits, symmetrical components, tensor analysis.

Instructor: Mackeown.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

PROFESSORS: LINUS PAULING, STUART J. BATES, JAMES E. BELL, WILLIAM N. LACEY, RICHARD C. TOLMAN
VISITING LECTURER: ALEXANDER R. TODD
ASSOCIATE PROFESSORS: ROSCOE G. DICKINSON, HOWARD J. LUCAS, DON M. YOST
RESEARCH ASSOCIATE: JOSEPH B. KOEPFLI
ASSISTANT PROFESSORS: RICHARD MCLEAN BADGER, ARNOLD O. BECKMAN, CARL NIEMANN, BRUCE H. SAGE, ERNEST H. SWIFT
SENIOR FELLOW IN RESEARCH: JAMES H. STURDIVANT
INSTRUCTOR: LINDSAY HELMHOLZ

UNDERGRADUATE SUBJECTS

Ch. 1 a, b, c. Chemistry. 12 units (3-6-3); first, second and third terms.

Lectures, recitations and laboratory exercises dealing with the general principles of chemistry. The first and second terms are devoted to the preparation and properties of substances and to the fundamental laws and theories of chemistry.

The subject matter for the third term is qualitative analysis of the common metals accompanied by lectures in various fields of chemistry by different members of the division staff.

Instructors: Bell, Helmholz, and Teaching Fellows.

Ch. 6. Engineering Chemistry. 9 units (3-0-6); first term.

Prerequisite: Ch. 1 a, b, c.

Reading, discussion and problems dealing with the application of chemical principles to engineering problems and the relations of engineering to the chemical industries.

Text: *Chemistry of Engineering Materials,* Leighou.

Instructor: Beckman.

Ch. 11. Quantitative Chemical Analysis. 10 units (2-6-2); third term.

Prerequisite: Ch. 1 c.

Laboratory practice in certain typical methods of gravimetric and volumetric analysis, supplemented by lectures and problems emphasizing the principles involved.

Text: Mimeographed notes.

Instructor: Swift.

Ch. 12 a, b. Analytical Chemistry. 10 units (2-6-2); first and second terms.

Prerequisite: Ch. 1 c.

Laboratory practice in the methods of gravimetric and volumetric, and advanced qualitative analysis, supplemented by lectures and problems in which the principles involved in the laboratory work are emphasized.

Text: *Analytical Chemistry,* Swift.

Instructor: Swift.

Ch. 12 c. Analytical Chemistry and Chemistry Review. 10 units (2-6-2); third term.

Prerequisite: Ch. 12 b.

A study of special methods of chemical analysis, including electrometric methods and analyses of selected alloys and minerals. Students are assigned individual prob-

lems for investigation. The class exercises are devoted to a discussion and review of the general principles of analytical and inorganic chemistry. The examination in this subject covers the chemistry work of the whole sophomore year.

Instructor: Swift.

Ch. 13 a, b. Inorganic Chemistry. 4 units (2-0-2); third and first terms.

Prerequisite: Ch. 12 b, 21 a, b.

The chemical and physical properties of the elements are discussed with reference to the periodic system and from the view-points of atomic structure and radiation-effects. Such topics as coordination compounds, the liquid ammonia system, the compounds of nitrogen, the halides, and selected groups of metals are taken up in some detail. The class work is supplemented by problems which require a study of current literature.

Instructor: Yost.

Ch. 14 a, b, c. Inorganic Chemistry Laboratory. 8 units (0-8-0), third term; 5 units (0-5-0), first term; 8 units (0-8-0), second term.

Prerequisite: Ch. 12 c, 21 a, b.

This subject consists of laboratory work upon selected research problems in inorganic chemistry, often in relation to the rarer elements.

Instructors: Swift, Yost.

Ch. 16. Instrumental Analysis. 8 units (0-6-2); first term.

Prerequisite: Ch. 12 c.

Laboratory practice designed to familiarize the student with special analytical apparatus and methods, used both for process control and for research.

Text: *Instrumental Methods of Chemical Analysis*, Lacey.

Instructor: Beckman.

Ch. 21 a, b, c. Chemical Principles. 10 units (4-0-6); first, second and third terms.

Prerequisites: Ch. 12 b; Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

Conferences and recitations dealing with the general principles of chemistry from an exact, quantitative standpoint, and including studies on the elements of thermodynamics; the pressure-volume relations of gases; on vapor-pressure, boiling point, freezing point, and osmotic pressure of solutions; on the molecular and ionic theories; on electrical transference and conduction; on chemical and phase equilibria; on thermochemistry, and the elements of thermodynamic chemistry and of electrochemistry. A large number of problems are assigned to be solved by the student.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructors: Bates, Dickinson.

Ch. 22 a, b. Thermodynamic Chemistry. 6 units (2-0-4); first and second terms.

A continuation of subject Ch. 21, given in much the same way. The topics considered include reaction rate and a further study of electrochemistry and thermodynamic chemistry. Practice is given in the computation of free energies, activities and entropies of typical substances.

Texts: *Chemical Principles,* Noyes and Sherrill, and mimeographs.

Instructor: Bates.

Ch. 23 a, b. Chemical Principles. 10 units (4-0-6); second and third terms.
Prerequisite: Ch. 21 a.
A selection of topics from Ch. 21 b, c, and from Ch. 22 a, b. This is a continuation of Ch. 21 a, adapted to the needs of Science Course students in the Physics, Geology, and Biology Options.
Texts: *Chemical Principles,* Noyes and Sherrill, and mimeographs.
Instructor: Dickinson.

Ch. 26 a, b. Physical Chemistry Laboratory. 8 units (0-6-2) or 4 units (0-3-1), second term; and 4 units (0-3-1), third term.
Prerequisites: Ch. 12 a, b; Ch. 21 a.
Laboratory exercises to accompany Ch. 21.
Text: *Laboratory Experiments on Physico-Chemical Principles,* Sherrill.
Instructors: Bates, Yost.

Ch. 29. Colloid and Surface Chemistry. 8 units (3-0-5); third term.
Prerequisite: Ch. 22.
Class-room exercises with outside reading and problems, devoted to the properties of surfaces, and interfaces, and to the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.
Texts: *Colloid Chemistry,* Thomas, and mimeographed notes.
Instructor: Badger.

Ch. 41 a, b, c. Organic Chemistry. 8 units (3-0-5), first and second terms; 6 units (2-0-4), third term.
Prerequisite: Ch. 12 c.
Lectures and recitations treating of the classification of carbon compounds, the development of the fundamental theories, and the characteristic properties of the principal classes including hydrocarbons, alkyl halides, alcohols, acids, ethers, esters, amines, carbohydrates, aromatics.
Text: *Organic Chemistry,* Lucas.
Instructor: Lucas.

Ch. 43. Organic Chemistry. 10 units (2-6-2); third term.
Prerequisites: Ch. 1 a, b, c.
Lectures and recitations, accompanied by laboratory exercises, dealing with the synthesis and the physical and chemical properties of the more important compounds of carbon.
Text: *Outlines in Organic Chemistry,* Moore and Hall.
Instructor: Lucas.

Ch. 46 a, b. Organic Chemistry Laboratory. 9 units (0-9-0) or 12 units (0-12-0), first term; 6 units (0-6-0) or 9 units (0-9-0), second term.
Prerequisite: Ch. 12.
Laboratory exercises to accompany Ch. 41 a, b. The preparation and purification of carbon compounds and the study of their characteristic properties. Qualified students may pursue research work.
Text: Mimeographed notes, Lucas.
Instructors: Lucas and Teaching Fellows.

Ch. 61 a, b, c. Industrial Chemistry. 6 units (2-0-4), first and third terms; 4 units (2-0-2), second term.

Prerequisites: Ch. 21 a, b.

A study of the more important industrial chemical processes, from the point of view not only of the chemical reactions, but of the conditions and equipment necessary to carry on these reactions.

Text: *Industrial Chemistry,* Riegel.

Instructor: Beckman.

Ch. 63 a, b. Chemical Engineering Thermodynamics. 6 units (2-0-4); second and third terms.

Prerequisite: Ch. 21 a.

Class exercises and problems in engineering thermodynamics studied from the point of view of the chemical engineer.

Instructor: Lacey.

Ch. 70-73. Chemical Research.

Opportunities for research are afforded to undergraduate students in all the main branches in chemistry; thus, in analytical or inorganic chemistry (Ch. 70), in physical chemistry (Ch. 71), in organic chemistry (Ch. 72), and in applied chemistry (Ch. 73). Such research may be taken as electives by students in honor standing in the sophomore and junior years; and every candidate for a degree in the Chemistry Option is required to undertake in his senior year an experimental investigation of a problem in chemistry. A thesis embodying the results and conclusions of this investigation must be submitted to the faculty not later than one week before the degree is to be conferred.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ch. 152. Colloid and Surface Chemistry. 8 units; third term.

This course is the same as Ch. 29.

Texts: *Colloid Chemistry,* Thomas, and mimeographed notes.

Instructor: Badger.

Ch. 153 a, b. Thermodynamic Chemistry. 6 units; first and second terms.

This subject is the same as Ch. 22 a, b.

Texts: *Chemical Principles,* Noyes and Sherrill, and mimeographs.

Instructor: Bates.

Ch. 154 a, b, c, d. Statistical Mechanics (Seminar). 6 units; four terms.

A discussion of statistical mechanics and its applications to physics and chemistry. The topics treated will include a sufficient exposition of classical and quantum theory mechanics to serve as a foundation for statistical mechanics and the relations between statistical mechanics and thermodynamics.

In charge: Tolman.

Ch. 155 a, b, c. The Nature of the Chemical Bond. 6 units; first, second and third terms.

This subject comprises the detailed non-mathematical discussion of the electronic structure of molecules and its correlation with the chemical and physical properties of substances. It is planned that the subject be given in 1938-9, and every third year thereafter.

Instructor: Pauling.

Ch. 156 a, b, c. Introduction to Quantum Mechanics, with Chemical Applications. 9 units; first, second and third terms.

A review of Lagrangian and Hamiltonian mechanics and of the old quantum theory is first given, followed by the discussion of the development and significance of the new quantum mechanics and the thorough treatment of the Schrödinger wave equation, including its solution for many simple systems such as the rotator, the harmonic oscillator, the hydrogen atom, etc. During the second and third terms various approximate methods of solution (perturbation theory, the variation method, etc.) are discussed and applied in the consideration of the resonance phenomenon, the structure of many-electron atoms and of simple molecules, the nature of the covalent chemical bond, the structure of aromatic molecules, and other recent chemical applications.

It is planned that this subject be given in 1939-40, and every third year thereafter.

Text: *Introduction to Quantum Mechanics, with Applications to Chemistry*, Pauling and Wilson.

Instructor: Pauling.

Ch. 157 a, b, c. The Structure of Crystals. 6 units; first, second and third terms.

The following topics are discussed:

The nature of crystals and X-rays and their interaction. The various experimental methods of investigation—Bragg, Laue, oscillation, Weissenberg, etc. The theory of space groups and the use of symmetry in the determination of the structures of crystals. The detailed study of representative structure investigations. The various known crystal structures and their relation to the physical and chemical properties of substances. The quantitative treatment of X-ray diffraction. Fourier-series methods of structure investigation.

It is planned that this subject be given every third year, including 1937-38.

Instructors: Pauling, Sturdivant.

Ch. 157 d, e, f. Crystal Structure Laboratory. Units determined by the instructors; any term.

Practical instruction is given in the methods of determining the structure of crystals with X-rays.

Instructors: Pauling, Sturdivant.

Ch. 158. Photochemistry. 6 units; third term.

Lectures and discussions on photochemical processes, especially in their relations to quantum phenomena. The following topics will be included: the photochemical absorption law; the processes—excitation, dissociation, ionization—accompanying the absorption of radiation; subsequent processes including fluorescence and collisions of the second kind; photosensitization; quantum yield and its relation to photochemical mechanism; catalysis and inhibition; temperature coefficients of photochemical reactions.

Instructor: Dickinson.

Ch. 159a. Kinetics of Homogeneous Reactions. 6 units; first term.

Lectures and discussions relating to homogeneous chemical reactions and to statistical mechanical, and other theories of such reactions.

Instructor: Dickinson.

Ch. 159b. Kinetics of Heterogeneous Reactions. 6 units; second term.
Lectures, discussions and problems relating to adsorption and contact catalysis.
Instructor: Badger.

Ch. 160. Inorganic Chemistry. 4 units; third and first terms.
Selected groups of inorganic compounds will be considered from modern physico-chemical view-points; thus with reference to their physical properties, their thermodynamic constants (their heat-contents, free-energies, and entropies), their rates of conversion into one another (including effects of catalysis and energy radiations), and their molecular structure and valence relations.
Instructor: Yost.

Ch. 161. Organic Chemical Analysis. 9 units; first term.
A laboratory study of the class reactions of carbon compounds and practice in the methods of identifying unknown substances.
Instructor: Lucas.

Ch. 162 a, b, c. Organic Chemistry (Special Topics). 6 units; first, second and third terms.
A series of lectures and discussions on selected topics of organic chemistry that have special interest from a theoretical, industrial, or biological view-point.
Instructor: Lucas.

Ch. 163. Introduction to the Spectra of Molecules. 6 units; first term.
The theory of the structure of the spectra of both the diatomic and the simpler polyatomic molecules is presented, and the transition rules and their relation to the symmetry elements of molecules are discussed. Emphasis is laid on the methods of interpreting and analyzing molecular spectra, and it is shown how from an analysis one obtains information regarding the structure and other properties of a molecule of interest to the chemist. Problems are given in the interpretation of actual data.
Instructor: Badger.

Ch. 164. Radioactivity and Isotopes. 6 units; third term.
Lectures and discussions on natural and artificial radioactivity. The fundamental particles and isotopes. The applications of natural and artificial radioactive substances and isotopes to the study of chemical and biochemical reactions are discussed.
Instructors: Dickinson and Yost.

Ch. 166 a, b, c. Chemical Engineering. 12 units (3-0-9); first, second and third terms.
Prerequisites: Ch. 61; Ch. 63 a, b.
Problems and discussions designed to bring the student in touch with the problems involved in carrying out chemical reactions efficiently on a commercial scale. The basic operations of chemical industry (such as heat production, heat transfer, mixing, filtration, distillation) are studied both as to principle and practice.
Text: *Principles of Chemical Engineering,* Walker, Lewis, McAdams, and Gilliland.
Instructor: Lacey.

Ch. 167. Phase Equilibria in Applied Chemistry. 6 units (2-0-4); first term.

Prerequisites: Ch. 21, 61.

Problems and discussions relating to industrial applications involving heterogeneous equilibria.

Instructors: Lacey and Sage.

Ch. 168 a, b. Thermodynamics of Multi-Component Systems. 8 units (2-0-6); second and third terms.

Prerequisites: Ch. 63 or ME. 16.

A presentation of the background necessary for a working knowledge of the thermodynamics of multi-component systems from the engineering view-point. The work includes numerous problems relating to the application of these principles to industrial practice.

Instructor: Sage.

Ch. 169. Research Manipulations. 3 units; second term.

Laboratory exercises in glass-blowing and machine shop operations for research students. Class-room discussions on topics of general interest for research in physical chemistry, such as high-vacuum technique, electrical apparatus including applications of vacuum tube circuits, and the measurement of pressure, temperature and radiant energy.

Students must obtain permission from the instructor before registering for this subject as the enrollment is necessarily limited.

Instructor: Beckman.

Ch. 170-173. Chemical Research.

Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical or inorganic chemistry (170), physical chemistry (171), organic chemistry (172), and applied chemistry (173).

The main lines of research now in progress are:

Free-energies, equilibria, and electrode-potentials of reactions.
Low temperature calorimetry.
Study of crystal structure and molecular structure by diffraction of X-rays and electron waves.
Application of quantum mechanics to chemical problems.
Application of magnetic methods to chemical problems.
Mechanism of homogeneous reactions.
Chemical reactions produced by atoms and molecules excited by radiations.
Application of radioactive indicators to chemical problems.
Band spectra and Raman spectra in their chemical relations.
Plant hormones.
The Walden inversion.
Isomerism, hydration and complex formation of unsaturated compounds.
Vitamin B_1 analogs.
Viscosity of gases and liquids at high pressures.
Solubility of gases in liquids at high pressures.
Properties of underground protective coatings.
High vacuum distillation.
Thermodynamic studies of hydrocarbons.

For a fuller survey of the researches in progress, see publications of the Gates Chemical Laboratory.

Ch. 174-179. Chemical Research Conferences.

Each 2 units; given all three terms, unless otherwise noted.

Ch. 174. General Research Conference in Chemistry.

Ch. 175. Organic Chemistry.

Ch. 176. Photochemistry.

Ch. 177. Crystal and Molecular Structure.

Ch. 178. Band Spectra and Molecular Structure. (First and second terms.)

Ch. 179. Applied Chemistry. (Second and third terms.)

These conferences consist of reports on the investigations in progress in the laboratory and on other researches which have appeared recently in the literature. They are participated in by all men engaged in related lines of research in the laboratory, and are conducted by the chemistry professors connected with the respective branches.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING*

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL
ASSOCIATE PROFESSOR: WILLIAM W. MICHAEL
ASSISTANT PROFESSOR: FRED J. CONVERSE

UNDERGRADUATE SUBJECTS

CE. 1. Surveying. 11 units (3-4-4); second or third term.

A study of the elementary operations employed in making surveys for engineering work, including the use, care, and adjustment of instruments, linear measurements, angle measurements, note keeping, stadia surveys, calculation and balancing of traverses, use of calculating machines, topographic mapping and field methods.

Text: *Surveying*, Breed and Hosmer.
Instructor: Michael.

CE. 2. Advanced Surveying. 12 units (3-6-3); first term.

Prerequisite: CE. 1.

A continuation of CE. 1, covering topographic surveys, plane table surveys, base line measurements, triangulation, determination of latitude and a true meridian by sun and circumpolar star observations, curves, cross-section surveys and earthwork estimates, stream gauging, draughting room methods and mapping, and the solution of problems.

Text: *Surveying*, Breed and Hosmer.
Instructor: Michael.

CE. 3. Plane Table Surveying. 8 units (1-6-1); third term.

A course offered primarily for students in geology but may be elected by arrangement with the department. Theory and use of the plane table as applied to geological surveys. The class devotes one entire day a week to field surveys over typical terrain completing a topographic map of the region covered.

Text: *Surveying*, Breed and Hosmer.
Instructor: Michael.

CE. 4. Highway Engineering. 6 units (3-0-3); second term.

Prerequisite: CE. 1.

A comparison of various types of highway construction; the design, construction and maintenance of roads and pavements; methods of road improvement; financing, contracts and specifications.

Text: *Highway Design and Construction*, Bruce.
Instructor: Michael.

CE. 8 a. Railway Engineering. 6 units (3-0-3); first term.

Prerequisites: CE. 1, 2.

A study of economic railway location and operation; railway plant and equipment; signaling; the solution of grade problems.

Text: *Elements of Railroad Engineering*, Raymond.
Instructor: Thomas.

*See Division of Physics, Mathematics and Electrical Engineering, pages 192-196, for subjects in Electrical Engineering.

CE. 8 b. Railway Surveying. 6 units (2-0-4); second term.
Prerequisite: CE. 1.
The theory of railway, highway and ditch location and surveys; problems relating to curves, grades, earthwork and track layout, including a study of the mass diagram as applied to railway and highway earthwork.
Text: *Railway Curves and Earthwork,* Allen.
Instructor: Michael.

CE. 8 c. Railway Surveying. 6 units (0-6-0); third term.
Prerequisite: CE. 8 b.
The class devotes one entire day a week to field surveys of a railroad location, applying the principles as outlined under course CE. 8 b.
Text: *Railway Curves and Earthwork,* Allen.
Instructor: Michael.

CE. 9. Elements of Structures. 12 units (3-3-6); second term.
Prerequisite: AM. 1 c.
An abridged course in design of simple structures of timber, steel, masonry, and reinforced concrete. Emphasis is placed upon methods and computations in numerous typical examples.
Text: *Structural Design,* Thomas.
Instructor: Michael.

CE. 10 a. Theory of Structures. 12 units (3-3-6); first term.
Prerequisite: AM. 1 c.
Methods used in the calculation of stresses in and proportioning of beams, girders, and columns of timber, steel and concrete; study of the effects of moving load systems; graphic statics applied to roofs and bridges.
Text: *Structural Theory,* Sutherland and Bowman.
Instructor: Martel.

CE. 10 b, c. Theory of Structures. 12 units (3-3-6), second term, and 9 units (3-0-6), third term.
Prerequisite: CE. 10 a.
A continuation of CE. 10 a, covering the computation of stresses in truss members, the design of structural parts, connections, portals, and bracing; a study of arch, cantilever, and continuous bridges; and deflection of trusses.
Text: *Structural Design in Steel,* Shedd.
Instructor: Martel.

CE. 12. Reinforced Concrete. 12 units (3-3-6); third term.
Prerequisites: AM. 1 c; CE. 10 a.
The theory of reinforced concrete design, with a study of the applications of this type of construction to various engineering structures.
Text: *Principles of Reinforced Concrete Construction,* Turneaure and Maurer.
Instructor: Martel.

CE. 14 a, b, c. Engineering Conferences. 2 units (1-0-1); first, second and third terms.
Conferences participated in by faculty and seniors of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences.
The technique of effective oral presentation of reports is emphasized through criticisms of the reports from the standpoint of public speaking by a member of the department of English.
Instructors: Michael, Eagleson.

FIFTH-YEAR SUBJECTS

CE. 15. Irrigation and Water Supply. 12 units (5-0-7); second term.
Prerequisite: Hy. 1.
A study of modern practice of the collection, storage and distribution of water for municipal, domestic and irrigation uses; design, construction and operation of systems; consideration of the conditions adapted to irrigation developments, dams, reservoirs, canals; laws pertaining to irrigation; the economic aspects of projects.
Text: *Water Supply and Utilization,* Baker and Conkling.
Instructor: Thomas.

CE. 16. Masonry Structures. 9 units (2-3-4); second term.
Prerequisite: CE. 12.
Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches.
Text: *Design of Masonry Structures,* Williams.
Instructor: Martel.

CE. 17. Sewerage. 9 units (3-0-6); third term.
Prerequisite: Hy. 1.
Systems for the collection and disposal of sewage; the design of sewers and storm drains; inspection of local sewage disposal plants; the drainage of land; cost assessments.
Text: *Sewerage and Sewage Disposal,* Metcalf and Eddy.
Instructor: Thomas.

CE. 21 a. Structural Design. 12 units (0-12-0); first term.
Prerequisites: CE. 10 a, b, c.
The design of a plate girder bridge and a truss bridge or a steel frame building; stress sheets and general drawings are made. Designing office practice is followed as affecting both computations and drawings.
Instructor: Thomas.

CE. 21 b. Structural Design. 9 units (0-9-0); second term.
Prerequisites: CE. 10 a, 12.
The design of a reinforced concrete building in accordance with a selected building ordinance, with computations and drawings.
Instructors: Thomas, Martel.

CE. 21 c. Civil Engineering Design. 9 units (0-9-0); third term.
Prerequisites: CE. 15, 21 a, b.
Special problems including preliminary investigations of irrigation or water power projects; study of stream flow data, the effect of reservoir storage upon distributed flow, determination of size and type of economic development.
Instructor: Thomas.

CE. 23. Statically Indeterminate Structures. 12 units; first term.
A study of such structures as continuous spans, rigid frames and arches by the methods of least work or slope-deflections; analysis of secondary stresses.
Text: *Continuous Frames of Reinforced Concrete,* Cross and Morgan.
Instructor: Martel.

CE. 30 a, b, c. Engineering Seminar. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and graduate students of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

ADVANCED SUBJECTS

Special problems in the various fields of civil engineering will be arranged to meet the needs of students wishing to do advanced work in this department. The following lines of work are possible: Stream Regulation and Utilization for Power, Irrigation, and Water Supply under the direction of Prof. Franklin Thomas; Advanced Structures under the direction of Prof. Martel; Sanitation and Sewerage under the direction of Profs. Thomas and Martel; Highways and Geodesy under the direction of Prof. Michael; Analysis of Earthquake Effects upon Structures under the direction of Prof. Martel.

CE. 101 a, b. Water Power Plant Design. 10 units; first and second terms.

A design of a power plant in conformity with the conditions of head, flow, and load fluctuations at a particular site. Includes selection of number and type of units, design of water passages and general structural features.

Instructor: Thomas.

CE. 105 b, c. Statically Indeterminate Structures. 12 units; second and third terms.

A continuation of the study of indeterminate structures as begun in CE. 23, with the use of analytical and instrumental methods of solution.

Instructor: Martel.

CE. 107 a, b, c. Geodesy and Precise Surveying. 6 units; first, second and third terms.

Methods of triangulation and surveying over extended areas. The adjustment of triangulation systems, the adjustment of observations by the method of least squares. Map projections, precise leveling determination of a true meridian.

Instructor: Michael.

CE. 108. Highway Problems. Units to be based on work done.

Cooperating with the Highway Research Board of the National Research Council, opportunities are offered for advanced studies in highway engineering. Arrangements may be made for special studies on subgrade materials, wearing surfaces, economics of vehicle operation, and allied subjects.

Instructor: Michael.

CE. 110 b, c. Sewage Treatment Plant Design. 10 units; second and third terms.

A design of treatment works for a selected community and site involving special conditions of location, volume, and character of disposal. Includes selection of process, arrangement of tanks and equipment, and general design of structures.

Instructor: Thomas.

CE. 111. Water Treatment Plant Design. Units to be based upon work done; any term.

Preparation of a layout and design of the general features of a plant to effect the purification and softening of water as may be required in specific circumstances. Includes design of typical structural features of the plant.

Instructor: Thomas.

CE. 112. Sanitation Research. Units to be based upon work done; any term.

Exceptional opportunities in this field are available at the sewage treatment plant of the city of Pasadena, where the activated sludge process is in operation, supplemented by a rotary kiln drier for the reduction of sludge to commercial fertilizer.

Instructor: Thomas.

CE. 113. Underground Water Investigations. Units to be based upon work done; any term.

A study of the relation between rainfall, runoff, percolation, and accumulations of ground water. Investigation of the location, extent, and yield of underground reservoirs.

Instructor: Thomas.

CE. 114. Analysis of Earthquake Effects Upon Structures. Units to be based upon work done; any term.

A comparison of analytical study and experimental effects of vibrations on simple structures with the effects of earthquakes upon buildings.

Instructor: Martel.

CE. 115. Foundations. 6 units; second term.

The application of the principles of soil mechanics to problems of foundations and earthwork engineering.

Instructor: Converse.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP
ASSOCIATE PROFESSOR: ROBERT T. KNAPP
ASSISTANT PROFESSORS: DONALD S. CLARK, ERNEST E. SECHLER
INSTRUCTORS: W. C. ROCKEFELLER, HOWELL N. TYSON

UNDERGRADUATE SUBJECTS

ME. 1. Mechanism. 9 units (3-3-3); first, second or third term.

Prerequisites: Ma. 1 a, b, c, d; Ph. 1 a, b, c, d; D. 1, 4, 12 a, b.

An analytical study of constrained motion in machines and of the relations of machine elements. Desirable types of motion; displacements of machine parts using simple valve motions, cam actuating parts, and other reciprocating and oscillating machine members as examples. Velocity studies; average and instantaneous values; velocity analysis by vectors using centros; relative velocities; application of vectors to cyclic trains and other differential motions. Acceleration analysis; inertia forces. The various linkages and combinations of machine elements are introduced and used as a means of mastering the geometry of machine motion.

Text: *Principles of Mechanism,* Vallance and Farris.

Instructors: Clapp, Tyson, Shapiro.

ME. 3. Materials and Processes. 11 units (3-3-5); second or third term.

A study of the materials of engineering and of the processes by which these materials are made and fabricated. The fields of usefulness and the limitations of alloys and other engineering materials are studied, and also the fields of usefulness and limitations of the various methods of fabrication and of processing machines.

The class work is combined with inspection trips to many industrial plants. The student is not only made acquainted with the technique of processes but of their relative importance industrially and with the competition for survival which these materials and processes continually undergo.

Text: *Materials and Processes,* Clapp and Clark.

Instructor: Clark.

ME. 5 a, b, c. Machine Design. 9 units (2-3-4), first and second terms; 9 units (0-9-0), third term.

Prerequisites: ME. 1; AM. 1 a, b.

Applications of mechanics of machinery and mechanics of materials to practical design and construction. Riveting and welding; boilers and plate vessels; bolts and screws; force and shrink fits; hydraulic cylinders; cylinders and cylinder heads for steam and gas engines; stuffing boxes and packing; pistons and piston rings; leaf springs, coil springs; piston pins; connecting rods and cross heads; cranks and crank-shafts; flywheels; spur gears; helical gears; bevel gears; worm gears; spiral gears; belting; pulleys; rope driving; chains; friction drives; wire rope and hoisting; plain bearings; ball bearings; roller bearings; shafts and couplings; clutches; brakes; high speed disks; piping. Also a study of manufacturing processes with especial reference to the economics of design.

Text: *Design of Machine Elements,* Faries.

Instructor: Clapp.

ME. 8. Machine Design. 12 units (3-3-6); first term.

Prerequisites: ME. 1; AM. 1 a, b.

An abbreviated course in machine design for aeronautical engineers. The energy and force problem; relations of stress and strain to failure and the determination of

proper safety factors; straining actions in machines; stresses with complex loading; screws and screw fastenings; axles, shafting, and couplings; friction and lubrication; journals and bearings.

Text: *Design of Machine Elements,* Faries.

Instructor: Sechler.

ME. 10. Metallurgy. 6 units (2-0-4); first term.

Prerequisites: ME. 3; Ch. 6.

A study of the principles underlying the heat treatment, properties, use, and selection of ferrous and non-ferrous alloys as applied to design.

Text: *Physical Metallurgy for Engineers,* Clark.

Instructor: Clark.

ME. 15. Heat Engineering. 12 units (3-3-6); second or third term.

Prerequisites: Ma. 2 a, b, c, d; ME. 1.

Principles of engineering thermodynamics; properties of gases; thermodynamic processes of gases; gas cycles; internal combustion engines; air compressors; and elements of different types of power plants. Inspection of local power plants, laboratory demonstration tests, and computing room exercises.

Text: *Heat Power Engineering,* Vol. I, Barnard, Ellenwood, and Hirshfeld.

Instructors: Rockefeller, Gongwer.

ME. 16. Heat Engineering. 12 units (4-0-8); third term.

Prerequisite: ME. 15.

Additional work in thermodynamics; properties of vapors; thermodynamic processes of vapors; vapor cycles; steam engines; steam turbines.

Text: *Heat Power Engineering,* Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 17. Heat Engineering. 9 units (3-0-6); first term.

Prerequisite: ME. 16.

Heat transmission; fuels; combustion; flue gas analysis; steam generators; and steam generator accessories.

Text: *Heat Power Engineering,* Vol. II, Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 18. Heat Engineering. 10 units (3-0-7); second term.

Prerequisite: ME. 15.

An abridgement of ME. 16 for students in Electrical Engineering.

Instructor: Daugherty.

ME. 19. Heat Engineering. 6 units (2-0-4); second term.

Prerequisite: ME. 17.

Flow of compressible fluids; condensers; feed water heaters; water softening; mixtures of air and water vapor; atmospheric water cooling; heating and ventilating; refrigeration.

Text: *Heat Power Engineering,* Vol. III, Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 20. Heat Engineering. 9 units (2-3-4).

An abridgement of ME. 15 for students in Civil Engineering.

Instructors: Rockefeller, Gongwer.

ME. 25. Mechanical Laboratory. 6 units (0-3-3); third term.
Prerequisite: ME. 15.
Tests of steam engine, steam turbine, blower and gas engine, etc., for efficiency and economy.
Text: *Power Plant Testing,* Moyer.
Instructors: Knapp, Budenholzer, Daily, Gongwer.

ME. 26. Mechanical Laboratory. 6 units (0-3-3); second term.
Prerequisite: ME. 15.
Additional work in the laboratory on air compressors, fuel and oil testing, and special work on steam and internal combustion engines.
Text: *Power Plant Testing,* Moyer.
Instructors: Knapp, Budenholzer, Gongwer.

ME. 27. Mechanical Laboratory. 9 units (0-3-6); first term.
Prerequisites: ME. 15 and Hy. 1.
An abridgement of ME. 25 and Hy. 2 for students in Electrical Engineering.
Instructors: Knapp, Budenholzer, Daily, Gongwer.

ME. 50 a, b, c. Engineering Conferences. 2 units (1-0-1); first, second and third terms.
Presentation and discussion of new developments in industry. Review of current literature.
Instructors: Daugherty, Huse.

FIFTH-YEAR AND ADVANCED SUBJECTS

ME. 100. Advanced Work in Engineering.
In addition to the regular fifth-year and other advanced courses which are here outlined, the staff of the mechanical engineering department will arrange special courses or problems to meet the needs of advanced students.

ME. 101 a, b. Advanced Machine Design. 12 units; second and third terms.
Prerequisites: ME. 5, 10.
The student must possess a comprehensive knowledge of mechanics, of materials, and also of the physical properties of the more common materials of construction. Strength of material formulae are studied as to their authority and limitations, and their application is extended to cover such cases as curved bars, thin plates, energy loads, stress concentration around holes, key seats, etc.; dynamic stresses as in rotating disks and flywheels; critical speeds of shafting; bending of bars on elastic foundations. Many examples of evolved designs are studied to determine the considerations which have led to the design. Theory of strengths and their application to the study of designs which have failed in service.
Instructor: Clapp.

ME. 110 a, b, c. Science of Metals. 6 units (3-0-3); each term.
Prerequisite: ME. 10.
A study of modern engineering metals and alloys; their mechanical and physical properties, and the effects upon these properties brought about by the various processes of manufacture and fabrication. A study of the physical principles governing metallic behavior.
Text: *Principles of Physical Metallurgy,* Doan.
Instructors: Clapp, Clark.

ME. 111 a, b, c. Metallography Laboratory. 6 units (0-6-0); first, second and third terms.

Prerequisite: ME. 110 a, b, c, or to be taken at the same time.

Pyrometry, thermal analysis, microscopy, preparation of metallographic specimens, photomicrography, structures of steels and cast irons, heat treatment of steel, structures and treatment of non-ferrous alloys, recrystallization and grain growth, macroscopy, inspection methods, special problems.

Instructor: Clark.

ME. 120. Heat Engineering. 12 units (3-0-9); first term.

Prerequisite: ME. 17.

Advanced work in engineering thermodynamics; thermodynamic processes of actual gases with variable specific heats; complex power plant cycles; heat transmission; combustion; heat balance of boilers; and other applications to practical cases.

Instructor: Daugherty.

ME. 121 and 122. Heat Engineering. 12 units (2-0-10); second and third terms.

Prerequisite: ME. 120.

Advanced study of internal combustion engines of all types, steam turbines, heating and ventilating, refrigeration, air conditioning, and steam power plants. Either term may be taken independently of the other.

Instructor: Daugherty.

ME. 125. Refrigeration Plants. Units to be based on work done; any term.

Design of various types of refrigeration plants best adapted to different conditions of service.

Instructors: Daugherty, Knapp.

ME. 130. Advanced Mechanical Laboratory. 15 units (1-9-5); first term.

Prerequisites: ME. 17, 26.

Advanced work on steam turbines, internal combustion engines, lubrication, and similar subjects. Each problem will be studied in enough detail to secure a thorough analysis. Conference hour for progress discussion.

Instructor: Knapp.

ME. 132. Engine Laboratory. 15 units; first, second and third terms.

Use of the dynamometer. Experimental work in engine performance, carburetion, ignition, fuel consumption, etc.

ME. 140 a, b. Research or Thesis. 18 units; second and third terms.

This work is arranged with the department to fit the needs and desires of the individual student.

ME. 150 a, b, c. Mechanical Engineering Seminar. 2 units each term.

Attendance required of graduate students in mechanical engineering. Conference on research work and reviews of new developments in engineering.

AERONAUTICS

PROFESSORS: THEODORE VON KÁRMÁN, HARRY BATEMAN
ASSOCIATE PROFESSORS: ARTHUR L. KLEIN, CLARK B. MILLIKAN
ASSISTANT PROFESSORS: IRVING P. KRICK, ARTHUR E. RAYMOND, ERNEST E. SECHLER
INSTRUCTORS: W. A. KLIKOFF, W. CURTIS ROCKEFELLER, WILLIAM R. SEARS

UNDERGRADUATE SUBJECTS

AE. 2 a, b. Aircraft Structures. 12 units; second and third terms.
Prerequisite: AM. 1 c.

A course adapted for students planning to take post-graduate work in Aeronautics. The course includes the analysis of forces by analytical and graphical methods and the calculation of stresses in beams, girders, columns, shafts and simple trusses of timber, steel and light alloys; study of continuous beams; beams under combined lateral and axial loads; trusses with redundant members; effect of flexure and direct stress; deflections in beams and trusses; tapered columns; circular rings; thin wall structures; loads upon an airplane.

Text: *Structural Design of Metal Airplanes,* Younger.
Instructor: Klikoff.
See also ME. 8.

FIFTH-YEAR AND ADVANCED SUBJECTS

AE. 251 a, b, c. Aerodynamics of the Airplane. 9 units; first, second and third terms.
Prerequisites: AM. 1 a, b, c, AM. 3.

Airfoils, wings, and tail groups, stability and control, drag, performance and spinning.

Texts: *Principles of Flight,* Stalker; *Dynamics of Airplanes,* Younger and Woods; *Technical Aerodynamics,* Wood; *Engineering Aerodynamics,* Diehl.
Instructor: Millikan.

AE. 252 a, b, c. Airplane Design. 12 units; first, second and third terms.
Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

The solution of problems connected with the structural design and analysis of complete airplanes, with special emphasis being placed on the problems dealing with monocoque construction. AE. 252 must be taken concurrently with or subsequently to 251.

Texts: *Airplane Structures,* Niles and Newell; *Strength of Materials,* Boyd; *Airplane Design,* K. D. Wood.
Instructors: Sechler, Raymond.

AE. 253 a, b, c. Airplane Design and Testing Procedure. 6 units; first, second and third terms.
Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

253a, drafting room technique, factory methods, factory equipment, materials used; 253b, control systems, flap systems, landing gears, power plants, and non-

structural components; 253c, performance prediction, performance reduction, flight testing.

Instructors: Klein, Raymond.

AE. 254 a, b, c. Advanced Problems in Airplane Design. 9 units; first, second and third terms.

Prerequisites: AE. 251, 252, 253.

254a, study of specific problems in airplane design; 254b, advanced problems concerning the aerodynamical design of airplanes; 254c, the design of flying boats and seaplanes.

Instructors: Klein, Raymond.

AE. 255. Wind Tunnel Operation and Technique. 6 units; first, second or third terms.

A one-term course given each term covering pressure and velocity measuring instruments, balances, model suspensions, wind tunnel calibrations and correction factors, data reduction and presentation, extrapolation of model results to full scale. Experiments on various aerodynamic phenomena are carried out by the students in a special wind tunnel constructed for instruction purposes.

Instructor: Sears.

AE. 260. Research in Aeronautics.

Theoretical and experimental research in one of the following fields: fluid mechanics; elasticity, including photoelasticity; structures and aerodynamics.

AE. 266 a, b. Theoretical Aerodynamics I. Perfect Fluids. 12 units, first term; 9 units, second term.

Prerequisites: Ma. 14; 114 a, b, or EE. 226 a, b, or Ma. 8 a, b, c (12 units).

Hydrodynamics of perfect fluids as applied to aeronautics, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, airfoils, three dimensional wing theory, monoplanes, biplanes, interference.

Texts: *The Elements of Aerofoil and Airscrew Theory,* Glauert; *Applications of Modern Hydrodynamics to Aeronautics,* Prandtl.

Instructor: Kármán or Millikan.

AE. 267. Theoretical Aerodynamics II. Real Fluids. 12 units; third term.

Prerequisites: AE. 266 a, b.

Hydrodynamics of viscous fluids, laminar motion in pipes and channels, turbulence and Reynolds' criterion, similarity laws, theory of drag, discontinuous flow and vortex streets, theory of skin-friction, boundary layer, general theory of turbulence.

Instructor: Kármán or Millikan.

AE. 268. Hydrodynamics of a Compressible Fluid. 12 units; one term.

Prerequisites: AE. 266 a, b.

Relation of the equations to the kinetic theory of gases, theory of jets and of the Venturi tube, motion with a velocity exceeding the velocity of sound, shock waves, cavitation.

Instructor: Bateman.

AE. 269 a, b, c. Advanced Problems in Theoretical Aerodynamics. 9 units; first, second and third terms.

A seminar course in the applications of theoretical aerodynamics to aeronautical problems for students who have had AE. 266 and AE. 267.

Instructors: Kármán, Millikan.

AE. 270 a, b, c. Elasticity Applied to Aeronautics. 12 units, first term; 6 units, second and third terms.

Prerequisites: Ma. 109 a, b, or AE. 265 a, b; AM. 1 a, b, c, 3.

Analysis of stress and strain. Hookes law. Theory of bending and torsion. Stresses in thin shells. Theory of elastic stability. Vibrations and flutter.

Instructors: Kármán, Sechler.

AE. 290 a, b, c. Aeronautical Seminar. 2 units; first, second and third terms.

Study and critical discussion of current contributions to aerodynamics and aeronautical engineering.

METEOROLOGY

PROFESSORS: BENO GUTENBERG, THEODORE VON KÁRMÁN
ASSISTANT PROFESSOR: IRVING P. KRICK
INSTRUCTOR: W. CURTIS ROCKEFELLER

AE. 272 a, b, c. Dynamic Meteorology. 9 units (3-0-6); first, second and third terms.

The application of hydrodynamics and thermodynamics to the study of atmospheric phenomena. Statics and kinematics of the atmosphere; general dynamics of air currents; energy of air movements, gusts, turbulence, etc.

Instructor: Rockefeller.

AE. 273 a, b, c. Synoptic Meteorology. 12 units (4-0-8); first, second and third terms.

Application of the principles of dynamic meteorology to the study of the phenomena of the weather map. Modern theories on the structure of the extratropical cyclone, general circulation of the atmosphere, air masses, frontogenesis and frontolysis. Upper air soundings and their use in synoptic meteorology, identification of air masses by evaluation of upper air data and by other criteria. Detailed discussion of weather forecasting by means of frontal and air mass analysis, especially in connection with aircraft operations. Forecasting of local weather phenomena such as fogs, thunder storms, etc., effects of topography upon frontal movements and upon properties of air masses.

Instructor: Krick.

AE. 274 a, b, c. Meteorological Laboratory. 15 units; first, second and third terms.

Decoding and plotting of daily weather maps by frontal and air-mass analysis methods. Surface data augmented by all available upper-air information in order to obtain, as far as possible, three-dimensional analyses. The Department of Commerce teletype service is utilized and actual operating conditions simulated in the laboratory, including practice forecasts for selected areas, both of a general nature and of a more detailed nature in connection with forecasts for aviation. The laboratory work is supplemented by observational work carried on at the Institute's Marine Observatory at San Pedro, California.

Instructor: Krick.

AE. 275. Structure of the Atmosphere. 3 units; third term.

Constituents of the atmosphere and their distribution. Theories underlying the probable structure and temperature of the stratosphere.

(Not given in 1938-39.)

Instructor: Gutenberg.

AE. 276. Meteorological Instruments. 6 units (6-0-0); first term.

Temperature measurements, including a study of mercury and other expansion thermometers, electrical thermometers; hygrometry; barometers; velocity measurements, including dynamic pressure and hot wire instruments, rain and snow gauges, cloud measurements; radiation measurements, including a study of sounding and pilot balloons and their equipment. Practical measurements are made at the Institute's Marine Observatory at San Pedro.

Instructor: Wood.

AE. 280 a, b. Meteorological Research. Units to be determined; second and third terms.

Selected problems in meteorology research assigned to meet the needs of advanced students.

Instructors: Gutenberg, Krick.

AE. 291 a, b, c. Meteorological Seminar. 2 units; first, second and third terms.

Reviews and discussions of current meteorological literature and problems.

In charge: Gutenberg, Krick.

Additional and supplementary courses are offered as the need arises. Lectures are given from time to time by visiting scientists and engineers from this country and Europe. Flying is not given officially at the Institute, but there are ample opportunities for a student to learn to fly at one of the neighboring flying fields.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.
ASSISTANT PROFESSOR: FRED J. CONVERSE

UNDERGRADUATE SUBJECTS

AM. 1 a, b. Applied Mechanics. 14 units (4-3-7); first and second terms.
Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d; Ph. 1 a, b, c, 2 a, b, c, d.

Action of forces on rigid bodies; composition and resolution of forces; equilibrium, couples, framed structures; cords and chains; centroids; displacement; velocity and acceleration; translation, rotation, and plane motion; moments of inertia; inertia forces; kinetic and potential energy; work and energy; impulse and momentum; impact; power; efficiency.

Text: *Engineering Mechanics,* Brown.
Instructors: Converse and assistants.

AM. 1 c. Strength of Materials. 14 units (4-3-7); third term.
Prerequisite: AM. 1 a, b.

Elasticity and strength of materials of construction; theory of stresses and strains; elastic limit; yield point; ultimate strength; safe loads; repeated stresses; beams; cylinders; shafts; columns; riveted joints; structural shapes.

Texts: *Elements of Strength of Materials,* Timoshenko and MacCullough; *Steel Construction,* A. I. S. C.
Instructors: Hinrichs, Converse, and assistants.

AM. 2 a, b. Applied Mechanics and Strength of Materials. 12 units (4-0-8); first and second terms.
Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d; Ph. 1 a, b, c, 2 a, b, c, d.

An abridged course for students electing the Applied Chemistry Option in the Science Course, condensing in the work of two terms as much as possible of the general field outlined above in AM. 1 a, b, c.

Texts: *Engineering Mechanics,* Brown; *Elements of Strength of Materials,* Timoshenko and MacCullough; *Steel Construction,* A. I. S. C.
Instructor: Hinrichs.

AM. 3. Testing Materials Laboratory. 6 units (0-3-3); second or third term.
Prerequisite: AM. 1 c.

Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limit; yield point; ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.

Text: *Materials of Construction,* J. B. Johnson.
Instructors: Converse and assistant.

ADVANCED SUBJECTS

AM. 105. Soil Mechanics. 6 units (2-2-2); first term.

A study of the physical and mechanical properties of soils, and the determination of principles which govern their behavior under load. The application of these principles to problems of foundations and of earthwork engineering.

Instructor: Converse.

ENGINEERING DRAWING

INSTRUCTORS: HOWELL N. TYSON, NATHANIEL W. WILCOX

D. 1. Freehand Drawing. 3 units (0-3-0); first term.

The study of geometrical forms and their representation by means of freehand perspective. Training in pencil rendering is given and the fundamental principles of perspective are illustrated by simple architectural and engineering studies. Emphasis is placed on careful observation and accurate drawing.

Instructors: Wilcox, Okun, Snelling.

D. 2. Advanced Freehand Drawing. Either 3 units (0-3-0) or 6 units (0-3-3); elective; second term.

Prerequisite: D. 1.

This course is similar to D. 1, but with advanced subject matter. The student is allowed, to a certain extent, to choose subjects for his work which are related to his chief field of interest.

Instructor: Wilcox.

Descriptive Geometry, D. 3 a, b, c, d and D. 4 are planned to cover a thorough study of shape description and representation. Especial emphasis will be placed upon the visualization of problems in order to develop three dimensional observation. The work will include practical as well as purely geometrical problems.

D. 3 a. Descriptive Geometry. 3 units (0-3-0); second term.

The study of the graphical representation of three dimensional geometrical constructions by means of orthographic projection. The work includes principle, auxiliary and oblique views.

Text: *Geometry of Engineering Drawing*, Hood.

Instructors: Wilcox, Okun, Snelling.

D. 3 b. Descriptive Geometry. 3 units (0-3-0); third term.

Prerequisite: D. 3 a.

A continuation of D. 3 a, covering the geometrical relationships of lines and planes.

Text: *Geometry of Engineering Drawing*, Hood.

Instructors: Tyson, Wilcox, Ashkenas.

D. 3 c. Descriptive Geometry. 3 units (0-3-0); first or second terms.

Prerequisite: D. 3 b.

A continuation of D. 3 b, covering problems involving curved lines and the intersection and development of surfaces.

Text: *Geometry of Engineering Drawing*, Hood.

Instructors: Tyson, Ashkenas, Snelling.

D. 3 d. Descriptive Geometry. 3 units (0-3-0); second or third terms.

Prerequisite: D. 3 c.

A continuation of D. 3 c, covering more complicated problems involving single curved surfaces, warped and double curved surfaces, and mining problems.

Text: *Geometry of Engineering Drawing*, Hood.

Instructors: Tyson, Ashkenas, Snelling.

D. 4. Advanced Descriptive Geometry. 6 units (0-6-0); elective any term.
Prerequisite: D. 3 a, b, c, d.
The study of lineal perspective and the execution of mechanical perspective drawings of machines, bridges, and other structures.

D. 5. Descriptive Geometry. 3 units (0-3-0); third term.
Prerequisites: D. 3 a, b.
This course is planned primarily for geology students and includes practical problems in mining and earth structures.
Text: *Geometry of Engineering Drawing,* Hood.

D. 6 a. Engineering Drawing. 6 units (0-6-0); first or second term.
Prerequisite: D. 1, 3 a, b.
This course is designed to give the student a general knowledge of the most important types of engineering drawings. Instruction is given in the proper use of drafting equipment and in the fundamental principles of drafting and lettering. The accepted standards for both machine and structural drawing are given, and plates are drawn which illustrate the use of these standards. The student is also given basic training in making pictorial drawings and engineering charts and graphs.
Text: *Drafting for Engineers,* second edition, Svensen.
Instructors: Bonell, Feuer, Van Der Werff.

D. 6 b. Engineering Drawing. 6 units (0-6-0); second or third term.
Prerequisites: D. 1, 3 a, b, c, 6.
This is a continuation of the course described above.
Text: *Drafting for Engineers,* second edition, Svensen.
Instructors: Tyson, Feuer.

D. 7. Advanced Engineering Drawing. Maximum of 6 units. Elective; any term.
Prerequisites: D. 3 a, b, c, d, 6 a, b.
The study and execution of drawings of machines or equipment designed by upper-class students in the engineering department.
Instructor: Tyson.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY
ASSOCIATE PROFESSOR: ROBERT T. KNAPP
ASSISTANT PROFESSOR: HUNTER ROUSE
INSTRUCTOR: ARTHUR T. IPPEN

UNDERGRADUATE SUBJECTS

Hy. 1 a, b. Hydraulics. 12 units (3-3-6), first or second terms; 9 units (3-0-6), third term.

Prerequisite: AM. 1 a, or to be taken at the same time.

Physical Properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydraulic turbines; centrifugal pumps and other hydraulic equipment.

Text: *Hydraulics*, Daugherty.

Instructors: Daugherty, Knapp, Ippen, Wagner.

Hy. 2. Hydraulics Laboratory. 6 units (0-3-3); second or third term.

Prerequisite: AM. 1 a, b.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.

Instructors: Knapp, Daily.

Hy. 3. Hydraulics Problems. 6 units (0-6-0); first term.

Prerequisite: Hy. 1.

Selected advanced problems in hydraulics such as penstock design, water hammer and surge chamber calculations, hydraulic jump determinations, etc.

Instructor: Rouse.

Hy. 4. Hydraulic Machinery. 9 units (3-0-6); third term.

Prerequisites: Hy. 1 and 2.

Theory, construction, installation, operation, and characteristics of hydraulic turbines and centrifugal pumps.

Instructor: Knapp.

ADVANCED SUBJECTS

Hy. 100. Applied Hydrodynamics. 12 units (3-0-9); second term.

Prerequisites: Hy. 1 and 2.

Velocity distribution; turbulence; pipe friction; cavitation; principles of similitude; model studies.

Instructors: Daugherty, Knapp.

Hy. 101. Hydraulic Machinery. Units to be based on work done; any term.

A study of such machines as the hydraulic turbine and the centrifugal pump and their design to meet specified conditions.

Instructors: Daugherty, Knapp.

Hy. 200. Advanced Work in Hydraulic Engineering.

Special problems in hydraulics will be arranged to meet the needs of students wishing to do advanced work in this field.

DIVISION OF THE GEOLOGICAL SCIENCES
GEOLOGY, PALEONTOLOGY, AND GEOPHYSICS

PROFESSORS: JOHN P. BUWALDA, BENO GUTENBERG, CHESTER STOCK
ASSOCIATE PROFESSORS: HUGO BENIOFF, IAN CAMPBELL
ASSISTANT PROFESSORS: HORACE J. FRASER, CHARLES F. RICHTER
INSTRUCTORS: FRANCIS D. BODE,[1] JOHN H. MAXSON, RAYMOND A. PETERSON

UNDERGRADUATE SUBJECTS

Ge. 1 a. Physical Geology. 9 units (3-3-3); first term.
Prerequisites: Ch. 1 a, b, c; Ph. 1 a, b, c.
A consideration of the composition and structure of the Earth and the internal and external processes which modify the crust and the surface. Dynamical and structural geology. Lectures, recitations, laboratory and field trips.
Text: *Text-book of Geology,* Part I, Longwell, Knopf and Flint.
Instructors: Buwalda, Peterson, Curry, Hoy, Jahns.

Ge. 1 b. Elementary Paleontology. 9 units (4-1-4); third term.
Prerequisite: Ge. 1 a.
A discussion of the principles on which the history of life is based. Illustrations of evolution taken from certain groups of animals of which the fossil record is essentially complete. Occasional field trips.
Text: *Organic Evolution,* Lull.
Instructors: Stock, Drescher.

Ge. 1 c. Historical Geology. 9 units (3-0-6); third term.
Prerequisite: Ge. 1 a.
A consideration of the geologic history of the earth, as shown by the changing patterns of land and sea and by the succession of faunas and floras. Conferences, lectures, and occasional field trips.
Text: *Historical Geology,* R. C. Moore.
Instructor: Maxson.

Ge. 3 a, b, c. Mineralogy. 12 units (3-6-3); each term.
Prerequisites: Ge. 1 a; Ch. 12 a, b.
A comprehensive course dealing with the materials of the earth's crust. The first part of the course constitutes an introduction to crystallography; the body of the course is concerned with physical, chemical and determinative mineralogy, and with the genesis, occurrence, association, extraction and use of minerals; the last part of the course deals especially with mineral aggregates (rocks), their classification, field determination, and geologic occurrence. This course is designed to give a working knowledge of the geographic occurrence and the geologic factors controlling the formation of mineral and ore deposits, and in conjunction with Ge. 121 a, knowledge of lithology sufficient for the needs of the beginning field geologist.
Text: *Dana's Textbook of Mineralogy* by W. E. Ford, 4th edition.
Instructors: Fraser (Ge. 3 a, b), Campbell (Ge. 3 c), Henshaw.

Ge. 14. Geologic Illustration. 10 units (0-10-0); first term.
Freehand sketching of landscape forms and visible geologic structures in the field developing both line and shading technique in representation. Also classroom exer-

[1] On leave 1937-1938.

cises utilizing various mediums. Training in the drawing of block diagrams illustrating land forms and geologic structure sections in perspective. Problems in projection.

Text: *Block Diagrams,* Lobeck.

Instructor: Ridgway.

Ge. 21. Senior Thesis Problem in Geology. Units to bring total load per term to 50.

Prerequisite: Ge. 121 a.

The student investigates a limited geologic problem in the field or laboratory. Individual initiative is developed, principles of research are acquired, and practice gained in technical methods. The student prepares a thesis setting forth the results of the research and their meaning. Last date for acceptance of thesis, May 25.

Instructors: Maxson, Peterson.

Ge. 22. Senior Thesis Problem in Paleontology. 8 units, first or third terms; 6 units, second term.

Prerequisites: Ge. 111 a, b, or Ge. 112 a, b; may be taken concurrently.

Special investigations in either invertebrate or vertebrate paleontology. Research on a limited problem involving either field relationships of fossil assemblages or consideration in the laboratory of the structural characters and relations of fossil forms. Preparation of a thesis.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ge. 100. Geology-Paleontology Club. 1 unit; all terms.

Presentation of papers on research in geological science by the students and staff of the Division of Geological Sciences, and by guest speakers.

Required of all senior and graduate students in the Division.

Ge. 105. Optical Mineralogy. 10 units (2-6-2); first term.

Prerequisites: Ge. 1, 3.

Study of optical mineralogy and use of the petrographic microscope in the identification of minerals.

Text: *Elements of Optical Mineralogy,* Vol. I, N. H. Winchell.

Instructors: Anderson, Jahns.

Ge. 106 a, b. Petrography. 10 units (2-6-2); second and third terms.

Prerequisites: Ge. 3 a, b, c, Ch. 21 a, 23 a.

A systematic study of rocks; the identification of their constituents by application of the polarizing microscope; interpretation of textures; problems of genesis; qualitative and quantitative classifications. Occasional field trips will be arranged.

Text: *Petrography and Petrology,* Grout.

Instructors: Campbell, Jahns.

Ge. 109. Structural Geology. 10 units (4-0-6); first term.

Prerequisite: Ge. 121 a.

A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation.

Instructor: Buwalda.

Ge. 110. Engineering Geology. 9 units (2-2-5); third term.

Prerequisite: Ge. 1 a.

A discussion of those geological conditions that affect particular engineering operations, such as tunnelling, the building of dams, the retention of water in reser-

voirs, foundation excavation, harbor work, control of erosion and landslides, materials of construction, etc. Lectures and assigned reading.

The course is planned primarily for civil engineers.

Instructor: Buwalda.

Ge. 111 a, b. Invertebrate Paleontology. 8 units (1-6-1), first term; 10 units (2-6-2), second term.

Prerequisites: Ge. 1 a, b, c.

Morphology and geologic history of the common groups of fossil invertebrates, with emphasis on progressive changes in structures and their significance in evolution and in adaptive modifications. Laboratory, conferences, lectures, and occasional field trips.

Instructor: Popenoe.

Ge. 112 a, b. Vertebrate Paleontology. 10 units (2-6-2); second and third terms.

Prerequisite: Ge. 1 b.

Osteology, affinities, and history of the principal groups of fossil mammals and reptiles. History of vertebrate life with special reference to the region of western North America.

Instructor: Stock.

Ge. 121 a, b. Field Geology. 10 units (1-8-1); second and third terms.

Prerequisites: Ge. 1 a, b, c, 3 a.

An introduction to the principles and methods used in geologic mapping. Field technique in determining rock types and their distribution, and in interpreting geologic relationships and structures. Practical experience in deciphering the geologic history of a region. To these ends a representative Coast Range area is mapped in detail and a report in professional form is prepared on its stratigraphy, structure and history. The field work, selected textbook assignments, and special geologic problems and computations are discussed in weekly class meetings.

Students taking this course are expected to go on the Annual Spring Field Trip described under Ge. 122.

Text: *Field Geology*, Lahee.

Instructors: Maxson, Peterson.

Ge. 122. Spring Field Trip. 1 unit; week between second and third terms.

Brief studies of various localities in the Southwest representative of important geologic provinces. Trips are conducted in successive years to Owens and Death Valleys where excellent Paleozoic sections are exposed, and Basin Range structure and morphology may be observed; to the Salton Basin and Lower California where the San Andreas fault and the Peninsular Range may be studied; to the San Joaquin Valley and the mountains to the west where important Tertiary formations are exposed and typical Coast Range structure may be seen; and to the Grand Canyon of the Colorado River where a fascinating record of Archean, Algonkian and Paleozoic geologic history may be investigated.

Required of junior, senior, and graduate students in the Division of Geological Sciences.

Instructors: Buwalda, Maxson.

Ge. 123. Summer Field Geology. 12 units.

Intensive field mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in even-numbered

years and in the Great Basin in odd-numbered years. As an occasional alternative an expedition will be conducted to localities important in California geology. The interpretations of classical localities afforded in the literature will be studied in the field. The course begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior year for the Bachelor's degree in the Geology course.

Instructors: Buwalda, Maxson.

Ge. 175. Elementary Geophysics. 5 units (2-0-3); third term 1938-1939.

A survey of pure and applied geophysics designed mainly for geological, engineering, and other students who do not expect to enroll in specialized courses in this field.

Instructor: Peterson.

Ge. 176. Elementary Seismology. 5 units (2-0-3); third term 1937-1938.

A survey of geological and physical seismology.

Instructor: Richter.

Ge. 187. Research.

Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields: (m) mineralogy, (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (v) economic geology, (w) general geophysics, (x) applied geophysics.

GRADUATE SUBJECTS

Ge. 200. Mineragraphy. 8 units (1-6-1); first term.

Prerequisites: Ge, 3, 105, 106, 121.

Technique of identification of opaque minerals in polished sections by means of etching and microchemistry.

Texts: *Microscopic Determination of Ore Minerals,* M. N. Short; U. S. G. S., Bull. 825, or new bulletin when issued; *Mineral Deposits,* 4th edition, Lindgren.

Instructors: Fraser, Dreyer.

Ge. 201. Introduction to Economic Geology. 5 units (2-0-3); first term.

Prerequisites: Ge. 3, 105, 106, 121.

A study of the factors affecting and controlling the deposition of ores.

Text: *Mineral Deposits,* 4th edition, Lindgren.

Instructor: Fraser.

Ge. 202. Metalliferous Deposits. 10 units (2-6-2); second term.

Prerequisites: Ge. 200, 201.

A study of the most important metalliferous deposits with respect to geographic distribution, structure, alteration, and mode of formation. The laboratory work will consist of a study of ore suites in polished and thin sections.

Text: *Mineral Deposits,* 4th edition, Lindgren.

Instructors: Fraser, Dreyer.

Ge. 210. Advanced Petrology. 8 units; second term.

Prerequisite: Ge. 106 a, b.

A continuation and amplification of Ge. 106 a, b; dealing especially with the metamorphic rocks in 1937-38, with the sedimentary rocks in 1938-39.

Texts: *Sedimentary Petrography,* Milner; *Metamorphism,* Harker.

Instructor: Campbell.

Ge. 211. Petrology (Seminar). 5 units; third term.

Discussion of classic and current literature with consideration of recent advances in the field of petrology. Occasional conferences on research problems are included.

In charge: Campbell.

Ge. 212. Non-Metalliferous Ore Deposits. 10 units (2-6-2); third term.

Prerequisite: Ge. 3, 106.

A study of the economically valuable non-opaque minerals: their geographic and geologic occurrence, and methods of extraction and utilization. In the laboratory, the course will be extended to include also a study of the non-opaque minerals associated with metalliferous deposits, thus affording the student greater familiarity with typically altered country rock than is possible within the scope of Ge. 106 a, b.

Text: *Mineral Deposits,* 4th edition, Lindgren.

Instructors: Campbell, Dreyer, Bryson.

Ge. 213. Advanced Economic Geology (Seminar). 5 units; second term, 1938-1939.

Prerequisite: Ge. 202.

Discussion of current literature with particular reference to metalliferous deposits of the North American Continent.

In charge: Fraser, Snow.

Ge. 214. Advanced Economic Geology (Seminar). 5 units; second term, 1937-1938.

Prerequisite: Ge. 202.

Discussion and investigation of factors involved in ore estimation and economics of mining.

In charge: Fraser, Snow.

Ge. 215. Mineralogy (Seminar). 5 units; first term.

Prerequisite: Ge. 200.

Discussion of current literature and special problems with particular reference to the sulphide minerals and ore deposition.

In charge: Fraser, Wilson.

Ge. 216. Advanced Study.

Students may register for not to exceed 8 units of advanced study in fields listed under Ge. 187. Occasional conferences; final examination.

Ge. 220. History of Geology. 5 units; second term of 1937-1938.

A study of the development of the geological sciences. The evolution of fundamental theories as influenced by earlier and contemporary geological investigators.

This brief course presents a connected sequence of the development of geological ideas and thereby aids in gaining a perspective of the science.

Lectures, assigned reading, and reports.

Instructor: Maxson.

Ge. 225. Geology of the Pacific Coast Region. 6 units (2-0-4); third term, 1937-1938.

An intensive review of the geomorphology, stratigraphy, and structure of the region most accessible from the California Institute, including Arizona, Nevada, and California. Presents an organized concept of the geologic history of the Colorado Plateau Province, the Basin and Range Province, and the Coast Range Province. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.

Instructors: Staff of the Division of the Geological Sciences.

Ge. 226. Geomorphology. 10 units; first term of 1938-1939.

Prerequisite: Ge. 109.

Nature and origin of the physiographic features of the earth. Geologic processes involved in their development. Use of physiography in elucidating the later geologic history of regions.

Instructor: Maxson.

Ge. 289 a. Structural Geology (Seminar). 5 units; first term.

Critical review of literature dealing with some part of the field of structural geology.

In charge: Buwalda.

Ge. 289 b. Physical Geology (Seminar). 5 units; third term.

Study and critical discussion of current contributions to geologic knowledge.

In charge: Buwalda.

Ge. 290 a, b. Vertebrate Paleontology (Seminar). 5 units; second and third terms.

Discussion of progress and results of research in vertebrate paleontology. Critical review of current literature.

In charge: Stock.

Ge. 291 a, b. Invertebrate Paleontology (Seminar). 5 units; first and second terms.

Conferences on research in invertebrate paleontology and reviews of literature. Discussions of particular aspects of invertebrate paleontology with special reference to the Pacific Coast.

In charge: Popenoe.

GEOPHYSICS

Advanced Calculus or Differential Equations or Introduction to Mathematical Physics is a prerequisite for all of the following courses in Geophysics except Ge. 265, for which the requirement is a thorough knowledge of calculus and physics.

Ge. 261. Theoretical Seismology. 6 units (2-0-4); first term, 1938-1939.

Studies and conferences on the principles of physical seismology.

Instructor: Gutenberg.

Ge. 262. Interpretation of Seismograms of Teleseisms. 5 units (0-2-3); second term, 1938-1939.

Prerequisite: Ge. 261.

Instructor: Gutenberg.

Ge. 263. Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes. 5 units (0-2-3); third term, 1938-1939.
Prerequisite: Ge. 261.
Instructor: Richter.

Ge. 265. Introduction to General Geophysics. 6 units (2-0-4); second term, 1938-1939.
Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density.
Instructor: Gutenberg.

Ge. 270. Seismic Instruments. 9 units (2-2-5); first term.
Description and theory of seismographs. Laboratory experiments.
Instructor: Benioff.

Ge. 273. Applied Geophysics I. 5 units (2-0-3); second term, 1937-1938.
Methods of seismology applied to geological problems and prospecting.
Instructor: Gutenberg.

Ge. 274. Applied Geophysics II. 6 units (3-1-2); second term, 1937-1938.
Measurements of gravity applied to geological problems and prospecting.
Instructor: Peterson.

Ge. 275. Applied Geophysics III. 6 units (2-2-2); third term, 1937-1938.
Measurements of earth magnetism and of electricity applied to geological problems and prospecting.
Instructors: Peterson, Soske.

Ge. 278. Interpretation of Field Seismograms. 5 units (0-2-3); third term, 1937-1938.
Prerequisite: **Ge. 273.**
Instructor: Gutenberg.

Ge. 282. Geophysics (Seminar). 3 units; third term.
Prerequisite: At least two courses in Geophysics.
Discussion of papers in both general and applied geophysics.
In charge: Gutenberg, Buwalda, Peterson, Richter.

Ge. 283. Geophysical Instruments (Seminar). 3 units; second term.
Prerequisite: Ge. 270.
Discussion of papers relating to geophysical field and station instruments.
In charge: Benioff.

Ge. 295 a, b, c. Geophysics Research Conference. 2 units; all terms.
Prerequisite: Ge. 282 and 283.
Discussion of geophysical problems. For advanced students.
In charge: Gutenberg, Buwalda, Benioff, Peterson, Richter.

For research see Ge. 187. For Physics of the Atmosphere see Meteorology.

DIVISION OF BIOLOGY

PROFESSORS: THOMAS HUNT MORGAN, HENRY BORSOOK, THEODOSIUS DOBZHANSKY, ALFRED H. STURTEVANT, FRITS W. WENT
ASSOCIATE PROFESSORS: ERNEST G. ANDERSON, STERLING EMERSON, A. J. HAAGEN-SMIT, CORNELIS A. G. WIERSMA
ASSISTANT PROFESSORS: ROBERT EMERSON,[1] HUGH M. HUFFMAN, GEORGE E. MACGINITIE
INSTRUCTORS: JAMES BONNER, ANTHONIE VAN HARREVELD, ALBERT TYLER, JOHANNES VAN OVERBEEK

For the study of biology, the Institute provides the following opportunities:

An option in biology has been introduced into the four-year undergraduate Course in Science. This option includes those fundamental biological subjects that are an essential preparation for work in any special field of pure or applied biology. This three-year course affords a far more thorough training in the basic sciences of physics, chemistry, and mathematics than students of biology, medicine, or agriculture commonly receive. Special opportunities are also offered for the pursuit of more advanced courses and extended researches leading to the degree of Doctor of Philosophy.

UNDERGRADUATE SUBJECTS

Bi. 1. Elementary Biology. 9 units (3-3-3); second term.
An introductory course intended to give the student of general science some information about the fundamental properties of living things.
Instructors: Morgan, Borsook, Bonner.

Bi. 2. Genetics. 9 units (3-4-2); third term.
An introductory course presenting the fundamentals of genetics in connection with some general biological problems, such as variation and evolution.
Instructor: Dobzhansky.

Bi. 3. General Botany. 14 units (2-9-3); first term.
A general survey of the morphology and life histories of plants.
Instructor: S. Emerson.

Bi. 4. Invertebrate Zoology. 10 units (2-6-2); third term.
A survey of the main groups of invertebrates (excluding insects—see Bi. 11).
Instructor: MacGinitie.

[1] On leave of absence until 1940.

Bi. 5 a, b. Plant Physiology. 12 units (3-6-3), second term; 8 units (2-4-2), third term.
A general study of water relations, growth and tropisms.
Instructor: Went.

Bi. 6. Embryology. 12 units (2-8-2); second term.
A course in descriptive and experimental embryology, covering both vertebrates and invertebrates.
Instructor: Tyler.

Bi. 7 a, b. Biochemistry. 10 units (2-4-4); second and third terms.
A lecture course on the chemical constitution of living matter; and the chemical changes in animal physiology, with laboratory work illustrating principles and methods in current use.
Instructors: Borsook and Huffman.

Bi. 8. Advanced Genetics. 8 units (2-3-3); third term.
A more advanced course than Bi. 2, dealing especially with mutation, crossing over, and chromosome aberrations.
Instructor: Sturtevant.

Bi. 11. Entomology. 8 units (2-3-3); third term.
A general survey of the structure and life histories of the insects, emphasizing the groups that present favorable material for experimental work.
Instructors: Dobzhansky and Sturtevant.

Bi. 12. Histology. 9 units (1-6-2); first term.
A course in technique and in the microscopic structure of animals.
Instructor: Tyler.

Bi. 13. Mammalian Anatomy. 5 units (1-2-2); first term.
The dissection of a mammal.
Instructor: van Harreveld.

Bi. 16 a, b. Animal Physiology. 10 units (3-2-5); first and second terms.
A survey of comparative and mammalian physiology.
Instructors: Wiersma and van Harreveld.

Bi. 17. Vertebrate Anatomy. 10 units; summer.
This course, given at the marine station at Corona del Mar, deals with the comparative anatomy of the vertebrates.
Instructor: MacGinitie.

Bi. 20. Biological Literature. 4 units (0-0-4); first term.
Assigned subjects and written reports. This course is intended to give the student practice in the finding and use of original literature. Students may register for this course with any member of the staff, after consultation.

Bi. 22. Research. 10 units; third term.
An opportunity will be given to follow special lines of research under direction. Students may register for this course with any member of the staff, after consultation.

ADVANCED COURSES

Instruction will be given by lectures and seminars; and research will be forwarded by intimate contact between students and instructors in the laboratories. In view of the great expense of modern research along physiological lines, the department will make careful selections of students of exceptional ability and aptitude in order to avoid the formal instruction that large numbers entail.

Bi. 100. Genetics Journal Club.
Meets twice monthly for presentation and discussion of current literature and original work.
Instructor: Sturtevant.

Bi. 101. Biology Journal Club.
Meets twice monthly for reports on current literature of general biological interest.
Instructor: Morgan.

Bi. 102. Biochemistry Seminar.
A seminar throughout the academic year on special selected topics and on recent advances.
In charge: Huffman.

Bi. 103. Plant Physiology Seminar.
Meets twice monthly.
In charge: Went.

Bi. 104. Genetics Seminar.
Reports and discussion on special topics.
In charge: Anderson.

Bi. 105. Experimental Embryology Seminar.
Reports on special topics in the field; meets twice monthly.
In charge: Tyler.

Bi. 110. Biochemistry.
Advanced work, with opportunity for research, is offered to graduate students who have completed work in General and Organic Chemistry.
Instructors: Borsook, Huffman.

Bi. 114 a, b, c. Chemistry of Bio-Organic Substances. 8 units (1-3-4); three terms.
A series of lectures on selected topics of organic chemistry which have special interest from a biological viewpoint. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of natural occurring substances. The following topic is chosen for second and third terms (1937-1938): "Biogenic amines and alkaloids." For undergraduates, prerequisite: Ch. 41 a, b, c. Ch. 46 a, b.
Instructor: Haagen-Smit.

Bi. 115. Chemistry of Bio-Organic Substances.
Advanced work with opportunity for research is offered to properly qualified graduate students.
Instructor: Haagen-Smit.

Bi. 117. Quantitative Organic Microanalysis. 20 units (0-20-0); second term.

Laboratory practice in the methods of quantitative organic microanalysis required for structure determinations of organic compounds. Students must obtain permission from the instructor before registering for this course as the enrollment is necessarily limited.

Instructor: Haagen-Smit.

Bi. 120. Experimental Embryology. 8 units (1-2-5).

Lectures and laboratory work on physiological embryology and related subjects.

Instructor: Tyler.

Bi. 125. Graduate Genetics. 6 units (2-0-4).

A course of advanced lectures, two per week, running through all three terms.

Instructors: Sturtevant, Anderson, Dobzhansky, S. Emerson.

Bi. 130. Biological Problems.

A course of lectures and reading, including such general topics as life cycles of protozoa and insects, secondary sexual characters and hormones; parthenogenesis, regeneration and grafting; the nature of biological theories, etc.

Instructor: Morgan.

Bi. 140 a, b, c. Plant Physiology. 6 units (2-0-4); first, second and third terms.

Reading and discussion of the main problems of plant physiology.

Instructors: Went, Bonner, van Overbeek.

Bi. 141. Plant Chemistry. 6 units (0-3-3); first, second and third terms.

Laboratory course in the analysis of plant materials by macro- and micro-chemical methods.

Instructor: Bonner.

Bi. 160. Advanced Physiology. 12 units (0-8-4); first and second terms.

A course in the methods of physiology, with special reference to those in nerve and muscle, with opportunity for research.

Instructors: Wiersma, van Harreveld.

Bi. 170. Research.

In special cases, not included in the preceding announcements, students doing advanced work in the department may register under this heading and receive a stated amount of credit. Students should consult with the instructor in charge of their major work before registering for this course.

DIVISION OF THE HUMANITIES

ENGLISH

PROFESSOR: CLINTON K. JUDY
ASSOCIATES: RICARDO QUINTANA, LOUIS B. WRIGHT
ASSOCIATE PROFESSOR: GEORGE R. MACMINN
ASSISTANT PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, L. WINCHESTER JONES, ROGER STANTON
INSTRUCTOR: DAVID L. STEVENSON

A course in English composition is prescribed for all students in the Freshman year, and a course in the survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of those authors, past and present, who are most significant in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular courses in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination is not confined to specific courses, but covers the general attainments of the students in their humanistic work throughout the first two years.

UNDERGRADUATE SUBJECTS

En. 1 a, b, c. English Composition and Reading. 6 units (3-0-3); first, second and third terms.

This course is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every inducement to self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. The members of the section are held to high standards of excellence in

writing and speaking, and are expected to undertake a considerable amount of cultural reading.

Texts: *Writing and Rewriting,* Shaw; *These United States,* Jones, Huse, and Eagleson; *College Readings in the Modern Short Story,* MacMinn and Eagleson; *Webster's Collegiate Dictionary.*

Instructors: Eagleson, Huse, Jones, MacMinn, Stanton, Stevenson.

En. 7 a, b, c. Survey of English Literature. 8 units (3-0-5); first, second and third terms.

Prerequisite: En. 1 a, b, c.

A selective study of English literature from the 16th Century to the 20th, focused on representative works by seven major authors: in the first term, Shakespeare; in the second, Swift, Wordsworth, and the Romantic Movement; in the third, Carlyle, Browning, and Masefield.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn, Stanton, Stevenson.

En. 8. Contemporary English and European Literature. 9 units (3-0-6); first, second or third term.

Prerequisite: En. 7 a, b, c.

A continuation of the survey of English literature to cover the period from 1890 to the present, with some extension into Continental literature. Wide reading is required.

Instructors: Eagleson, Judy.

En. 9. Contemporary American Literature. 9 units (3-0-6); first or second term; second term only in 1937-1938.

Prerequisite: En. 7 a, b, c.

A survey of the literature of the United States during the past half-century, with emphasis upon the chief writers of the present time. Special attention is given to the reflection of national characteristics in the novel, the short story, drama, and poetry.

Text: *American Poetry and Prose,* Part II, Foerster.

Instructor: MacMinn.

En. 10. Modern Drama. 9 units (3-0-6); first, second or third term.

Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production. Wide reading of plays is required.

Text: *Twenty-five Modern Plays,* Tucker.

Instructors: Huse, Stanton.

En. 11. Literature of the Bible. 9 units (3-0-6); third term.

Prerequisite: En. 7 a, b, c.

A study of the Old and New Testaments, exclusively from the point of view of literary interest. Special attention is given to the history of the English Bible. Opportunity is offered for reading modern literature based on Biblical subjects.

Text: *The Bible* (Authorized Version).

Instructor: MacMinn.

En. 12 a, b, c. Debating. 4 units (2-0-2).

Elective, with the approval of the Registration Committee, for upper classmen in the first and second terms. Study of the principles of argumentation; systematic practice in debating; preparation for intercollegiate debates.

Elective, with the approval of the Freshman Registration Committee, for Freshmen, 2 units (1-0-1) in the second term, and 4 units (2-0-2) in the third term. Lectures on the principles of formal logic and the theory of argumentation and debate.

Instructor: Untereiner.

En. 13 a, b, c. Reading in English and History. Units to be determined for the individual by the Department.

Elective, with the approval of the Registration Committee, in any term.

Collateral reading in literature and related subjects, done in connection with regular courses in English and History, or independently of any course, but under the direction of members of the Department.

En. 14. Special Composition. 2 units (1-0-1); any term.

This course may be prescribed for any student whose work in composition, general or technical, is unsatisfactory.

En. 15 a, b, c. Journalism. 3 units (1-0-2).

Elective, with the approval of the Registration Committee.

A study of the principles and practice of newspaper writing, editing, and publishing, especially as applied to student publications at the Institute.

Instructors: MacMinn, Stevenson.

En. 16. Spelling. No credit.

This course may be prescribed for any student whose spelling is unsatisfactory.

En. 20. Summer Reading. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En. 100. Literature. 9 units; first, second and third terms.

A study of some selected period, or type, or author, or group of authors in American, English or European literature, with an introduction to the methods of research and criticism applicable thereto.

Instructors: Guedalla, Quintana, Wright.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

The courses in modern languages are arranged primarily to meet the needs of scientific students who find it necessary to read books, treatises, and articles in French, German, and Italian. In the study of these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English. An elective course in Greek is offered to students interested in that language.

UNDERGRADUATE SUBJECTS

L. 1 a, b. Elementary French. 10 units (4-0-6); second and third terms.

A course in grammar, pronunciation, and reading that will provide the student with a vocabulary and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject. Students who have had French in the secondary school should not register for these courses without consulting the Professor of Languages.

Texts: *An Introduction to the Study of French,* Bond; *Aventures par la Lecture,* Bovée.

Instructor: Macarthur.

L. 11. Elementary Italian. 9 units (3-0-6); one term, as required.

A course designed to give the student who has already some acquaintance with Latin or with another Romance language sufficient knowledge of the forms and vocabulary of Italian to enable him to read scientific Italian, especially in the field of Mathematics.

Texts: *Elementary Italian,* Marinoni and Passarelli; *L'Italia nel Passato e nel Presente,* Capocelli.

Instructor: Macarthur.

L. 32 a, b, c. Elementary German. 10 units (4-0-6); first, second and third terms.

This subject is presented in the same manner as the Elementary French. Students who have had German in the secondary school or junior college should not register for these courses without consulting the Professor of Languages.

Texts: *First German Course for Science Students,* Fiedler and Sandbach; *An Introduction to Scientific German,* Wild.

Instructors: Macarthur, Dekker.

L. 35 a, b, c. Scientific German. 10 units (4-0-6); first, second and third terms.

Prerequisite: L. 32 a, b, c, or one year of college German.

This is a continuation of L. 32 a, b, c, with special emphasis on the reading of scientific literature.

Text: *Technical and Scientific German,* Greenfield.

Instructors: Macarthur, Dekker.

L. 39 a, b, c. Reading in French, Italian, or German. Units to be determined for the individual by the department. Elective, with the approval of the Registration Committee, in any term.

Reading in scientific or literary French, Italian, or German, done under direction of the department.

L. 40. German Literature. 9 units (3-0-6); third term.

Prerequisites: L. 32 a, b, c; L. 35 a.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature. Elective and offered only to students whose work in the prerequisites has been above average. Selected readings from Schiller and other classical authors.

Text: *Historical Survey of German Literature,* S. Liptzin.

Instructor: Macarthur.

L. 51 a, b, c. Greek. 6 units (3-0-3).

This is a course in the elements of the classical Greek language. Special reference is made to scientific nomenclature. Outside reading upon topics drawn from Greek literature, art, philosophy, and science is reported on in term papers. The course is elective, and will be offered only if six or more persons request it and agree to take it throughout the year.

Texts: *Alpha,* Frost; Xenophon's *Anabasis; The Study of Greek Words in English, Including Scientific Terms,* Hoffman.

Instructor: Macarthur.

HISTORY AND GOVERNMENT

PROFESSOR: WILLIAM B. MUNRO
VISITING PROFESSORS: PHILIP GUEDALLA, ALLAN NEVINS
ASSOCIATES: GODFREY DAVIES, EDWIN F. GAY
ASSOCIATE PROFESSOR: RAY E. UNTEREINER
ASSISTANT PROFESSOR: J. E. WALLACE STERLING
INSTRUCTORS: HARDIN CRAIG, JR., WILLIAM H. PICKERING

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination does not cover specific courses, but the general attainments of the students in their systematic work throughout the first two years.

UNDERGRADUATE SUBJECTS

H. 1 a, b, c. Ancient and Medieval History. 5 units (3-0-2); first, second and third terms.

Lectures and discussions upon the early civilizations out of which modern Europe developed, and upon the institutions of the Middle Ages. The students are referred to original sources in the library. In connection with this course, Freshmen are expected to attend a performance of the classical play presented in the fall term, and to make one visit to the Huntington Collections.

Instructors: Craig, Untereiner.

H. 2 a, b, c. Modern European History. 6 units (2-0-4); first, second and third terms.

Prerequisites: H. 1 a, b, c.

The general political and social history of Europe from 1789 to 1938, presented as the background and development of movements underlying present conditions.

Instructors: Guedalla, Munro, Sterling.

H. 5 a, b. Current Topics. 2 units (1-0-1); first and second terms.

This course is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion.

Instructor: Pickering (with lectures by other members of the Division of Humanities).

H. 10. The Constitution of the United States. 2 units (1-0-1); third term.

A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.

Instructor: Munro.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. Seminar in History and Government. 9 units (1-0-8); first, second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

First term: Recent American History.
In charge: Nevins.

Second term: The Industrial Revolution.
In charge: Gay.

Third term: English History in the Nineteenth Century.
In charge: Davies.

ECONOMICS

PROFESSOR: GRAHAM A. LAING
ASSOCIATE: EDWIN F. GAY
LECTURER: ARCHIBALD B. YOUNG
ASSOCIATE PROFESSORS: HORACE N. GILBERT, RAY E. UNTEREINER
ASSISTANT PROFESSOR: PHILIP S. FOGG

The subjects in this group have the twofold purpose of giving the student an insight into fundamental economic principles, and of acquainting him with some of the aspects of the practical operation of business enterprises. They furnish the important connecting link between the technical engineer and the man of affairs.

UNDERGRADUATE SUBJECTS

Ec. 2. General Economics and Economic Problems. 10 units (4-0-6); second or third term.

The purpose of this course is to describe in as great detail as possible the economic life of the community. It includes a study of production, distribution, and exchange of goods, the nature of money and credit, the development of economic institutions, and an analysis of a number of pressing economic problems. The course is given in the second and again in the third term.

Instructors: Laing, Fogg, Gilbert, Untereiner, with occasional lectures by Gay.

Ec. 17. Accounting. 9 units (3-0-6); first, second or third term. Open only to engineering students in their Junior year.

This is a course in the interpretation of the financial statements with which engineering students who enter business will come in contact. A description of bookkeeping methods is presented, but not in sufficient detail to enable the average student to keep a set of business books. Emphasis is placed upon the study of actual business problems involving the executive interpretation of accounting reports. A liberal amount of descriptive material regarding business activities accompanies the instruction.

Text: *Accounting*, Porter and Fiske.

Instructor: Fogg.

Ec. 20. Financial Organization. 8 units (3-0-5); first term.

Prerequisites: Ec. 2 or 5.

A general study of the financial organization of society. The course includes a study of the following topics: Principles of money; nature and functions of credit; the varieties of credit instruments; the marketing of low and high grade securities; the functions of the corporation and the stock exchange as capital-raising devices; the development of the banking system and the general principles of banking, including studies of commercial banking, the national banking system, and the Federal Reserve system.

Instructor: Laing.

Ec. 25. Business Law. 6 units (3-0-3); first term.

The principles of law as applied to business affairs; a study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability.

Instructor: Young.

Ec. 34. Corporation Finance. 8 units (2-0-6); first term.

Corporation promotion; the issue and payment of securities; underwriting; the sale of speculative securities. Discussion of the principles of capitalization, the management of corporate income, and the relation of dividend to income. Financial problems of expansion, combination, and reconstruction of corporations.

Instructor: Laing.

Ec. 45 a, b. Seminar in Social and Economic Organization. 4 units (2-0-2); third term.

This course consists in weekly lectures and discussions of the development of economic and social organization from a broad standpoint, and includes consideration of such subjects as primitive economic and political groupings and methods, development of gild and feudal systems, evolution of the competitive and quasi-competitive systems in economic life and democratic organization in political life. A considerable amount of outside reading is expected from each student. The class meets once a week for two hours, the first being devoted to lecture and the second to discussion of the problems treated in the lecture. The number of students is limited and the seminar is open to juniors and seniors. The seminar meets on Thursday evenings at the home of Professor Laing.

In charge: Laing.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ec. 100 a, b, c. Business Economics. 12 units (4-0-8); first, second and third terms. Open to graduate students.

This course endeavors to bridge the gap between engineering and business. It is intended for students in applied science and technology who wish to use their technical training as an approach to the administrative side of business and industry.

The course includes, in brief (a) a description of business and industry, and (b) a consideration of principles of business economics which are relevant to the fields of interest of engineers and applied scientists. The principal subjects treated are (1) business organization, (2) industrial promotion and finance, (3) factory problems, and (4) the marketing of industrial goods. An introduction is given to industrial statistics and accounting. Students are made familiar with the operations of the Federal Reserve system and with various other significant subjects in business economics. Several industries are studied in detail as to the nature of their particular economic problems and as to the actual companies operating in them. The case method of instruction developed by the Harvard Graduate Business School is employed to a considerable extent throughout the course.

Texts: *Introduction to Business,* Gilbert and Gragg; *Modern Economic Society,* Slichter.

Instructor: Gilbert.

Ec. 106 a, b, c. Business Economics Seminar. Units to be arranged; first, second and third terms. Open to graduate students.

Special studies of current economic problems are presented by the instructor, after which an open discussion is held. Emphasis is placed on the materials of economic science, i.e., statistics of production, consumption, prices, banking and finance, etc. These quantitative studies are accompanied, where advisable, by reference to economic doctrine.

In charge: Gilbert.

PHILOSOPHY, ETHICS AND SOCIOLOGY

PROFESSORS: THEODORE G. SOARES, GRAHAM A. LAING

UNDERGRADUATE SUBJECTS

Pl. 1. Introduction to Philosophy. 9 units (3-0-6); first and second terms.
An endeavor to see how the most fundamental questions have been answered by typical thinkers in the past, and how the modern student may arrive at a philosophy.
Texts: First term, *Types of Philosophy,* Hocking; second term, *First Adventures in Philosophy,* Ferm.
Instructor: Soares.

Pl. 4. Ethics. 9 units (3-0-6); third term.
The fundamental ethical concepts and theories that have emerged in the process of human thought. The major social problems of modern life.
Texts: *A Critical Introduction to Ethics,* Wheelwright; *Readings in Ethics,* Clark and Smith.
Instructor: Soares.

Pl. 5. Sociology. 9 units (3-0-6); first term.
The genesis and evolution of human society. The influence of economic, religious and social forces. The nature of social control and the analysis of mores, morals and legal codes. The development of social institutions and the nature of change in these institutions.
The class is conducted as a discussion group.
Instructor: Laing.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl. 100. A Study of Some Aspects of Philosophical, Ethical or Social Development. 9 units; first, second and third terms.
Instructor: Soares.

DIVISION OF PHYSICAL EDUCATION

PHYSICAL DIRECTOR: WILLIAM L. STANTON
ASSISTANT DIRECTOR AND MANAGER OF ATHLETICS: HAROLD Z. MUSSELMAN
CONSULTING PHYSICIAN: DR. E. D. KREMERS
PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

PE. 1, 2, 3, 4. Physical Education. First, second and third terms.

All undergraduate students are required to participate either in the intramural or intercollegiate sports on which the physical education program is based. The intramural sports comprise competition between student houses, classes and clubs, in all sports, including football, cross-country running, track and field events, baseball, basketball, swimming, boxing, wrestling, tennis, handball, etc., and is required of all students not taking part in intercollegiate sports. Representative freshmen and varsity teams in the major sports are developed and trained by experienced coaches. Fair-spirited and clean-cut athletic competition is encouraged for its social and physical values, and as a foundation for genuine college spirit. During the freshman and sophomore years, all students are given physical strength and skill tests in the first and third terms. These tests are used as a basis of comparison with other men of the same weight and height. Corrective or special exercises are prescribed for those who cannot compete in intramural or intercollegiate sports.

DEGREES CONFERRED, JUNE 11, 1937

Doctor of Philosophy

Charles Kirkwood Alexander, A.B., Oberlin College
David Fulmer Bender, B.S., and M.S., California Institute
Richard Theobold Brice, B.S., and M.S., Emory University
William Gilbert Clark, B.A., University of Texas
Robert Alma Clarke, B.S., and M.S., Brigham Young University
Francis Hettinger Clauser, B.S., and M.S., California Institute
Milton Ure Clauser, B.S., and M.S., California Institute
William Maurice Cogen, B.S., and M.S., California Institute
Kenneth Carl Crumrine, A.B., and A.M., Kansas University
Lewis Alexander Delsasso, A.B., University of California at Los Angeles
Raymond Howard Griest, B.S., and M.S., California Institute
Paul Frederick Hawley, B.S., University of Arizona; M.S., California Institute
Arthur Hemmendinger, B.A., Cornell University
Donald Holmes Hyers, A.B., and M.A., University of California at Los Angeles
Vincent Cooper Kelley, B.A., University of California at Los Angeles; M.S., California Institute
Luis Emmett Kemnitzer, A.B., Stanford University; M.S., California Institute
Paul Eugene Lloyd, A.B., Stanford University
James Wilson McRae, B.App. Sc., University of British Columbia; M.S., California Institute
H. David Michener, B.S., California Institute
Carl F. J. Overhage, B.S., and M.S., California Institute
Edwin Woolman Paxson, B.S., California Institute
William Clement Putnam, A.B., and A.M., Stanford University
John Russell Schultz, A.B., University of Illinois; M.S., Northwestern University
James Harold Wayland, B.S., University of Idaho; M.S., California Institute
Robert Wallace Webb, A.B., University of California at Los Angeles; M.S., California Institute
Hung Chang Yin, B.S., Nankai University

Master of Science in Science

PHYSICS

Robert Adolph Becker, B.S., College of Puget Sound
Foster Clyde Bennett, B.S., University of Illinois
Donald Kennedy Coles, B.S., Illinois Wesleyan University
Roderic Charles Davis, B.A., Earlham College
Engle Ellis, B.S., Texas Christian University
Bruce Lathan Hicks, B.S., California Institute
Charles B. Jordan, B.S., California Institute
William Burdette McLean, B.S., California Institute
Nash Hugh Miller, A.B., Hardin-Simmons University
John Sargent Rinehart, B.S., and A.B., Northeast Missouri State Teachers College
Ellis William Shuler, Jr., B.S., Southern Methodist University
Thomas Foster Strong, B.S., University of Wisconsin
Martin Summerfield, B.S., Brooklyn College
Harold Forbes Wiley, B.A., Denison University

CHEMISTRY

Charles Ward Best, B.S., California Institute
Harry Lotzkar, B.A., and M.A., University of British Columbia

CHEMICAL ENGINEERING

Theodore Vermeulen, B.S., California Institute

GEOLOGY AND PALEONTOLOGY

Robert Pearne Bryson, A.B., University of California at Los Angeles
Harry Victor Church, Jr., B.A., Carleton College
Charles Alexander Dawson, Jr., B.S., California Institute
Robert Marx Dreyer, B.S., Northwestern University
William Morris Fiedler B.A., Carleton College
Willard Dickison Pye, A.B., Oberlin College
Walter Stanley White, A.B., Harvard College

Master of Science in Engineering

ELECTRICAL ENGINEERING

Lawrence William H. Baldwin, B.S., California Institute
Anthony Easton, B.S., University of Washington
George Floyd Francis, B.S., University of Nevada
Ross Lowell Hand, B.S., California Institute
Arthur Elliott Harrison, B.S., University of California
Paul F. Jones, B.S., University of New Mexico
Harold Leon Levinton, B.S., Massachusetts Institute of Technology
Conrad Roeben Muller, B.S., California Institute
Wasson Walter Nestler, B.S., California Institute
Peter Hines Wyckoff, B.S., Carnegie Institute of Technology

MECHANICAL ENGINEERING

Willard Newton Bell, B.A., University of Texas
Irving Berler, B.S., New York University
Roland Anthony Budenholzer, B.S., New Mexico State College of Agriculture and Mechanical Arts
John Kenneth Bussey, B.S., University of California
Wesley Theodore Butterworth, B.S., Northwestern University
Ju-Yung Cheng, Ae.E., New York University
James Wallace Daily, A.B., Stanford University
E. Paul DeGarmo, B.S., University of Washington
Holley Buckingham Dickinson, B.S., California Institute
Melville Arthur Dike, B.S., Northwestern University
Louis Gerhardus Dunn, B.S., California Institute
John Christopher Dykes, B.A., Cambridge University
Minor Louis Fahrmann, B.S., California Institute
Hsu-Tsi Fan, Eng. in M.E., Harbin Polytechnic Institute
Robert Bethel Johnston, B.S., University of Utah
Hisayuki Kurihara, B.S., California Institute

George Rolland Mellinger, B.A., Drake University
John Lloyd Nollan, B.S., California Institute
Robert Sorg Schairer, B.S., Swarthmore College
Apollo Milton Olin Smith, B.S., California Institute
Jean Wylie, A.B., Princeton University
Shao-Wen Yuan, B.S., University of Michigan

CIVIL ENGINEERING

Harold John Alwart, B.S., Northwestern University
Raymond Hudson Ferris Boothe, B.S., California Institute
Alfred Culver Buxton, B.S., University of Southern California
William John Ellison, Jr., B.S., Georgia School of Technology
Vernon Arthur Charles Gevecker, B.S., Missouri School of Mines
Henry John Goodwin, B.S., California Institute
Ray Jensen, B.S., California Institute
Samuel Lloyd Lipson, B.App.Sc., University of British Columbia
Alfred E. Munier, C.E., Rensselaer Polytechnic Institute
Abdurrahim Servet, B.S., University of Michigan
Erling Sanborn Walseth, B.S., South Dakota State College

AERONAUTICS

Walter Henry Albach, Lieut. U.S.N., B.S., United States Naval Academy
Frederick Hamilton Allardt, B.S., and M.S. in M.E., California Institute
Robert M. Losey, First Lieut. U.S.A., B.S., United States Military Academy, M.S. in Meteorology, California Institute
Shirley Snow Miller, Lieut. U.S.N., B.S., United States Naval Academy
Charles Kenneth Moore, B.S., University of Illinois
Joseph Nathaniel Murphy, Lieut. U.S.N., B.S., United States Naval Academy
Joe Nelson Smith, Capt. U. S. Marine Corps, United States Naval Academy
Bradley Hobart Young, B.S., and M.S. in M.E., California Institute

METEOROLOGY

Milton Wylie Arnold, First Lieut. U.S.A., B.S., United States Military Academy
Arthur C. W. Baskin, Lieut. U.S.N., B.S., United States Naval Academy
Frederick Aroyce Berry, Jr., Lieut. U.S.N., B.S., United States Naval Academy
Theodore M. Bolen, First Lieut., U.S.A., United States Military Academy
Robert Dunshee Elliott, B.S., California Institute
Donald Philip Graul, First Lieut. U.S.A., B.S., United States Military Academy
Dale R. Harris, B.S., University of Washington
Jack Maginnis, Lieut. U.S.N., B.S., United States Naval Academy
Robert G. H. Meyer, First Lieut. U.S.A., B.S., United States Military Academy; M.S., Yale University
Raymond H. Odell, B.Aero.E., University of Minnesota
H. Dean Parry, A.B., Brigham Young University
Eugene Howard Quinn, A.B., University of California at Los Angeles
Herbert Barnett Shapiro, B.S., California Institute
Sam Houston Wiseman, First Lieut. U.S.A., B.S., United States Military Academy

Bachelor of Science

SCIENCE

Joseph Meyer Axelrod
Thomas Russell Belzer
John Blue
Stanford Briggs
Thomas Robert Burnight
Elmer Joseph Dauben
Don Charles DeVault
Bruce W. Dunbar
John Stevenson Edwards, Jr.
*‡Charles F. Gates
John Wesley George
Richard Rohrer Goodell
‡Alan John Grobecker
‡Thomas Sinclair Harper
John Burton Hatcher
‡Boyd Richard Hopkins
George Henry Horne, Jr.
Leon Horovitz
*Robert Caldwell Jones
John Allan Legge, Jr.
Robert Bruce Lockwood
Harry Heyburn Miller
Donald Charles Nellis
Dean Nichols
Claude Byron Nolte
Richard Emil Offeman
Noel Robertson Park
David Pressman
‡Edward Thomas Price, Jr.
Fremont Fisher Radcliffe
T. Robert Sandberg
Leonard Frederick Schombel
Thomas Newton Shaw
Charles Wilcox Sheppard
Joe Mauk Smith
Luther Payne Spalding
Meyer Joseph Test
Vsevolod Tulagin
Charles Cramer Woolsey
William Dickinson Yale

ENGINEERING

*‡Irving Louis Ashkenas
Alfred Dudley Auger
John Reynolds Austen
Hoyt Austin
Jay Richard Bailey
Ralph Stahlnaker Benton, Jr.
‡Gordon Lucas Bussard
Robert Samuel Campbell
*Harry Hall Carrick
George Edward Carroll
Ellsworth William Cornwall
Frederic Eugene Dion
George Martin Dorwart
William P. Ellery
Virgil Erickson
Ted Fahrner
Willard Farnham
Warren Emanuele Fenzi
I. Stanley Feuer
Lawrence Thomas Fleming
Holloway Halstead Frost
‡Daniel Lauder Gerlough
*LeVan Griffis
Charles Franklin Hadley
‡Edward James Horkey
Carl Burdett Johnson
Owen Champlin Johnson
Vincent Knowles Jones, Jr.
Dorr Kimball
John Cary Kinley

*Graduated with honor in accordance with a vote of the Faculty.
‡Awarded the Honor Key by the Associated Student Body for participation in student activities.

Carl Elmer Larson
Jasper Ridgely Leggett
Eustace Arden Lycett
Ethan St. Clair MacMichael
‡Robert Matthew Mahoney
‡George Edward Mann, Jr.
Winthrop Gilman McSparran
‡Wendell Bower Miller
Charles Smyth Milliken
Ernest Moncrief
Walter Leon Moore
Bruce Fitzgerald Morgan
Noble M. Nojima
Noel LeGrande Owen, Jr.
William Lee Penn, Jr.
Joseph James Peterson
Martin Joseph Poggi
Frank A. Rechif
‡Richard Lee Ridgway
Douglas Keesee Rollow
Paul Corwin Schaffner
Daniel Schuman
James Ray Seaman, Jr.
John Peter Selberg
Herbert Ramsey Sheppard
Harold Lewis Smith
Wilbur Fisher Snelling
William Valentine Stackhouse
John Sullwold, II
Donald Spenser Teague, Jr.
*Robert Dawson Townsend, Jr.
George Yoshio Tsubota
Jay Boreas Van Der Werff
Bernard W. Walley
Hugh Francisco Warner
‡Martin Haskell Webster
‡William Owen Wetmore
Walter George Wheeler
Clark Hamilton Wiget
Edward Earl Wileman
Eldon Emerson Wright
W. Gordon Wylie
‡Albert Herman Zimmerman

*Graduated with honor in accordance with a vote of the Faculty.
‡Awarded the Honor Key by the Associated Student Body for participation in student activities.

UNDERGRADUATE SCHOLARSHIPS, 1937-38

JUNIOR SCHOLARS:

G. Asakawa
R. H. Bishop
C. F. Carstarphen
P. S. Devirian
A. P. Green
K. G. Macleish
C. D. Mills, Jr.
M. M. Mills
E. J. Pinney
L. J. Rainwater
Sylvan Rubin
R. W. White

CHARLES L. DENISON JUNIOR SCHOLAR:

George O. Crozier

DRAKE SOPHOMORE SCHOLAR:

W. B. Scarborough

SOPHOMORE SCHOLARS:

Leo Brewer
W. E. Brown
F. G. Brunner
Leo Davis
R. W. Grigg
J. T. Harlan
W. D. Hayes
J. Kohl
D. E. Loeffler
P. A. Longwell
J. F. Manildi
L. W. Merryfield
H. S. Mickley
D. E. Nagle
J. M. Richardson
R. D. F. Thompson
G. J. Todd
E. P. Wald

HARRIET HARVEY FRESHMAN SCHOLAR:

Robert Hall, Alameda High School

WALTER HUMPHRY FRESHMAN SCHOLAR:

Robert Buss, Centerville, Iowa, High School

BLACKER FRESHMAN SCHOLARS:

Charles Mallory Buchzik, North Hollywood High School
Donald Edwin Dawson, Pasadena Junior College
Paul Stephen Farrington, Shortridge High School, Indianapolis, Indiana
Robert Edwin Fisher, Los Angeles High School
Frank Andrew Fleck, Technical High School, Memphis, Tennessee
Berl Dave Levenson, Los Angeles High School
Stanley John Mitchell, Alhambra City High School
John Gilbert Small, San Rafael High School
Clyde Adolph Wahrhaftig, Fresno High School
Roger William Wallace, Oak Park and River Forest Township High School, Oak Park, Illinois

DRAKE FRESHMAN SCHOLARS:

Wayne Gordon Abraham, Kearnsey College, Natal, South Africa
John Howland Barber, Philips Exeter Academy, Exeter, New Hampshire
Stanley Stroud, Fillmore High School

INSTITUTE FRESHMAN SCHOLARS:

Robert H. Harris, Fairview High School, Dayton, Ohio
Thomas Jason Hassard, Sweetwater Union High School, National City

GRADUATE STUDENTS

Abbreviations: Eng., Engineering; Sci., Science; A.Ch., Applied Chemistry; AE, Aeronautical Engineering; A.Ph., Applied Physics; Ay, Astronomy; Bi, Biology; CE, Civil Engineering; Ch., Chemistry; Ch.E., Chemical Engineering; EE, Electrical Engineering; Ge, Geology; Ma, Mathematics; ME, Mechanical Engineering; My, Meteorology; Ph, Physics.

(†) following a student's name indicates that he has been admitted to candidacy for the degree of Doctor of Philosophy.

Name	Major Subject	Home Address
Ackerman, John Bevier B.S., United States Military Academy, 1932	My	Munnsville, New York
Ackermann, Hermann August Diploma, Technische Hochschule Fridericiana, Karlsruhe, 1923	Ge	Zurich, Switzerland
Addicott, Fredrick Taylor A.B., Stanford University, 1934	Bi	Palo Alto
Albrecht, Gustav Alexander M.A., University of California at Los Angeles, 1936	Ch	Van Nuys
Alsaker, Allan Kallan Northwestern University, 1932-1936	EE	Chicago, Illinois
Anderson, LeRoy Hagen B.S., Montana State College, 1927	Ch	Conrad, Montana
Armi, Edgar Leo Diploma, Munich Institute of Technology, 1931	Ph	Pasadena
Arnold, Hubert Andrew (†) A.B., University of Nebraska, 1933	Ma	Lincoln, Nebraska
Arnold, Lee B.A., Duke University, 1937	AE	Chicago, Illinois
Ashkenas, Irving Louis B.S., California Institute, 1937	AE	Los Angeles
Axelrod, Joseph B.S., California Institute, 1937	Ch	Los Angeles
Bailey, Howland Haskell A.B., Haverford College, 1932	Ph	Hyde Park, Massachusetts
Baldwin, Lawrence William B.S., California Institute, 1935; M.S., 1937	EE	Kansas City, Missouri
Baumgarten, Werner Diploma, University of Munich, 1937	Ch	Pasadena
Becker, Robert Adolph B.S., College of Puget Sound, 1935; M.S., California Institute, 1937	Ph	Tacoma, Washington
Beeson, Carrol Menefee (†) A.B., University of California at Los Angeles, 1935	Ch	Los Angeles
Bell, Willard Newton B.A., University of Texas, 1935; M.S., California Institute, 1937	AE	Fort Worth, Texas
Bergren, William Raymond (†) B.S., California Institute, 1932	Bi	Pasadena
Berler, Irving B.S., New York University, 1936; M.S., California Institute, 1937	AE	New York, New York
Bevan, Thomas Judson B.S., University of Chicago, 1936	Ph	New Holland, Illinois
Bonell, John Arthur B.S., South Dakota State College, 1936	CE	Brookings, South Dakota
Bonner, David Mahlon B.A., University of Utah, 1936	Bi	Salt Lake City, Utah
Bradner, Hugh A.B., Miami University, 1936	Ph	Hamilton, Ohio
Brunner, Eugene Mittell (†) B.S., California Institute, 1933; M.S., 1934	Ph	Santa Paula

Name	Major Subject	Home Address
Bruyere, Richard Newbold	Ph	Houston, Texas
B.A., Texas Christian University, 1936		
Bryson, Robert Pearne	Ge	Los Angeles
A.B., University of California at Los Angeles, 1934; M.S., California Institute, 1937		
Budenholzer, Roland Anthony	ME	Belen, New Mexico
B.S., New Mexico State College, 1935; M.S., California Institute, 1937		
Burcik, Emil Joseph	Ch	Pittsburgh, Pennsylvania
B.S., Carnegie Institute of Technology, 1937		
Bussey, John Kenneth	AE	Los Angeles
B.S., University of California, 1935; M.S., California Institute, 1937		
Butterworth, Wesley Theodore	AE	Evanston, Illinois
B.S., Northwestern University, 1936; M.S., California Institute, 1937		
Byrne, Ralph Edward, Jr.	CE	Pasadena
B.S., California Institute, 1933; M.S., 1934		
Carroll, George Edward	CE	Los Angeles
B.S., California Institute, 1937		
Chen, Shang Yi	Ph	Peiping, China
B.S., Yenching University, 1932; M.S., 1934		
Cheng, Shui-Chou	EE	Shanghai, China
Diploma, Harbin Polytechnic Institute, 1935		
Christensen, John Whittaker	Ph	Cedar City, Utah
B.S., University of Utah, 1937		
Chu, Djen-Yuen (†)	Ph	Nanking, China
B.S., National Central University, Nanking, 1924; M.S., California Institute, 1936		
Claflin, Waldo Milton	AE	Philadelphia, Pennsylvania
B.S.E., Princeton University, 1934		
Coles, Donald Kennedy (†)	Ph	North Vancouver, British Columbia
B.S., Illinois Wesleyan University, 1932; M.S., California Institute, 1937		
Curry, Harry Donald (†)	Ge	Tulare
B.A., State University of Iowa, 1929; M.S., 1930		
Daily, James Wallace	ME	South Gate
A.B., Stanford University, 1935; M.S., California Institute, 1937		
Davis, Leverett, Jr.	Ph	Susanville, Oregon
B.S., Oregon State College, 1936		
Davis, Roderic Charles	Ma	Richmond, Indiana
B.A., Earlham College, 1936; M.S., California Institute, 1937		
Dekker, Albert Orno (†)	Ch	Glendale
B.S., California Institute, 1935		
DeLong, James Henry, Jr.	Ge	Easton, Pennsylvania
A.B., Lafayette College, 1937		
Dery, Robert John	Ch	Eugene, Oregon
B.S., University of Oregon, 1931		
Dewees, Norman Branson	ME	San Gabriel
B.S., California Institute, 1935		
Dike, Melville Arthur	ME	Evanston, Illinois
B.S., Northwestern University, 1936; M.S., California Institute, 1937		
Dilworth, Robert Palmer	Ma	Hemet
B.S., California Institute, 1936		
Doescher, Russell Nimtz	Ch	Santa Monica
B.S., California Institute, 1933; M.S., 1934		
Doll, Edward Bushnell (†)	EE	Los Angeles
B.S., California Institute, 1934; M.S., 1935		
Doolittle, Russell Carter	Ge	Houston, Texas
A.B., Princeton University, 1935		
Dorwart, George Martin	CE	Pasadena
B.S., California Institute, 1937		
Drescher, Arthur Bernard	Ge	Elmhurst, Illinois
B.S., South Dakota School of Mines, 1937		

Name	Major Subject	Home Address
Dreyer, Robert Marx (†)	Ge	Chicago, Illinois
B.S., Northwestern University, 1934; M.S., California Institute, 1937		
Dunn, Louis Gerhardus	AE	Ermelo, Transvaal, South Africa
B.S., California Institute, 1936; M.S., 1937		
Dykes, John Christopher	AE	Cambridge, England
B.A., Cambridge University, 1936; M.S., California Institute, 1937		
Easton, Anthony	Ph	Seattle, Washington
B.S., University of Washington, 1932; M.S., California Institute, 1937		
Eichelberger, Alexis Martin, Jr.	EE	Beverly Hills
A.B., University of California at Los Angeles, 1937		
Elliott, Norman (†)	Ch	Glendora
B.A., Oberlin College, 1929; M.A., 1930		
Evans, Harry Dean	Ch.E.	Champaign, Illinois
B.S., University of Illinois, 1937		
Eyster, Eugene Henderson (†)	Ch	Wheaton, Minnesota
B.Ch., University of Minnesota, 1935		
Fan, Hsu Tsi	AE	Tientsin, China
Eng. in M.E., Harbin Polytechnic Institute, 1935; M.S., California Institute, 1937		
Farnham, Duane Wesley	AE	Alamosa, Colorado
B.S., United States Naval Academy, 1930		
Farquhar, John Percival	Ch	Pasadena
B.S., Harvard College, 1935		
Feuer, Irwin Stanley	ME	Hollywood
B.S., California Institute, 1937		
Feustel, Robert Griffiths	Ph	Winnetka, Illinois
B.S., Northwestern University, 1937		
Fine, Paul Charles (†)	Ph	Idabel, Oklahoma
B.A., University of Oklahoma, 1935; M.S., California Institute, 1936		
Foster, Mark Gardner	Ph	Oxford, Ohio
A.B., Miami University, 1935		
Fox, Sidney Walter	Bi	Los Angeles
A.B., University of California at Los Angeles, 1933		
Fuetsch, Frederic Theodore	AE	Reno, Nevada
B.S., University of Nevada, 1934		
Gardner, Edward Markham	EE	Elizabeth, New Jersey
B.S., University of London, 1923		
Garner, Clifford Symes (†)	Ch	Pasadena
B.S., California Institute, 1935		
Gates, Charles Fredrick	EE	Los Angeles
B.S., California Institute, 1937		
Gephart, Harry Lane	AE	Silver City, New Mexico
B.S., New Mexico State Teachers College, 1937		
Gershzohn, Morris	My	New York, New York
B.S., Brooklyn College, 1937		
Geselbracht, Willis George	ME	Glendale
B.S., Washington University, 1937		
Glenn, William Holt, Jr.	Ma.	Glendale
A.B., University of California at Los Angeles, 1935; M.A., 1937		
Goering, Kenneth Justin	Ch	Bozeman, Montana
B.S., Montana State College, 1936		
Gongwer, Calvin Andrew	AE	Guntersville Dam, Alabama
B.S., Columbia University, 1937		
Goodell, Richard Rohrer	Ph	Puente
B.S., California Institute, 1937		
Goodman, Hyman	My	Chicago, Illinois
B.S., University of Illinois, 1933		
Gould, Martin James	Ge	Houston, Texas
B.A., Rice Institute, 1935; M.A., 1936		

Name	Major Subject	Home Address
Gould, Wendell Oliver B.S. and M.S., Washington State College, 1930	Ph	Pullman, Washington
Green, William Jeffrey B.A., University of Manitoba, 1937	My	Fort William, Ontario, Canada
Greenwood, Marvin Henderson B.S., Rice Institute, 1937	AE	Houston, Texas
Griffis, LeVan B.S., California Institute, 1937	CE	Berkeley
Gringorten, Isaac B.A., University of Toronto, 1935; M.A., 1936	My	Toronto, Ontario, Canada
Gullekson, Ellsworth Eugene B.S., University of North Dakota, 1937	Ch.E.	Beltrami, Minnesota
Gutierrez, Arnulfo Gomez B.S., National University of Mexico, 1936	EE	Mexico City, Mexico
Hadley, Charles Franklin B.S., California Institute, 1937	EE	Redlands
Hall, Newman Arnold (†) A.B., Marietta College, 1934	Ma	Marietta, Ohio
Harris, Franklin Stewart, Jr. A.B., Brigham Young University, 1931; M.A., 1936	Ph	Provo, Utah
Harrison, Arthur Elliot B.S., University of California, 1936; M.S., California Institute, 1937	EE	Berkeley
Hatcher, John Burton B.S., California Institute, 1937	Ch	Pasadena
Heegaard, Erik Vilhelm B.S., Royal Technical College of Copenhagen, 1936	Ch	Pasadena
Helfer, Robert George B.S., Baldwin-Wallace College, 1936	Bi	Cleveland, Ohio
Henshaw, Paul Carrington A.B., Harvard College, 1936	Ge	Rye, New York
Hepner, Franklin Ross B.A., University of Wyoming, 1937	Ch	Laramie, Wyoming
Hicks, Bruce Lathan (†) B.S., California Institute, 1936; M.S., 1937	Ph	Pasadena
Hinds, John Francis B.A., Queen's University, 1935; M.A., 1936	Ph	Orillia, Ontario, Canada
Hlynka, Isydore B.Sc., University of Alberta, 1935; M.Sc., 1937	Bi	Edmonton, Canada
Holzman, Benjamin (†) B.S., California Institute, 1931; M.S., 1933	My	Washington, D. C.
Hopper, Richard H. (†) A.B., University of California at Los Angeles, 1935; M.A., 1936	Ge	Los Angeles
Horkey, Edward James B.S., California Institute, 1937	AE	La Canada
Horowitz, Norman Harold B.S., University of Pittsburgh, 1936	Bi	Pittsburgh, Pennsylvania
Hoy, Robert Beck A.B.S., Lafayette College, 1937	Ge	Easton, Pennsylvania
Hsueh, Chao-Wang B.S., National University of Peking, 1931	Ph	Shantung, China
Hughey, Albert Hall B.S., Purdue University, 1934	AE	Allentown, Pennsylvania
Ives, Philip Truman (†) B.A., Amherst College, 1932; M.A., 1934	Bi	Amherst, Massachusetts
Jack, Samuel Sloan B.S., United States Naval Academy, 1927	AE	Glendale, Arizona
Jahns, Richard Henry B.S., California Institute, 1935; M.S., Northwestern University, 1937	Ge	Alhambra

Name	Major Subject	Home Address
Jennings, Stephen B.S., Trinity College, 1936	Ph	Hartford, Connecticut
Jetter, Ulrich Diploma, Technische Hochschule, Stuttgart, 1937	Ph	Stuttgart, Germany
Johnson, Kenneth D. B.S., Emmanuel Missionary College, 1932	Ch	Los Angeles
Jordan, Charles Borromeo B.S., California Institute, 1936; M.S., 1937	Ph	Los Angeles
Kanemitsu, Sunao B.S., University of California, 1937	AE	Artesia
Koch, Walter Louis Diploma, Technische Hochschule, Hannover, 1936	AE	Bremen, Germany
Kruse, Henry Oscar B.A., University of Cincinnati, 1937	My	Cincinnati, Ohio
Ku, Gong-Gyiu B.S., La Universitato Utopia, Shanghai, 1929; M.S., Colorado School of Mines, 1936	Ge	Shanghai, China
Kuo, I. Cheng B.S., National University of Peking, 1928	Ph	Peiping, China
Kurihara, Hisayuki B.S., California Institute, 1936; M.S., 1937	AE	Pasadena
Kyropoulos, Peter Rudolf Diploma, Kaiser Wilhelm II Realgymnasium, Gottingen, 1934	AE	Pasadena
Lake, George Ryder B.S., University of Texas, 1929; M.A., 1933	Ch	Long Beach
Langmuir, Robert Vose (†) A.B., Harvard College, 1935	Ph	Englewood, New Jersey
LaSalle, Joseph Pierre B.S., Louisiana State University, 1937	Ph	Baton Rouge, Louisiana
Lauritsen, Thomas (†) B.S., California Institute, 1936	Ph	Pasadena
Leggett, Jasper Ridgely B.S., California Institute, 1937	EE	Los Angeles
Levy, Henri Arthur (†) B.S., California Institute, 1935	Ch	Oxnard
Lewis, Glenn Harry B.S., California Institute, 1936	EE	Payette, Idaho
Liang, Carr Chia-Chang B.Sc., Catholic University of Peiping, 1937	ME	Peiping, China
Lilleland, Ole B.S., University of California, 1922	Bi	South Pasadena
Lindstrom, William Julius M.E., Rensselaer Polytechnic Institute, 1935	My	Georgetown, Connecticut
Lombard, Albert Eaton, Jr. B.S., California Institute, 1928; M.S., 1929	AE	Ferguson, Missouri
LuValle, James Ellis A.B., University of California at Los Angeles, 1936; M.A., 1937	Ch	Los Angeles
MacKnight, Robert Harlan B.A., Columbia University, 1936	Bi	New York, New York
MacPhail, Donald Campbell B.A., University of British Columbia, 1937	ME	Vancouver, British Columbia Canada
Mann, George Edward, Jr. B.S., California Institute, 1937	AE	El Centro
Marmont, George Heinemann B.S., California Institute, 1934	Bi	Hollywood
McCann, Gilbert Donald B.S., California Institute, 1934; M.S., 1935	EE	Pasadena
McIntyre, Robert Alfred B.S., California Institute, 1936	ME	Martinez

Name	Major Subject	Home Address
McLean, William Burdette (†) B.S., California Institute, 1935; M.S., 1937	Ph	Santa Barbara
McLeish, Charles William B.A., University of British Columbia, 1937	EE	Vancouver, British Columbia, Canada
McMaster, Robert Charles B.S., Carnegie Institute of Technology, 1936	EE	Wilkinsburg, Pennsylvania
McRary, Willard Lee, Jr. B.S., California Institute, 1936	Bi	Los Angeles
Mechling, Wallace Bristol B.S., United States Naval Academy, 1927	AE	Arlington, Virginia
Mellinger, George Rolland B.A., Drake University, 1936; M.S., California Institute, 1937	AE	Waseca, Minnesota
Meredith, Edward Clopton B.S., University of Alabama, 1928	My	Pasadena
Miller, Dwight Dana B.A., Whittier College, 1937	Bi	Whittier
Miller, Park Hays, Jr. B.S., Haverford College, 1936	Ph	Drexel Hill, Pennsylvania
Milliken, Charles Smyth B.S., California Institute, 1937	EE	Pasadena
Moore, Walter Leon B.S., California Institute, 1937	CE	Pasadena
Moorman, Thomas Samuel B.S., United States Military Academy, 1933	My	Altadena
Morgan, Bruce Fitzgerald B.S., California Institute, 1937	EE	Seattle, Washington
Morse, Charles Adelbert B.S., California Institute, 1936	CE	Los Angeles
Muller, Conrad Roeben B.S., California Institute, 1936; M.S., 1937	EE	Portland, Oregon
Nellis, Donald Charles B.S., California Institute, 1937	Ch.E.	Burbank
Nojima, Noble B.S., California Institute, 1937	AE	Long Beach
Nollan, John Lloyd B.S., California Institute, 1936; M.S., 1937	AE	Los Angeles
Nunan, James Kneeland B.S., University of Southern California, 1936	EE	Los Angeles
Nysewander, Cecil Wright B.S., University of Illinois, 1930	Ch.E.	Whiting, Indiana
Ofsthun, Sidney Andrew B.S., United States Military Academy, 1929	My	St. Paul, Minnesota
Okun, Daniel Alexander B.S., Cooper Union Institute of Technology, 1937	CE	New York, New York
Oliver, Bernard More B.A., Stanford University, 1935; M.S., California Institute, 1936	EE	Santa Cruz
Omer, Guy Clifton, Jr. B.S., University of Kansas, 1936; M.S., 1937	Ph	Lawrence, Kansas
Oppenheimer, Frank B.A., Johns Hopkins University, 1933	Ph	New York, New York
Orr, James McPhail B.A., University of British Columbia, 1936	Ge	Nelson, British Columbia, Canada
Ortiz, Jose Pulido Diploma, National University of Mexico, 1928	CE	Mexico City, Mexico
Osborne, Darrell Wayne (†) A.B., University of California at Los Angeles, 1935	Ch	Los Angeles
Palmer, Kenneth James (†) B.S., University of California, 1935	Ch	Pasadena

Name	Major Subject	Home Address
Parrish, John Bertrand, Jr. B.S., Princeton University, 1937	AE	Richmond, Virginia
Parry, H. Dean A.B., Brigham Young University, 1934; M.S., California Institute, 1937	EE	Ogden, Utah
Pasternack, Simon B.S., University of Alberta, 1935	Ph	Calgary, Alberta, Canada
Pease, Daniel Chapin B.A., Yale University, 1936	Bi	New York, New York
Putt, Donald Leander B.S., Carnegie Institute of Technology, 1928	AE	Yakima, Washington
Reamer, Howard Hollis A.B., University of Redlands, 1937	Ph	Beaumont
Redemann, C. Ernst (†) A.B., University of California at Los Angeles, 1931	Ch	Los Angeles
Rexroad, Francis Howard B.A., Marietta College, 1937	Ch	Parkersburg, West Virginia
Rhoads, Waldon Rice A.B., University of California at Los Angeles, 1936	AE	Los Angeles
Robinson, Charles Franklin A.B., Missouri State Teachers College, 1935; B.S., Drury College, 1936	Ph	Springfield, Missouri
Ruch, Paul Elmer B.S., Massachusetts Institute of Technology, 1928	My	Akron, Ohio
Rumph, Lewis Benning, Jr. B.S., Georgia School of Technology, 1933	AE	Marshallville, Georgia
Schairer, Robert Sorg B.S., Swarthmore College, 1936; M.S., California Institute, 1937	AE	Bronxville, New York
Schoech, William Alton B.S., United States Naval Academy, 1928	AE	Washington, D. C.
Schomaker, Verner Frederick Henry (†) B.S., University of Nebraska, 1934; M.S., 1935	Ch	Nehawka, Nebraska
Schwartz, Jack William B.S., California Institute, 1935	CE	Hollywood
Scoles, Albert Buddy B.S., United States Naval Academy, 1927	AE	Washington, D. C.
Sentker, Lawrence C. B.S., University of Utah, 1937	ME	Los Angeles
Shapiro, Herbert Barnett B.S., California Institute, 1936; M.S., 1937	My	Los Angeles
Sheppard, Charles Wilcox B.S., California Institute, 1937	Ph	Coldwater, Ontario, Canada
Sklar, Maurice B.S., California Institute, 1936	Ge	Los Angeles
Smith, Apollo Milton Olen B.S., California Institute, 1936; M.S., 1937	AE	Inglewood
Smith, Harold Lester B.S., United States Military Academy, 1930	My	Washington, Pennsylvania
Smith, Jack Carlton B.E., Ohio State University, 1935; M.Sc., 1936	Ph	Akron, Ohio
Smith, Robert Beaton B.A., Ohio State University, 1936	AE	Columbus, Ohio
Snelling, Wilbur Fisher B.S., California Institute, 1937	AE	Penryn
Snow, William Eugene (†) B.A., University of British Columbia, 1935; M.A., 1936	Ge	North Vancouver, British Columbia, Canada
Stephens, William Edwards (†) B.A., Washington University, 1932; M.S., 1934	Ph	Brentwood, Missouri
Stewart, Homer Joseph B.Aero.E., University of Minnesota, 1936	AE	Minneapolis, Minnesota

Name	Major Subject	Home Address
Stewart, William Sheldon	Bi	Beverly Hills
A.B., University of California at Los Angeles, 1936; M.A., 1937		
Stone, William Sebastian	My	Riverside
B.S., United States Military Academy, 1934		
Stosick, Arthur James	Ch	Milwaukee, Wisconsin
B.S., University of Wisconsin, 1936		
Streib, John Fredrick	Ph	Pasadena
B.S., California Institute, 1936		
Summerfield, Martin	Ph	Brooklyn, New York
B.S., Brooklyn College, 1936; M.S., California Institute, 1937		
Taylor, Donald Stinson (†)	Ch	McMinnville, Oregon
B.A., Linfield College, 1935		
Taylor, Hodge Scott	Ch.E.	Chicago, Illinois
B.S., University of Illinois, 1937		
Test, Meyer Joseph	Ph	Kansas City, Missouri
B.S., California Institute, 1937		
Tomlinson, Everett Parsons	Ph	Montclair, New Jersey
B.S., Yale University, 1936		
Townes, Charles Hard	Ph	Greenville, South Carolina
B.A. and B.S., Furman University, 1935		
Townsend, Robert Dawson, Jr.	ME	Arcadia
B.S., California Institute, 1937		
Tregidga, Angus Campbell (†)	Ph	Vancouver, B. C., Canada
B.A., University of British Columbia, 1932; B.App.Sci., 1933; M.A., 1935		
Tsao, Chi-Cheng	AE	Yangchow, China
Diploma, Central Aviation School, China, 1933; California Institute, 1935-1937		
Tsien, Hsue-Shen (†)	AE	Chekiang, China
B.S., Chiao-tung University, Shanghai, 1934; M.S., Massachusetts Institute of Technology, 1936		
Tsubota, George Yoshio	AE	Riverside
B.S., California Institute, 1937		
Van Der Werff, Jay Boreas	ME	Pasadena
B.S., California Institute, 1937		
Van Ornum, Delbert George	My	Seattle, Washington
B.S., University of Washington, 1936		
Vargus, Joseph Anthony, Jr.	Ph	Elmhurst, New York
B.A., Amherst College, 1934; B.A., Cambridge University, 1936		
Voss, William Baker	Ph	St. Helens, Oregon
A.B., Willamette University, 1936		
Wagner, Warren Orval	CE	Spokane, Washington
B.S., State College of Washington, 1934; M.S., University of Michigan, 1936		
Walton, Sylvan Brooks	ME	Los Angeles
B.S., University of Southern California, 1934		
Wang, Hsih Heng	CE	Tientsin, China
C.E., Harbin Polytechnic Institute, 1935		
Wang, Tsun Kuei	AE	Shansi, China
B.S., National University of Peking, 1933		
Ware, Joseph Fulton	AE	Blacksburg, Virginia
B.S., Virginia Polytechnic Institute, 1937		
Watanabe, Kenichi	Ph	Honolulu, Hawaii
B.S., California Institute, 1936		
Weaver, Robert Lee	My	Grand Junction, Colorado
B.A., University of Colorado, 1936		
Webb, John Leyden	Bi	Altadena
B.S., California Institute, 1936		
Weir, Charles Edward	Ph	Washington, D. C.
B.S., University of Chicago, 1932; M.S., Howard University, 1934		

Name	Major Subject	Home Address
Wells, John Cawse B.S., University of Idaho, 1936	Ge	Weiser, Idaho
Wetmore, William Owen B.S., California Institute, 1937	ME	Taft
Wiancko, Thomas B.S., University of Oklahoma, 1937	Ph	Guthrie, Oklahoma
Wiggins, John Shearon A.B., Earlham College, 1936	Ph	Richmond, Indiana
Wileman, Edward Earl B.S., California Institute, 1937	AE	Fillmore
Wilson, Bruce Harry David B.Sc., University of Manitoba, 1936	Ge	Winnipeg, Manitoba, Canada
Wilson, John Norton (†) B.A., University of British Columbia, 1934; M.A., 1936	Ch	Vancouver, B. C., Canada
Winstein, Saul (†) A.B., University of California at Los Angeles, 1934; M.A., 1935	Ch	Los Angeles
Wood, Reuben Esselstyn B.S., California Institute, 1936; M.S., University of Chicago, 1937	Ch	Monrovia
Wright, Frederick Hamilton A.B., Haverford College, 1934	Ph	Washington, D. C.
Wyman, Max B.Sc., University of Alberta, 1937	Ma	Edmonton, Alberta, Canada
Yale, William Dickinson B.S., California Institute, 1937	Ch.E.	Burbank
Yuan, Luke Chia-liu B.S., Yenching University, 1932; M.S., 1934	Ph	Tientsin, China
Zumwalt, Lloyd Robert (†) B.S., University of California, 1936	Ch	Oakland

UNDERGRADUATE STUDENTS

Students whose names are starred attained honor standing during the preceding year.

SENIOR CLASS

NAME	OPTION	HOME ADDRESS
Ahlroth, Carl Wilhelm	Ge	Hollywood
Allen, Richard Harvey	Ge	San Diego
Althouse, William S.	ME	Glendale
Ambroff, Michel	ME	Los Angeles
Baker, John Raymond	ME	South Pasadena
Balsley, James Robinson	Ge	West Los Angeles
Barry, Robert Joseph	ME	Los Angeles
Beavon, David Kent	A.Ch.	Los Angeles
Bennett, Elliott Powell	CE	Pasadena
Bertness, Theodore Arnold	A.Ch	La Mesa
Bertram, Sidney	EE	Los Angeles
Boller, Harry Berthold	ME	Alhambra
Bonham, Elliott H.	ME	Pomona
Borgeson, Lawrence G.	EE	Pasadena
Brenner, William Carl	EE	Pasadena
Browne, John Jake	ME	Clovis
Cardwell, William Thomas	A.Ch	Pasadena
Carr, Robert Edgar	ME	Rosemead
Clarke, Charles William	ME	Los Angeles
Connelly, Ronald B.	EE	Huntington Park
Cowie, Roger Harrison	Ge	Minneapolis, Minnesota
Custer, Robert Stanley	A.Ch	Glendale
Davidson, Donald Douglas	A.Ch	Glendale
Davidson, Robert Craig	A.Ch	Royal Oak, Michigan
Dennis, Paul Arthur	A.Ph	Los Angeles
Dixon, Blaine Andrew	A.Ph	Glendale
Dougherty, Jack Francis	Ge	Beverly Hills
Dowd, Munson White	CE	El Centro
Downing, Arthur Clifford	ME	Glendale
DuFresne, Armand Frederick	EE	Lakeside
Ellings, Arthur Clement	A.Ch	Santa Barbara
Elliott, Bruce Cass	ME	Los Angeles
Ellis, Herbert Bailey	ME	Los Angeles
Engelder, Paul Oscar	EE	Douglas, Arizona
Evans, Henry King	CE	Santa Maria
Farneman, John D.	EE	Los Angeles
Folkins, Richard Wilson	CE	Redlands
Forward, Richard Blair	ME	Santa Barbara
Freede, William John	A.Ch	Oklahoma City, Oklahoma
Friend, Carl Frederick	AE	Los Angeles
Frisius, Edward Nathaniel	CE	Hollywood
Goff, Peter Clayton	EE	Beverly Hills
Grainger, Boyne B.	ME	Redondo Beach
Graybeal, Oran Avery, Jr.	ME	Los Angeles

NAME	OPTION	HOME ADDRESS
Gregory, Chris	Ph	Hollywood
Gross, Arthur George	AE	Beverly Hills
Harker, Ralph Wackerle, Jr.	CE	Scarsdale, New York
Harris, Clyde Winger	Ma	Lakewood, Ohio
Holmes, George B., Jr.	EE	Santa Ana
Hopkins, Henry Stuart	ME	Butte, Montana
Horine, Carlton Leon	A.Ch	Cristobal, Canal Zone
Hotz, George Marion	ME	Los Angeles
Hudson, Donald E.	ME	Pasadena
Hulbirt, Lowell Harrison	A.Ph	Glendora
Ivanoff, Nickolas Giorgievich	AE	Los Angeles
Jewett, Frank Baldwin, Jr.	ME	Short Hills, New Jersey
Johannessen, Jack	EE	Wilmington
Johnson, Evan Albert	ME	La Habra
Jones, Ralph Wilson, Jr.	ME	Pasadena
Jones, Wilson Burdette	CE	Alhambra
Jurs, Albert E., Jr.	EE	Piedmont
Kazan, Benjamin	Ph	New York, New York
Keller, Samuel Harris	CE	Glendale
Kelly, Leroy Bruce	ME	Alhambra
Knight, Jack William	Ge	Glendale
Konecnik, John	ME	Los Angeles
Kybal, Dalimil	AE	Mexico City, Mexico
Lavender, Harrison Morton	A.Ch	Douglas, Arizona
Lentz, John Jacob	EE	Los Angeles
Levin, Gerald Balfour	Ge	Los Angeles
Levit, Robert Jules	Ma	San Francisco
Lewis, Clay Warden	Ch	Topeka, Kansas
Lilly, John Cunningham	Bi	St. Paul, Minnesota
Llewellyn, Fred Eaton	EE	Glendale
Lowe, Frank C.	CE	Monterey Park
Lowell, Arthur Carter	ME	San Francisco
Luckenbill, David Brown	A.Ch	Redlands
Mason, C. Keith	ME	Riverside
McGraw, John Thomas	ME	Los Angeles
McLaughlin, Stuart Watson	Ch	Pasadena
McLean, John Godfrey	A.Ph	Santa Barbara
Merriam, John L.	CE	San Gabriel
Metzner, Robert G.	EE	Los Angeles
Milburn, William Edward	CE	Redondo Beach
Minasian, John K.	CE	Los Angeles
Moore, Frederic Hollway	A.Ch	Hollywood
Nagamatsu, Henry Takeshi	AE	Huntington Beach
Nash, William Francis	AE	San Diego
North, Harper Qua	A.Ph	Pasadena
Olds, Robert Horner	Ph	Los Angeles
Osborn, George Havice	ME	Azusa
Parker, John Eversole	A.Ch	Pasadena
Peat, John McCowan	Ge	South Pasadena
Piro, Joseph Frank	EE	Los Angeles
Porter, Edwin Jewett	ME	Whittier
Radovich, Frank	A.Ch	Los Angeles

Name	Option	Home Address
Rhett, William	ME	Huntington Park
Rosencranz, Richard, Jr.	A.Ch	Evansville, Indiana
Rowell, Richard Merrill	ME	Lancaster
Rudkin, George Thomas	Bi	San Marino
Rynearson, Garn Arthur	Ge	Van Nuys
Saurenman, Phillip E.	ME	Pasadena
Schlatter, Maurice Jay	Ch	Pasadena
Scully, Charles Norman	A.Ch	Pasadena
Segelhorst, August Van Ness	ME	Taft
Shanahan, Edmond Francis	EE	Los Angeles
Sharp, Harold W.	ME	Santa Paula
Shepherd, Philip Frick	ME	Altadena
Sherwood, David Marx	Ph	Palo Alto
Sidler, Arthur William	CE	San Bernardino
Siechert, Paul Charles	A.Ch	Santa Paula
Smith, Clay Taylor	Ge	Glendale
Smith, Fred Lester	Ph	Leadville, Colorado
Stevens, J. Farren	EE	Phoenix, Arizona
Stone, Roland Cruse	A.Ch	Ogden, Utah
Stones, J. Eugene	A.Ph	Bakersfield
Tejada, Luis Hernan	EE	Los Angeles
Thomas, Robert Coggeshell	AE	Los Angeles
Tilker, Paul Owen	CE	Los Angeles
Twiss, William Edward	ME	Los Angeles
Van Fleet, John Ricard	CE	Santa Barbara
Van Horn, James W.	EE	Los Angeles
Velazquez, Jose Luis	AE	Mexico City, Mexico
Voorhees, Stanley Van	ME	Hollywood
Wald, George	A.Ch	Alhambra
Walker, Albert Clark	Ch	Fresno
Warren, Donald Rexford	CE	Glendale
Watson, James Wendell	Ph	Grand Island, Nebraska
Watson, Samuel Eugene, Jr.	Ge	Chanaral, Chile
Weinberger, Edward Lee	A.Ch	Los Angeles
Wilkinson, Lupton Allemong, Jr.	AE	Charleston, South Carolina
Wilson, Gardner Pond	EE	Fresno
Wimpress, Richard Norman	A.Ch	Glendale
Windsor, Emanuel	Bi	Los Angeles
Wolfberg, Stanley T.	ME	Los Angeles
Wood, Homer Jesse	ME	Porterville
Woodbury, William White	Ma	Alhambra
Woolson, John Robert	Ma	Spokane, Washington
Youngs, Homer Smith	Ch	Glendale

JUNIOR CLASS

Name	Option	Home Address
Anderson, Clarence Russell	ME	Los Angeles
Anderson, Noah Herbert, Jr.	ME	Texarkana, Texas
Arvin, George Howard	A.Ch	Long Beach
*Asakawa, George	A.Ch	San Diego
Axtman, Grice	A.Ch	South Pasadena
Barber, Jack Edward	EE	Los Angeles

NAME	OPTION	HOME ADDRESS
Battle, John Allen	Ge	Los Angeles
Bauer, Charles Henry, Jr.	ME	Carmel
Beard, Leo Roy	CE	San Gabriel
Beck, Duane Wesley	ME	Los Angeles
Berg, William Eugene	Bi	Round Mountain, Nevada
*Bishop, Richard Hawley	Ph	Milwaukee, Wisconsin
Black, John William	ME	Hollywood
Blackinton, Roswell Jones	A.Ch	Bell
Bowers, Orrin C.	EE	Walnut Park
Bradshaw, Richard	CE	Walnut Park
Bragg, Kenneth Rankin	ME	San Marino
Braithwaite, James William	AE	Arcadia
Brown, Claude H., Jr.	ME	Los Angeles
Brown, George Reynolds	EE	Colorado, Texas
Brown, Perry H.	ME	Los Angeles
Brown, William Lowe	EE	Tulsa, Oklahoma
Caldwell, Donald Andrew	A.Ch	San Diego
*Carstarphen, Charles Fredrick	ME	Denver, Colorado
Carter, Robert Trissel	A.Ch	Glendale
Chung, David	ME	Los Angeles
Collins, R. Kenneth	EE	Pasadena
Cooper, Robert William	A.Ch	Los Angeles
Cox, Robert Osborne	ME	Watertown, New York
Craft, Claude Howard	Ch	Elsinore
Crawford, Virgil Kenmore	A.Ch	Burbank
Crozier, George Olds	ME	Monrovia
Davis, Harry Owens, Jr.	ME	Los Angeles
Degnan, Thomas Junior Joseph	ME	Pasadena
*Devirian, Philip Sarkis, Jr.	ME	Altadena
Dibble, Barry, Jr.	Ph	Redlands
Dickey, Frank Host	Ch	Los Angeles
Diehm, Walter	EE	Pasadena
Englander, Herman Sigmund	Ma	Sierra Madre
Evvard, John C.	Ph	Phoenix, Arizona
Flint, Delos Edward	Ge	Pasadena
Frampton, William Rex	A.Ch	Glendale
Fraser, Stuart MacMillan	ME	San Diego
Gale, George Phipps	EE	Paynesville, Minnesota
Gassaway, James Scott	ME	Los Angeles
Gerhart, Ray Van Deusen	A.Ch	Pasadena
Gombotz, Joseph John	Ge	San Marino
Goodell, Jack H.	ME	Pasadena
Goodin, Harry Allen	ME	South Pasadena
*Green, Albert Pennington	EE	Los Angeles
Green, William Manning	EE	Delta, Utah
Griffiths, John Robert	Ge	Santa Barbara
Griswold, Edgar Allen	CE	Los Angeles
Guillou, Alfred Victor	AE	Van Nuys
Hagen, Robert Christian	Ge	Riverside
Hall, Marcus A.	AE	Pasadena
Hance, Harold Vivian	EE	Los Angeles
Hannon, Andrew Lucien	EE	Los Angeles

NAME	OPTION	HOME ADDRESS
Haussler, Robert Walter	CE	Los Angeles
Hiatt, John Bradby	A.Ch	Alhambra
Hofeller, Gilbert Walter	ME	Pasadena
Hoff, Frederick Carl	ME	Pasadena
House, William Carl	AE	Eau Claire, Wisconsin
Ingalls, Francis Chandler	A.Ch	Alhambra
Israel, Richard Alfred	EE	Glendale
James, Raymond Allen	Ph	Salt Lake City, Utah
Kimball, Robert Barry	EE	Glendale
Kostoch, Francis Robert	A.Ch	Los Angeles
Krieger, Stuart	AE	Los Angeles
Kyte, Robert McClung	Ch	Walnut Park
Lavatelli, Leo Silvio	Ph	Los Angeles
Lawrie, Donald Gibb	ME	Milwaukee, Wisconsin
Lawson, William George	ME	Pasadena
Lee, Curtis Munn	ME	San Diego
Levet, Melvin Newton	Ge	Monterey Park
Longfelder, Harlowe Julius	AE	Los Angeles
MacDonald, Donald Charles	AE	Billings, Montana
*Macleish, Kenneth Gordon	Ph	Santa Barbara
Matthew, Tyler	EE	Hollywood
Mayeda, Takashi	ME	Honolulu, Hawaii
McClung, Roderick Marshall	ME	Winslow, Arizona
McCreery, Frank Ewing	ME	Coronado
McKee, Dwight Irwin	A.Ph	Sturgis, Kentucky
McKinlay, James Robb	EE	Glendale
Merrick, William Deming	EE	Glendale
Meyer, David Elmore	EE	San Marino
Miller, Charles Norman	EE	San Francisco
*Mills, Chester David	Ph	San Diego
*Mills, Mark Muir	Ph	Estes Park, Colorado
Morikawa, George Kiyoshi	AE	San Diego
Munk, Walter Heinrich	A.Ph	Vienna, Austria
Nicholson, David Field	Ch	Los Angeles
Norton, William Mear	ME	Beverly Hills
Oakley, Spencer Whittemore	ME	Pasadena
Ogg, James Truman	EE	Eagle Rock
Osborn, John E.	CE	Pasadena
Parker, Edward Haig	A.Ch	Los Angeles
Paul, Carl Hutton	ME	Hollywood
Pettingall, Charles Edward	EE	Burbank
Phillips, Robert Austin	EE	Rivera
*Pinney, Edmund	Ma	Seattle, Washington
Pond, Richard Kelley	ME	Pasadena
Pullen, Keats A.	Ph	Los Gatos
*Rainwater, Leo James	Ph	Hanford
Rasmussen, Volney Kinne	Ph	Hamburg, New York
Regan, Louis John	Ge	Hollywood
Richards, Raymond Gardner	ME	Exeter
Ritchey, James Clifton	CE	Lynwood
Robertson, Francis Allen	A.Ch	South Pasadena
Robinson, Nigel Edgar	A.Ch	Inglewood

Name	Option	Home Address
Root, William Arthur	EE	Huntington Park
Ropp, William Franklin	CE	Glendale
Rose, Charles Herrick	ME	Glendale
Rothman, Sanford	ME	Los Angeles
Roudebush, Bert Victor	A.Ph	Glendale
*Rubin, Sylvan	Ph	Pasadena
Ruggiero, Ralph John	Ph	Los Angeles
Rush, Hugh M.	AE	Tulsa, Oklahoma
Schneider, Selmer Guerton	EE	Beverly Hills
Scott, David Holcomb	Ge	Pasadena
Shultise, Quido Miles	EE	Pasadena
Silvertooth, E. Wilbur	A.Ph	Long Beach
Skei, Thurston	Ch	Portland, Oregon
Smith, Josiah Edward	AE	Corona
Smith, Paul Louis	ME	Pasadena
Smith, Philip Ernest	A.Ch	Santa Ana
Smith, Robert Louis	CE	Los Angeles
Smith, William	ME	Porterville
Snyder, Willard M.	CE	Hermosa Beach
Springer, Lee M.	AE	Los Angeles
Steel, Collis Kachler	EE	Butte City
Streightoff, Frank Doan	Bi	Indianapolis, Indiana
Strong, Herbert Davis	ME	Glendale
Sullivan, Edwin Franklin	CE	San Bernardino
Svimonoff, Constantine	CE	Bakersfield
Tangren, Robert Fulton	AE	Grass Valley
Thomas, Neal	AE	Hollywood
Van Dusen, Laurence William	ME	San Diego
*White, Robert William	Ch	Chelsea, Massachusetts
Wilson, Lindley Sothern	EE	Long Beach
Winchell, Robert Winslow	EE	Beverly Hills
Young, David Arthur	A.Ph	Utica, Missouri
Younger, Udene Earl	Ph	Los Angeles
Zukerman, Lester Goffin	EE	Hollywood

SOPHOMORE CLASS

Name	Course	Home Address
Abbey, Edward Kirk	Sci.	San Diego
Acker, Roy Mitchell	Eng.	Riverdale
Adams, Robert Powell	Eng.	Arcadia
Alcock, Robert Ward	Sci.	Iowa City, Iowa
Alexander, James Frederick	Eng.	Beverly Hills
Alonso, Francisco Antonio	Eng.	Los Angeles
Anderson, Keith Elliott	Sci.	South Pasadena
Baker, Friend Frederick	Sci.	Burbank
Barber, George Claire	Eng.	Pasadena
Baumgarten, Erwin	Sci.	Pasadena
Beller, Gordon Melvin	Eng.	Los Angeles
Benedict, Elson Gorman	Sci.	Carmel
Bennett, Dwight Henry	Eng.	Tulsa, Oklahoma
Bergmann, Frank Henry	Eng.	Beverly Hills

NAME	COURSE	HOME ADDRESS
Berlot, Robert Raymond	Sci.	Los Angeles
Biddison, Cydnor Mark	Eng.	San Gabriel
Billheimer, John S.	Sci.	Altadena
Brewer, Alexander Frederick	Eng.	Hollywood
*Brewer, Leo	Sci.	Los Angeles
Brooks, Marshall	Sci.	Pasadena
Brose, Frederic Morgner	Eng.	Hollywood
*Brown, William Emil	Sci.	Walnut Park
Brumfield, Robert Clarence	Eng.	Los Angeles
*Brunner, Frederick Calvert	Sci.	Alhambra
Campbell, Donald Cameron	Eng.	Pasadena
Carey, John Crawford	Eng.	Hollywood
Carter, Donald Franklin	Sci.	Phoenix, Arizona
Christie, Lee Stirling	Sci.	Whittier
Cleveland, William Roy, Jr.	Sci.	Whittier
Clinton, Raymond Otto	Sci.	Glendale
Compton, Arthur Mandeville	Eng.	Davenport, Iowa
Conant, E. Eugene	Eng.	Occidental Negros, Philippine Islands
Crane, Sheldon Cyr	Sci.	Los Angeles
Crawford, James Vaile	Eng.	Burbank
Croft, William F.	Eng.	Glendale
Daams, Gerrit	Sci.	Alhambra
Daly, David D.	Sci.	Pasadena
*Davis, Leo	Sci.	Los Angeles
Davis, Robert Ross	Sci.	Pasadena
Day, John Paul	Sci.	Arcadia
Deniston, William	Eng.	South Pasadena
Dessel, Frank William	Sci.	San Francisco
Diamond, Robert Henry	Eng.	San Diego
Dickerson, Edward Oakes	Eng.	Redlands
Eakin, John Alburn	Sci.	Santa Paula
Eddy, Barry Thudichum	Sci.	Denver, Colorado
Epstein, Ludwig	Sci.	Beverly Hills
Fleming, Robert Ernest	Sci.	Glendale
Foster, Gerald Pentland	Eng.	Los Angeles
France, Albert Finley	Eng.	Long Beach
Freehafer, Paul Robinson	Sci.	Payette, Idaho
German, Irvine Fisk, Jr.	Sci.	Garden Grove
Golson, George Albert	Sci.	New York, New York
Goodman, Harry Wolf	Eng.	Chicago, Illinois
Goodmanson, Lloyd Twedt	Eng.	Eagle Rock
Green, Elliott Aaron	Eng.	Hollywood
*Grigg, Robert Webb	Eng.	Pasadena
Haffner, Bernhard	Sci.	Kimberly, Nevada
Hankey, Eugene Daniel	Eng.	Los Angeles
Hardenbergh, George Adams	Sci.	St. Paul, Minnesota
*Harlan, James Turner	Sci.	South Pasadena
Harper, John Cline	Sci.	Denver, Colorado
Haugen, Edward Bernard	Sci.	Los Angeles
*Hayes, Wallace Dean	Sci.	Palo Alto
Held, Edward Emil	Sci.	Pasadena

Name	Course	Home Address
Hiehle, Ernest Michael	Eng.	Walnut Park
Hines, Marion Earnest	Sci.	Long Beach
Hirons, Robyn	Eng.	Portland, Oregon
Hitchings, Theodore Chester	Eng.	Denver, Colorado
Hofmann, Walter	Eng.	Bell
Hohwiesner, Henry George, Jr.	Eng.	Sacramento
Howard, Kenyon Bales	Sci.	Altadena
Jacobs, Millard W.	Eng.	Los Angeles
Janssen, Robert Ramsey	Eng.	Whittier
Jongeneel, James William	Sci.	Honolulu, Hawaii
Kemp, Leroy James	Eng.	Bell
Keyser, John Harold, Jr.	Eng.	Ely, Nevada
Kluge, William Thomas	Sci.	Portland, Oregon
*Kohl, Jerome	Sci.	Los Angeles
Koolish, Philip Hartley	Sci.	Los Angeles
Kupfer, Donald Harry	Sci.	Los Angeles
Larson, Walter Ramey	Eng.	Los Angeles
Lemm, Willys	Eng.	Pasadena
Levitt, Leo Charles	Sci.	Sierra Madre
*Loeffler, Donald Edward	Sci.	Inglewood
Lolmaugh, Orson Bernard	Eng.	Hemet
Long, Calvin Washburn	Eng.	Pasadena
*Longwell, Paul Alan	Sci.	Santa Monica
Love, Bernard	Sci.	Los Angeles
MacKay, Wallace Matthew	Eng.	Los Angeles
Main, John Hamilton	Sci.	Evanston, Illinois
Maker, Robert Roy	Sci.	Santa Barbara
Maleev, Leonid Vladimir	Eng.	Los Angeles
*Manildi, Joe Frank	Eng.	Soquel
Marriott, William Robert	Sci.	Los Angeles
Mayer, Jules Frederick	Eng.	Los Angeles
*Merryfield, Lloyd William	Sci.	Los Angeles
Meyer, Robert B.	Eng.	Alhambra
*Mickley, Harold Somers	Sci.	Long Beach
*Nagle, Darragh Edmund	Sci.	Scarsdale, New York
Nakada, Yoshinao	Eng.	Azusa
Newby, Clinton Toms	Eng.	Long Beach
Nickerson, Douglas Blain	Eng.	Redlands
Oakes, Gibson	Eng.	Seattle, Washington
Oder, Frederic Emil	Sci.	Alhambra
Oldson, Norman P.	Eng.	Pasadena
Palmer, Charles Sumner	Eng.	Pasadena
Palmer, John Gordon	Eng.	Brawley
Partch, Newell	Eng.	Pasadena
Paul, Ralph Graham	Sci.	Laguna Beach
Payne, Charles Melvin	Eng.	Denver, Colorado
Perry, Norman Conrad	Sci.	Los Angeles
Powell, Richard Wells	Eng.	Twin Falls, Idaho
Ray, Robert Stanley	Sci.	Riverside
Reynolds, Howard William, Jr.	Eng.	Beverly Hills
*Richardson, John Mead	Sci.	San Francisco
Rogers, Lawrence Arnold	Sci.	Los Angeles

NAME	COURSE	HOME ADDRESS
Rosanoff, Richard Albert	Sci.	Rosemead
Rugar, Jack	Eng.	Park City, Utah
Samuel, Hubert David, Jr.	Eng.	Los Angeles
Sandiford, Perry Lathrop	Eng.	Huntington Park
Sargent, Herbert, Jr.	Sci.	Pasadena
*Scarborough, William Bertram	Sci.	Denver, Colorado
Schrader, Carl George	Eng.	Mill Valley
Shisler, David Shepard	Eng.	San Anselmo
Skalecky, Frank Hamilton	Sci.	Coronado
Skaling, Percy Eaton	Sci.	Syracuse, New York
Smith, Randlow	Sci.	Los Angeles
Spalding, Delman Seward	Eng.	Guilford, Connecticut
Spielberger, Robert Elmer	Eng.	Manila, Philippine Islands
Spooner, William Austin	Sci.	Long Beach
Spraker, Jack David	Eng.	Los Angeles
Staatz, Dumont Sutherland	Sci.	Olive View
Staatz, Mortimer Hay	Sci.	Olive View
Steinmetz, David Henry III	Eng.	Los Angeles
Stevens, Jean Barrieu	Eng.	Long Beach
Stone, William Welch	Sci.	West Los Angeles
Stowell, Ellery Cory, Jr.	Sci.	Santa Barbara
Sullivan, Richard Louis	Eng.	Glendale
Sweningson, Oliver	Eng.	Long Beach
Tajima, Yuji	Sci.	Pasadena
Thomas, Delbert	Sci.	Pasadena
*Thompson, Ross Donald F.	Sci.	Los Angeles
Tielrooy, Jack	Sci.	North Hollywood
*Todd, George Judson	Eng.	Altadena
Tomiyasu, Kiyo	Eng.	Las Vegas, Nevada
Van Dyke, Gilbert Rusk	Sci.	Fallbrook
Varnes, David Joseph	Sci.	Los Angeles
Vetter, Warren Herman	Eng.	Los Angeles
*Wald, Edwin Prescott	Eng.	Chloride, Arizona
Walker, Richard Langan	Eng.	Alhambra
Walter, Don Lombard	Eng.	Glendale
Wasem, Richard	Sci.	Fort Dodge, Iowa
Watkins, James M., Jr.	Sci.	Pasadena
Wayman, Robert William	Eng.	Los Angeles
Weaver, Theodore Sol	Sci.	Hollywood
Weir, Gordon Bruce	Sci.	Los Angeles
White, Howard Jack	Eng.	Los Angeles
Whittlesey, David Walter	Eng.	Portland, Oregon
Whittlesey, James Wright	Eng.	Portland, Oregon
Widenmann, John Adolph	Sci.	Burlingame
Wilbur, Charles Clarence	Sci.	Pasadena
Williamson, Herbert Edward	Sci.	Pasadena
Wood, Harry Alfred, Jr.	Sci.	Los Angeles
Worcester, Herbert Moore, Jr.	Eng.	Pasadena
Young, Robert Busbey	Eng.	Los Angeles

FRESHMAN CLASS

Name	Home Address
Abraham, Wayne Gordon	Groutville, Natal, South Africa
Anderson, Robert Edwin	North Hollywood
Balazs, Joseph Stephen	Youngstown, Ohio
Barber, John Howland	Mexico City, Mexico
Beers, Kenneth Hurst	Los Angeles
Benson, Arthur Searle	Hollywood
Berman, Dave	Phoenix, Arizona
Bezdecheck, William Dionecious	Long Beach
Billman, Glenn Wagner	Long Beach
Billmeyer, Fred Wallace, Jr.	Pasadena
Boardman, Warren	Glendale
Bolles, Arthur Stanard	Whittier
Bortner, Henry Webster	Everett, Washington
Bowles, Robert Ryland	Denver, Colorado
Bowlus, Robert Glenhart	San Marino
Bramhall, George Hardy	Webster Groves, Missouri
Brandt, Roger	San Marino
Brooks, Philip Daniel	Alhambra
Buchzik, Charles Mallory	North Hollywood
Buss, Robert	Centerville, Iowa
Capron, Sanford Donley	Santa Monica
Carey, Joseph Patrick	Seattle, Washington
Carr, John Henry	Rosemead
Casserly, Frank Gordon	Pasadena
Chapin, William Francis	Long Beach
Clark, Donald Edward, Jr.	Santa Monica
Clark, Joseph Ernest	San Diego
Clarke, Frederick Weaver III	Omaha, Nebraska
Collison, William Fraser	Niagara Falls, New York
Connell, Robert Charles	Santa Barbara
Cook, Carroll Francis	Santa Barbara
Cooper, Robert George	Pasadena
Corcoran, William Harrison	Los Angeles
Critchlow, Arthur Jess	Alhambra
Davis, Walter Z.	Spokane, Washington
Dawson, Donald Edwin	Pasadena
Deniston, John Joseph	Hollywood
Doheny, William Henry	Beverly Hills
Dorr, Roger	Palos Verdes Estates
Eakin, Birch Hitt	Washington, D. C.
Edmund, William James	Santa Cruz
Edwards, Gene Lloyd	Crockett
Elliott, Quentin	Aurora, Nebraska
Elmer, David Arthur	South Pasadena
Erickson, James Legner	Beverly Hills
Eusey, Merritt Varns	Pasadena
Fahs, James Roger	Fullerton

Name	Home Address
Farmer, Mark Kearns	Turlock
Farrington, Paul Stephen	Indianapolis, Indiana
Faust, Paul Harry	Pasadena
Fisher, Robert Edwin	Los Angeles
Fleck, Frank Andrew	Jackson, Mississippi
Frank-Jones, Glyn	Los Angeles
Galeski, Robert Benjamin	Los Angeles
Gallaher, Homer Sumner	Salem, Oregon
Geib, Elden Ray	Redlands
Geitz, Robert Charles	McKeesport, Pennsylvania
Given, Frank Issac	San Diego
Gluckman, Lewis Francis	Los Angeles
Gold, Sydney Kendall	Hollywood
Green, Jerome	Los Angeles
Greene, Winfield Kurt	Santa Barbara
Greenhalgh, Francis Marion	Los Angeles
Hall, Robert Franklin	Long Beach
Hall, Robert Noel	Alameda
Hardin, Paul Verle	Arcadia
Harr, George Bowman	Long Beach
Harris, Robert Hutchison	Dayton, Ohio
Hassard, Thomas Jason	Chula Vista
Head, Richard Moore	Altadena
Hicks, Frank Randall	Honolulu, Hawaii
Hill, Harold Eugene	Los Angeles
Hill, Kim, Jr.	Glendale
Horne, Othniel	El Centro
Howenstein, John Barrett	Westmorland
Ikawa, Miyoshi	Venice
Ingersoll, William Lee	West Linn, Oregon
Jones, Gilbert Alllan	Scottsdale, Arizona
Jones, Jeremy Aldan	San Marino
Kaiser, Harold Robert	Tracy
Kashiwabara, Naomi	Los Angeles
Kennedy, Maurice Paul	Los Angeles
Kingsmill, Robert Edmond	Long Beach
LaBombard, Emerson Hogue	Santa Monica
Lakos, Eugene Alexander	Santa Barbara
Lawrence, Bruce Ernest	Pasadena
Levenson, Berl Dave	Los Angeles
Lewis, Joseph Walters	South Pasadena
Lyle, Francis Vivian	Los Angeles
Makepeace, Gershom Reynolds	Northfield, Massachusetts
Malone, Eugene Ives	Alhambra
Maninger, Ralph Carroll	Pasadena
McClain, John Franklin, Jr.	Coronado
McIntosh, James	Victoria, British Columbia
Meyer, George Frederick	Eagle Rock

Name	Home Address
Mitchell, Stanley John	San Gabriel
Moore, Charles Leroy	Mojave
Murr, William Carl	Beverly Hills
Murtaugh, Clyde Richard	Orrville, Ohio
Myers, Robert Francis	Redondo Beach
Noble, Edward Dodds	Yuma, Arizona
Noland, Robert LeRoy	San Diego
Nyborg, Meredith McRae	San Anselmo
Partlow, John Graydon	Los Angeles
Peters, Ralph	Corn, Oklahoma
Pickles, Arthur Montgomery	Victoria, British Columbia
Pollycove, Myron	Los Angeles
Porter, John Henry	Denver, Colorado
Porter, Livingstone, Jr.	Pasadena
Priest, James Virginius	North Hollywood
Reimers, George Irving	New York, New York
Rice, Edmund	La Jolla
Rinker, Robert Jay	Lindsay
Robinson, Theodore Bliss	Coronado
Rockdale, Lloyd Harold	Baldwin Park
Roen, Charles Brandt	Alhambra
Rominger, Joseph Franklin	Long Beach
Routt, Robert Patterson	Hollywood
Rupert, Claud Stanley	Exeter
Rutherford, Charles Ettinger	Beverly Hills
Sakai, George Chitsugi	Pasadena
Sandkuhle, Raymond Carl	Danville
Schaff, Alfred	Panama City, Republic of Panama
Schubert, William	Huntington Park
Small, John Gilbert	San Rafael
Smallberg, Merle Leroy	Los Angeles
Snodgrass, Reuben	Tulsa, Oklahoma
Sohler, Stanley Edward	Portland, Oregon
Spikes, John Daniel	Redondo Beach
Stadum, Clarence Bernhard	Sioux Falls, South Dakota
Stewart, Wilton Alexander	San Diego
Stroud, Stanley Grouer	Fillmore
Sturdevant, C. Victor, III	Pasadena
Sullivan, Oliver Russell	Laurel, Montana
Taylor, Thayle Flandars	Los Angeles
Terry, Foss Bell	Chicago, Illinois
Thayer, Charles Louis	Ogden, Utah
Thiele, Fredrick William	Hollywood
Tilbury, George Herbert, Jr.	Kennewick, Washington
Trauerman, Joe Klee	Fort Dodge, Iowa
Trindle, Joseph Warren	Seattle, Washington
Turner, Dale Edward	Kingsburg

Name	Home Address
Tyler, Edmund Forrest	Hollywood
Van Camp, Lincoln	Denver, Colorado
Vartikian, Onick	Fresno
Vaughan, Richard	Burbank
Vey, Ebenezer	Grates Cove, Newfoundland
Wagner, William John	Los Angeles
Wahrhaftig, Clyde Adolph	Fresno
Wallace, Roger William	Oak Park, Illinois
Weiss, Joseph	Pasadena
Weller, Carl Barry	South San Francisco
White, John Robertson	Los Angeles
White, Thomas Leeming	Los Angeles
Widdoes, Lawrence Curtis	Sebastopol
Wilcox, Carlos Robert	Payette, Idaho
Wilmoth, Robert Carlyle	North Hollywood
Wood, David Shotwell	Sierra Madre
Yett, Frank Alexander	Portland, Oregon
Young, Cecil Gilbert	Palmyra, Missouri
Zebb, Keirn	Denver, Colorado

SUMMARY

GRADUATE SCHOOL

Research Fellows

National Research Fellows	3	
Research Fellows of the Institute	20	
Commonwealth Fund Fellows	3	
International Research Fellows of the Rockefeller Foundation	3	
Fellow, Institute of International Education	1	
Associate of Rockefeller Institute for Medical Research	1	
Kellogg Research Fellow	1	
Research Fellow and Lecturer of University of Sydney	1	
Lalor Foundation Fellow	1	
Woodworth Travelling Fellow, Harvard University	1	
National Tsing Hua University Fellow	1	
Fellow of Kiangu Provincial Government, Chin Kiang, China	1	
International Exchange Fellow	1	
Research Assistants of the Institute	21	
		59

Graduate Students

Physics	53	
Chemistry	32	
Chemical Engineering	6	
Mathematics	6	
Geology	18	
Biology	16	
Meteorology	17	
Electrical Engineering	21	
Mechanical Engineering	14	
Civil Engineering	12	
Aeronautics	45	
		240

UNDERGRADUATE SCHOOL

Seniors	139	
Juniors	144	
Sophomores	166	
Freshmen	161	
		610
Total Number of Students		850

COURSES AND OPTIONS OF UNDERGRADUATE STUDENTS

Science Course	Seniors	Juniors
Physics	11	19
Chemistry	5	6
Applied Chemistry	22	17
Mathematics	4	2
Geology	11	8
Biology	3	2
Total	56	54
Engineering Course		
Electrical	20	28
Civil	16	11
Mechanical	38	38
Aeronautics	9	13
Total	83	90

INDEX

SUBJECT	PAGE
Abbreviations	161
Administrative Officers	7
Admission	
To Freshman Class	75
Application for	77
To Upper Classes	78
To Graduate Standing	136
Advisory Council	7
Aeronautics	
Laboratories, Description of	105
Study and Research	105
B.S. in	108; n., 136
M.S. in	108; n., 136
Special Regulations, Ph.D. Degree	150
Schedule of Courses	166, 176
Undergraduate Subjects	214
Fifth-Year and Advanced Subjects	214
Applied Mechanics	
Undergraduate Subjects	219
Advanced Subjects	219
Arms, Charles, Laboratory of Geological Sciences	64, 109
Assembly	68, 161
Assistantships	153
Associated Students of the California Institute of Technology, Inc.	68
Associates	55
Associates, Hall of the	66
Astronomy	167, 168
Astrophysical Observatory	113
Astrophysical Instrument Shop	64, 114
Astrophysical Optical Shop	64, 114, 115
Astrophysical Laboratory	64, 114
Astrophysics	113
Athenæum	63, 66, 157
Athletic Council	69
Auditorium	62
Bachelor of Science, Degree of	94
Candidacy for	94
Courses Leading to	162-174
Conferred, June 11, 1937	248
Balch Graduate School of the Geological Sciences	108
Big T, School Annual	69
Biological Sciences	
Laboratories, Description of	112
Study and Research	112
Schedule of Courses	174
Undergraduate Courses	230
Advanced Subjects	232
Blacker House	63, 67
Board of Trustees	6
Bridge Laboratory of Physics	62, 95
Buildings and Facilities	62
Calendar	4, 5
California Institute Associates	55
California Tech, School Paper	69
Chairmen of Divisions	7
Chemistry and Chemical Engineering	
Laboratories, Description of	97
Study and Research	97
Special Regulations, Ph.D. Degree	148
Schedule of Courses	171, 172, 178
Undergraduate Subjects	197
Fifth-Year and Advanced Subjects	200
Civil Engineering	
Study and Research	100
Special Regulations, Ph.D. Degree	150
Schedule of Courses	165, 175
Undergraduate Subjects	205
Fifth-Year Subjects	207
Advanced Subjects	208
Clubs	69
Commencement	5
Committees of the Faculty	8
Conditions	90
Conger Peace Prize	86
Councils	
Advisory	7
Executive	7
Observatory	52
Course Schedules	
First Year	162
Second Year, Engineering	163
Second Year, Science	167
Third and Fourth Years, Engineering	164-166

SUBJECT	PAGE
Course Schedules (Contd.)	
Third and Fourth Years, Science	168-174
Courses in Engineering, Described	158
Courses in Science, Described	159
Credits	91
Crellin Laboratory of Chemistry	62, 97
Culbertson Hall	62
Dabney Hall of the Humanities	63, 117
Dabney House	64, 67
Deans	7
Debating	70
Degrees Conferred, 1937	245
Deposits	82
Description of Undergraduate and Fifth-Year Courses	158
Discipline	89
Dismissal	89
Divisions of the Institute	92
Doctor of Philosophy, Degree of	
Regulations and Requirements	140
Admission to Candidacy	144
Conferred June 11, 1937	245
Dormitory	67
Dramatics	69
Drawing	
Freshman	220
Descriptive Geometry	220
Engineering	220
Economics	
Undergraduate Subjects	240
Fifth-Year and Advanced Subjects	241
Educational Policies	59
Educational Facilities	62
Electrical Engineering	
Study and Research	104
Laboratories, Description of	105
Special Regulations, Ph.D. Degree	146
Schedule of Courses	164, 175
Undergraduate Subjects	192
Fifth-Year Subjects	194
Advanced Subjects	195
Emergency Hospitalization Fee	83
Emergency Hospitalization Fund	72
Employment	87
Engineering, General Description	99
Engineering Research Laboratory and Heating Plant	63
Engineering Societies	69
English	
Undergraduate Subjects	234
Fifth-Year and Advanced Subjects	236
Enrollment	75
Entrance Examinations	76
Entrance Requirements	75
Ethics (see Philosophy)	243
Examinations	
Term	5
Entrance, Undergraduate	76
Languages for Ph.D. Candidacy	144
Excess Units	94
Executive Council	7
Expenses	82
Experimental Station (Biology)	65, 112
Extra-Curricular Opportunities	68
Facilities, Educational	59
Faculty Committee on Student Relations	8
Faculty, Officers and Committees of	8
Fees	82, 137
Fellowships and Assistantships	153
Institute	154
National	154
Drake	154
Blacker	154
Henry Laws	154
Caroline W. Dobbins	154
Elizabeth Thompson Stone	155
Bridge	155
George Ellery Hale	155
Noyes	155
Fifth-Year Courses	60, 158, 175
Finance Committee of Board of Trustees	6
Fleming House	64, 67
Four-Year Courses	60, 158, 162
Freshman Admissions	75
Freshman Prize Scholarships	85
Gas Engine Laboratory	65
Gates and Crellin Laboratories of Chemistry	62, 97
Geological Sciences (Geology, Paleontology and Geophysics)	
Laboratories, Description of	109
Study and Research	110
Special Regulations, Ph.D. Degree	152
Schedule of Courses	173, 179

SUBJECT	PAGE
Geological Sciences (Contd.)	
Fifth-Year Subjects	179
Undergraduate Subjects	223
Undergraduate or Graduate Subjects	224
Graduate Subjects	226
Geophysics (see Geological Sciences)	108, 223
Grades on Degrees	146
Grading, Scholastic	90, 142
Graduate Assistants	37, 153
Graduate Life	157
Graduate School of Aeronautics	105
Graduate Standing, Admission to	136
Graduate Students	251
Graduates, 1937	245
Graduation	93
Guests	157
Guggenheim Aeronautical Laboratory	63, 105
Guggenheim Airship Institute	106
Hall of the Associates	66
Hall of the Humanities	63, 117
Health Service	72
Heating Plant	63
High-Potential Research Laboratory	63, 105
Historical Sketch	57
History and Government	
Undergraduate Subjects	239
Fifth-Year and Advanced Subjects	239
Holidays	5
Honor System	89
Honor Standing	93
Honor Students, Aid for	93
Honor Students, Committee on	93
Honors and Scholarships, 1937	250
Hospital Services	72
Hospitalization Fee	72, 82
House Dues	82
Humanities	116, 234
Humanities, Library and Art Gallery	117
Hydraulic Laboratory	65
Hydraulic Machinery Research Laboratory	103
Hydraulics	
Laboratories, Description of	64, 65, 101
Hydraulics (Contd.)	
Study and Research	101
Undergraduate Subjects	222
Advanced Subjects	222
Hydraulic Structures Laboratory	64, 102
Institute Associates, California	55
Institute Research Fellowships	154
Kellogg Radiation Laboratory	64, 96, 105
Kerckhoff Laboratories of Biology	63, 112
Leave of Absence	94
Lectures	68
Libraries	65
Little T, School Handbook	69
Loan Funds	
Cleveland	86
Hughes	87
Herman	87
Noble	87
Jackson	87
Marine Biology	113
Marine Station at Corona del Mar	113
Mathematics	
Study and Research	97
Special Regulations, Ph.D. Degree	146
Schedule of Courses	170, 177
Undergraduate Subjects	186
Undergraduate or Graduate Subjects	187
Graduate Subjects	189
Master of Science, Degree of	
Candidacy for	138
Courses Leading to	162-179
Conferred June 11, 1937	245
Mechanical Engineering	
Study and Research	101
Special Regulations, Ph.D. Degree	150
Schedule of Courses	166, 176
Undergraduate Subjects	210
Fifth-Year and Advanced Subjects	212
Meteorology	
Study and Research	106
B.S. in	108; n., 136
M.S. in	108

SUBJECT PAGE

Meteorology (Contd.)
Special Regulations, Ph.D. Degree 150
Schedule of Courses 177
Subjects 217
Million-Volt Transformer 96, 105
Mount Wilson Observatory 113
Mudd, Seeley W., Laboratory of the Geological Sciences 65, 109
National Research Fellowships 154
National Youth Administration 87
Observatory Council 52
Officers
Board of Trustees 6
Administrative Officers of the Institute 7
Executive Council 7
Officers and Committees of the Faculty 8
California Institute Associates 55
Options 159
Paleontology (see Geological Sciences) 108, 223
Part-Time Schedules 94
Philosophy, Ethics and Sociology 243
Physical Education 72, 244
Physical Examination 72, 77
Physician, Institute, Services of 72
Physics
Study and Research 95
Laboratories, Description of 96
Special Regulations, Ph.D. Degree 146
Schedule of Courses 168, 169, 177
Undergraduate Subjects 180
Undergraduate or Graduate Subjects 181
Graduate Subjects 183
Pi Kappa Delta 70
Placement Service 88
Prizes 85
Probation 91
Publications of the Staff 119
Public Lectures 68
Radiation Laboratory 64, 95
Registrar 7
Registration
For Undergraduates 89
For M.S. Degree 139
For Ph.D. Degree 141

SUBJECT PAGE

Regulations
General, for Undergraduates 89
General, for Graduate Students 136
For M.S. Degree 137
For Ph.D. Degree 140
Reinstatement 92
Requirements for Admission
To Undergraduate Standing 75
To Graduate Standing 136
Requirement for Graduation 93
Requirements, Scholastic 90
Research at the Institute 95
Research Assistants 37, 45
Research Fellows 30, 45
Research Fellowships 154
Research Scholarships 154
Residence Requirement 141
Ricketts House 64, 67
Room and Board, Cost of 82
Roster of Students 251
Schedules of Undergraduate Courses 161
Schedules of Fifth-Year Courses 175
Scholarship Grading and Requirements 90
Scholarships
Undergraduate
Freshman 85
Sophomore 85
Junior 85
Drake 85
Blacker 85
Harriet Harvey 86
Walter Humphry 86
Graduate
Elizabeth Thompson Stone 155
Holders of Undergraduate Scholarships 250
Science, Courses in 159
Seismological Research Laboratory 63, 111
Sigma Xi 70
Sociology 243
Soil Conservation Laboratory 64, 103
Special Fellowship Funds 156
Staff of Instruction and Research 9
Steam Laboratory 65

SUBJECT	PAGE
Student Employment	87
Student Health Program	72
Student Houses	67, 82, 84
Student Organizations	68
Student Relations, Faculty Committee on	8, 68
Students, Roster of	251
Study and Research at the Institute	95
Subjects of Instruction	180
Summary of Staff of Instruction and Research	44
Summer Review Courses, Mathematics and Physics	80
Supplies, Cost of	82
Tau Beta Pi	70
Teaching Fellows	37, 45
Telescope, 200-Inch	113
Terms	5, 161
Thesis	
For M.S. Degree	139
For Ph.D. Degree	145
Throop Hall	62
Trustees, Board of	6
Undergraduate Courses, Schedules	161
Tuition	
Undergraduate	82
Graduate	137
Undergraduate Student Houses	67
Undergraduate Students	260
Units	91
Vaccination	77, 81
Vacations	5
Upper Class Admissions	78
Units	
Explanation of	91, 161
For Graduation	91
Y. M. C. A.	71

CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA