BULLETIN OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

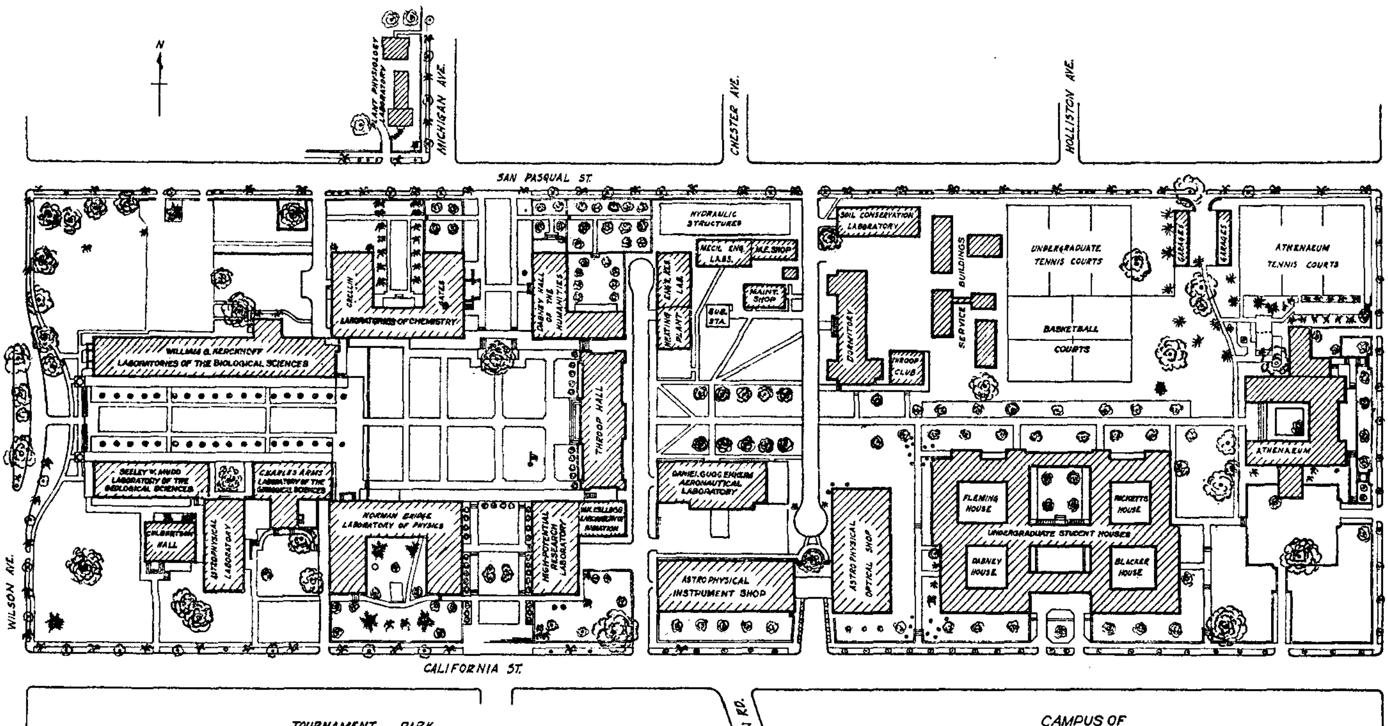
VOLUME 49 NUMBER 1

CATALOGUE NUMBER *for* 1940

PUBLISHED BY THE INSTITUTE, JANUARY, 1940

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



CAMPUS OF
CALIFORNIA INSTITUTE OF TECHNOLOGY
MARCH 22, 1939

BULLETIN OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

VOLUME 49 NUMBER 1

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

CATALOGUE NUMBER *for* 1940

PASADENA · CALIFORNIA · JANUARY, 1940

CALENDAR

1940

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	29	..	..
..	..	..	..	..	..	..

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	..	..	..	..
..	..	..	..	..	..	..

1941

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

1940

JANUARY 2	Registration (9 A. M. to 3 P. M.)
JANUARY 20	Examinations for Removal of Conditions
MARCH 1	Last Day for Application for Fellowships and Assistantships
MARCH 11-16	Term Examinations
MARCH 16	Notifications of Awards of Fellowships and Assistantships
MARCH 16	End of Second Term (12 M.)
MARCH 17-24	Recess
MARCH 22	Meeting of Freshman Registration Committee
MARCH 23	Meeting of Registration Committee
MARCH 9 and 16	Examinations for Admission to Freshman Class and for Freshman Scholarships (see page 76)
MARCH 25	Registration (9 A. M. to 3 P. M.)
APRIL 13	Examinations for Removal of Conditions
APRIL 13	List of Approved Candidates for Bachelor of Science Degree Posted
MAY 23	Last Day for Examinations and Presenting Theses for the Degree of Doctor of Philosophy
MAY 30	Memorial Day Recess
JUNE 1	End of Examinations for Candidates for the Degrees of Bachelor of Science and Master of Science
JUNE 3-8	Term Examinations for All Undergraduates Except Seniors
JUNE 4	Meetings of Committees on Course in Engineering and Course in Science (10 A. M.)
JUNE 5	Faculty Meeting (10 A. M.)
JUNE 6	Class Day
JUNE 7	Commencement
JUNE 7	Annual Meeting of Alumni Association
JUNE 1, 7, 8	Examinations for Admission to Upper Classes
JUNE 8	Entrance Examinations in Chemistry and English for High School Juniors
JUNE 8	End of College Year (12 M.)
JUNE 17	Meeting of Freshman Registration Committee
JUNE 18	Meeting of Registration Committee
SEPTEMBER 13 and 14	Examinations for Admission to Upper Classes
SEPTEMBER 20	Examinations for Removal of Conditions
SEPTEMBER 17	Registration of Freshmen (1:30 P. M.)
SEPTEMBER 19	Registration of Students Transferring From Other Colleges (9 A. M. to 3 P. M.)
SEPTEMBER 20	General Registration (9 A. M. to 3 P. M.)
SEPTEMBER 23	Beginning of Instruction
NOVEMBER 16	Last Day for Announcing Candidacy for Bachelor's Degree
NOVEMBER 21-24	Thanksgiving Recess
DECEMBER 9-14	Term Examinations
DECEMBER 14	Last Day for Applications for Candidacy for the Degree of Doctor of Philosophy in June, 1941
DECEMBER 14	End of First Term (12 M.)
DECEMBER 20	Meeting of Freshman Registration Committee
DECEMBER 21	Meeting of Registration Committee
JANUARY 3, 1941	Registration (9 A. M. to 3 P. M.)

THE BOARD OF TRUSTEES

(Arranged in the order of seniority of service)

OFFICERS

FINANCE COMMITTEE

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, Aeronautics, and Meteorology
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.

VANNEVAR BUSH, President, Carnegie Institution of Washington.

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

JOHN C. MERRIAM, President Emeritus, 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, Linus Pauling

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, J. P. Buwalda, R. L. Daugherty, P. S. Fogg, F. W. Hinrichs, Jr., C. K. Judy, William N. Lacey, Max Mason, W. W. Michael, C. B. Millikan, R. A. Millikan, T. H. Morgan, W. B. Munro, L. Pauling, W. R. Smythe, R. W. Sorensen, A. H. Sturtevant, F. Thomas, R. C. Tolman, R. E. Untereiner, Morgan Ward.

FACULTY COMMITTEES

ADMISSION TO UPPER CLASSES: S. J. Bates *(chairman)*, C. D. Anderson, W. N. Birchby, W. H. Clapp, F. J. Converse, P. S. Fogg, G. R. MacMinn, E. E. Sechler, L. E. Wear.

ALUMNI RELATIONS: D. S. Clark *(chairman)*, W. Hertenstein, W. Huse, A. E. Lombard, Jr., W. B. Munro, R. W. Sorensen, F. Thomas.

ASSEMBLY: C. K. Judy *(chairman)*, R. L. Daugherty, H. Eagleson, H. N. Gilbert, R. A. Millikan, S. G. Mudd, W. B. Munro, T. G. Soares, F. Thomas.

COMMENCEMENT EXERCISES: L. W. Jones *(chairman)*, D. S. Clark, H. Eagleson, W. Herteinstein, H. Z. Musselman.

COURSE IN ENGINEERING: W. W. Michael *(chairman)*, W. H. Clapp, F. L. Converse, R. L. Daugherty, H. N. Gilbert, F. C. Lindvall, G. R. MacMinn, E. E. Sechler.

COURSE IN SCIENCE: W. R. Smythe *(chairman)*, W. V. Houston, R. N. Lacey, S. S. Mackeown, J. H. Maxson, R. Stanton, E. H. Swift, A. Tyler, L. E. Wear.

FRESHMAN REGISTRATION: J. E. Bell *(chairman)*, J. W. M. DuMond, H. Eagleson, P. S. Fogg, H. N. Tyson, R. E. Untereiner, H. C. Van Buskirk.

FRESHMAN ADMISSION: P. S. Fogg, *(chairman)*, C. D. Anderson, W. N. Birchby, J. P. Buwalda, L. Helmholz, L. W. Jones, F. C. Lindvall, J. R. Macarthur, R. E. Untereiner, E. C. Watson.

GRADUATE STUDY: R. C. Tolman *(chairman)*, C. D. Anderson, E. G. Anderson, J. A. Anderson, R. M. Badger, H. Bateman, E. T. Bell, H. Borsook, I. S. Bowen, J. P. Buwalda, I. Campbell, W. H. Clapp, R. L. Daugherty, R. L. Dickinson, T. Dobzhansky, J. W. M. DuMond, P. S. Epstein, A. Goetz, B. Gutenberg, A. J. Haagen-Smit, W. V. Houston, R. T. Knapp, I. P. Krick, C. C. Lauritsen, F. C. Lindvall, H. J. Lucas, J. R. Macarthur, S. S. Mackeown, R. R. Martel, M. Mason, A. Michal, C. B. Millikan, R. A. Millikan, T. H. Morgan, C. Niemann, J. R. Oppenheimer, L. C. Pauling, G. Potapenko, R. W. Sorensen, C. Stock, A. H. Sturtevant, F. Thomas, T. von Karman, M. Ward, E. C. Watson, F. W. Went, D. M. Yost, F. Zwicky.

HONOR STUDENTS: M. Ward *(chairman)*, C. D. Anderson, J. E. Bell, H. J. Fraser, F. W. Hinrichs, Jr., G. R. MacMinn, E. E. Swift, R. E. Untereiner, E. C. Watson, L. E. Wear.

LECTURES AND VISITS FROM OUTSIDE ORGANIZATIONS: H. N. Gilbert *(chairman)*, T. Dobzhansky, W. Hertenstein, W. V. Houston, G. Laing, S. S. Mackeown, W. W. Michael, V. Veysey.

LIBRARY: E. C. Watson *(chairman)*, S. J. Bates, E. T. Bell, H. Borsook, H. Craig, Jr., H. J. Fraser, R. A. Millikan, E. E. Sechler, R. C. Tolman.

MUSICAL ACTIVITIES: F. Thomas *(chairman)*, R. G. Dickinson, H. N. Gilbert, A. Goetz, B. Gutenberg, L. V. Metcalf, A. Stong, L. E. Wear.

PHYSICAL EDUCATION: R. W. Sorensen *(chairman)*, W. H. Clapp, H. Craig, Jr., W. W. Michael, H. Z. Musselman, W. L. Stanton, R. E. Untereiner.

PUBLICATIONS AND PUBLICITY: W. Huse *(chairman)*, E. C. Barrett, P. S. Fogg, I. Howard, E. E. Sechler, F. Thomas.

REGISTRATION: P. S. Fogg *(chairman)*, W. H. Clapp, H. J. Fraser, F. W. Hinrichs, Jr., R. R. Martel, F. W. Maxstadt, W. R. Smythe, R. Stanton, E. H. Swift, H. C. Van Buskirk, L. E. Wear.

RELATIONS TO HIGH SCHOOLS: J. E. Bell *(chairman)*, P. S. Fogg, W. Huse, M. Mason, R. A. Millikan, W. B. Munro, R. E. Untereiner, E. C. Watson.

STUDENT AID: F. W. Hinrichs, Jr. *(chairman)*, E. C. Barrett, R. W. Sorensen, R. E. Untereiner, M. Ward, E. C. Watson.

STUDENT BODY FINANCE: H. N. Gilbert *(chairman)*, L. W. Jones, V. Veysey.

STUDENT HEALTH: H. Borsook *(chairman)*, F. W. Hinrichs, Jr., E. D. Kremers, T. H. Morgan, S. G. Mudd, R. W. Sorensen, R. E. Untereiner.

STUDENT RELATIONS: F. Thomas *(chairman)*, H. Craig, Jr., H. Eagleson, F. W. Hinrichs, Jr., L. W. Jones, J. R. Macarthur, S. S. Mackeown, W. B. Munro, E. E. Sechler, T. G. Soares, R. E. Untereiner.

STUDENT SOCIAL FUNCTIONS: L. W. Jones *(chairman)*, D. S. Clark, H. Eagleson, G. Laing, V. Veysey, W. O. Wetmore.

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, National Academy of Sciences, and Pontificia Accademia delle Scienze; Commandeur de l'Ordre National de la Légion d' Honneur, 1936. California Institute, 1916-

1640 Oak Grove Avenue, San Marino

Max Mason, Ph.D., LL.D., Sc.D.

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, San Marino

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; Corresponding Member, Accademia di Scienze Lettere et Arti, Padova, 1937; Foreign Associate, Académie des Sciences de l'Institut de France, 1938. 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

Carl David Anderson, Ph.D., Sc.D., Nobel Laureate

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. Member of National Academy of Sciences and American Philosophical Society. Assistant and Teaching Fellow in Physics, California Institute, 1927-1930; Research Fellow, 1930-1933; Assistant Professor, 1933-1937; Associate Professor, 1937-1939; Professor, 1939-

280 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's 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. Chairman, Los Angeles Section, American Society of Mechanical Engineers, 1937-1938; Alternate, American Engineering Council, 1937-1938; member, Executive Committee, Los Angeles Engineering Council, 1938-1939. 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, Stanford University, 1909; M.E., 1914. Assistant in Mechanics, Stanford 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

ROSCOE GILKEY DICKINSON, PH.D.
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, 1928-1938; Professor, 1938-

530 Bonita 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; Privatdocent, Moscow University, 1909-1913; Privatdocent, University of Zurich, 1919-1922; Exchange Professor, Aachen Inst. Tech., 1927 and 1929. Member National Academy of Sciences. California Institute, 1921-

1484 Oakdale Street

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; Privatdozent 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., Sc.D.

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. Privatdocent, 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; Member of National Academy of Sciences, 1938. 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; Josiah Willard Gibbs Lecturer of the American Mathematical Society, 1939. 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, Stanford University; M.S., 1913; Ph.D., University of California, 1915. Assistant in Chemistry, Stanford 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-

195 N. Euclid 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-

809 Fairfield Circle

Aristotle D. Michal, Ph.D.

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, 1929-1938; Professor, 1938-

2002 Oakdale Street

Seeley G. Mudd, M.D.

Professor of X-Ray Therapy

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

1550 Oak Grove Avenue

Charles Grosvenor Osgood, Ph.D.

Visiting Professor of English Literature

B.A., Yale University, 1894; Ph.D., 1899. Assistant Professor of English, University of Colorado, 1899; Instructor in English, Yale University, 1899-1905; Preceptor in English, Princeton University, 1905-1913; Professor, 1913-1937; Chairman of Department, 1918-1926; Professor Emeritus and Lecturer, 1937-. California Institute, 1940.

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-. Assistant Professor, California Institute of Technology, 1928-1934; Associate Professor, 1934-1937; Professor, 1937-. California Institute, 1928-.

Athenæum

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-

3500 East Fairpoint Street, Sierra Madre Villa

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; D.D., Meadville Theological School, 1938. 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., D.SC.

Professor of Electrical Engineering

B.S., in Electrical Engineering, University of Colorado, 1905; E.E., 1928; D.Sc. (hon.), 1938. 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

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; Fellow of the John Simon Guggenheim Memorial Foundation, 1939-1940. 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

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

LÁSZLÓ ZECHMEISTER, DR. ING.
Professor of Organic Chemistry

Diploma in Chemistry, Zurich, 1911; Dr. Ing., 1913. Assistant and Chief Assistant, Kaiser Wilhelm Institut für Chemie, 1912-1914; Instructor, Danish Royal Veterinary Academy, Copenhagen, 1921-1923; Professor of Chemistry and Director of the Chemical Laboratory, Medical School of the University of Pécs, 1923-; Lecturer, California Institute, 1938. Member of the Hungarian Academy of Science. Laureate of Grand Prize of the Hungarian Academy, 1937; Medaille Pasteur, 1935. Professor of Organic Chemistry, California Institute, 1939-

---

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. 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; Graduate in the School of Astronomy, University of Virginia, 1896; 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 (Department of Terrestrial Magnetism, 1918-1923; 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

Edwin R. Buchman, Dr. Phil. Nat.
Research Associate in Organic 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; Research Fellow, California Institute, 1937-1938; Research Associate, 1938-

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

George H. Edgell, Ph.D.
Visiting Lecturer in Art and Architecture

A.B., Harvard, 1909; Ph.D., 1913. Fellow of American Academy, Rome, 1910-1912. Assistant, Instructor, Assistant Professor, and Professor of Fine Arts, Harvard, 1909-1935; Dean of the Faculty of Architecture and Chairman of the Council of the School of Architecture, 1922-1935. Curator of Paintings, Boston Museum of Fine Arts since 1934; Director, 1935-. California Institute, 1940.

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

†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.

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

Vlastimil Kybal, Dr. Phil.

Visiting Lecturer in History and Economics

Dr. Phil., Czech University of Prague, 1903. Assistant in History, Czech Historical Seminar, 1902-1908; Ancien Élève of the École des Hautes Études, Sorbonne, and of the École des Sciences Politiques, Paris; Hospitant of the Preussische Universität in Bonn am Rhein; member of the Istituto Austriaco di Studi Storici, Rome, 1908-1913; Research Fellow of the Austrian Government and of the Czech Academy, 1908-1914; Docent of the General History of Western Europe of the Middle and Modern Ages, Czech University, Prague, 1911-1918; Professor Regius, 1919-. Recipient of the Jubilee Prize of the Czech Royal Society of Sciences, 1904, of two Jubilee Prizes of the Czech Academy, 1910, 1915, and of the Prize of the City of Prague, 1914. Member of the Czech Royal Society and of the Czech Academy. Plenipotentiary Minister of Czechslovakia to Italy, 1920-1925; to Brazil and Argentine, 1925-1927; to Spain and Portugal, 1927-1933; to Mexico, Guatemala, El Salvador, Honduras, and Nicaragua, 1935-1939. Member of the Spanish Academy of History, Madrid; Academy of Belles Lettres, Barcelonne; Ibero-American Academy, Cadiz; Colegio de Doctores of the University of Madrid; Mexican Society of Geography and Statistics; Society of History and Geography of Guatemala; charter member of the Spanish and Ibero-American Institute and Czechoslovak-Latin-American Chamber of Commerce, Prague. Grand Cross of the Crown of Italy, Grand Cross of the Order of Isabelle the Catholic, Aztec Eagle of Mexico. Visiting Lecturer at the National University of Mexico, 1936; at the University of California at Berkeley and at Los Angeles; Stanford University; University of Southern California; Claremont Colleges. Visiting Lecturer in Modern History at the California Institute of Technology, 1939-

250 South Hudson 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; Council of American Ornithological Union. California Institute, 1929-

Meadow Grove Place, Flintridge

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

Arthur George Rene Strickland

Visiting Lecturer in Protozoology

Bach. Es. Sci., Lausanne, 1904; Dipl. Ing., Eidgen. Politechnikum, Zürich, 1908. Research Assistant in Biology, Stanford University, 1935-1939; Research Associate, 1939-. California Institute, 1939-1940.

EDWARD A. WHITNEY, M.A.
Associate in English and History

A.B., Harvard College, 1917; M.A., Harvard University, 1922; Instructor, Assistant Professor and Associate Professor of History and Literature in Harvard University, 1920-39; Master of Kirkland House, Harvard University, 1931-1935. Research Fellow, Huntington Library, 1938-1939; member of the Research Staff, 1939-. California Institute, 1939-

1245 Arden Road

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, 1928-

220 North San Rafael Avenue

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; Visiting Professor, University of Michigan, summer, 1935. 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

ARTHUR HOWLAND YOUNG
Visiting Lecturer on Industrial Relations

Supervisor of Labor and Safety, Illinois Steel Co., 1912-1917; Director, American Museum of Safety, 1917-1918; Chief Safety Expert, U. S. Arsenals and Navy Yards, World War, also Chief Safety Expert of U. S. Employees Compensation Commission, 1917-1918; Manager of Industrial Relations of International Harvester Company, 1918-1924; Industrial Relations Counsel to Industrial Relations Counselors, Inc., 1924-1934; Secretary Consultant International Labor Organization, Geneva, 1925-1932; Vice-President, U. S. Steel Corporation, 1934-1937; Lecturer on Industrial Relations, Harvard Graduate School of Business Administration, 1929-1931, and Wharton School of Commerce and Industry, 1930-1937; Consulting Professor of Industrial Relations, Leland Stanford University, 1937-. California Institute, 1939-

Athenæum

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

Richard McLean Badger, Ph.D.

Associate 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, 1929-1938; Associate Professor, 1938-

215 Highland Place, Monrovia

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, La Canada

Frederick J. Converse, B.S.

Associate 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, 1933-1939; Associate Professor, 1939-

2167 Lambert Drive

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

Jesse William Monroe DuMond, Ph.D.

Associate Professor of 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; Acting Associate Professor of Physics, Stanford University, 1931. Research Associate, California Institute, 1931-1938; Associate Professor, 1938-

1585 Homewood Drive, Altadena

Harvey Eagleson, Ph.D.

Associate 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. Assistant Professor, California Institute, 1928-1938; Associate Professor, 1938-

Blacker House

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. Assistant Professor, California Institute, 1928-1937; Associate Professor, 1937-. California Institute, 1928-

391 South Wilson Avenue

Philip Shearer Fogg, M.B.A.

Associate Professor of Business Economics
Registrar

A.B., Stanford University, 1925; M.B.A., Harvard University, 1929. Instructor, American Institute of Banking, 1932-1938; Instructor in Economics, California Graduate School of Design, 1937-; Assistant Professor of Business Economics, California Institute, 1930-1938; Associate Professor, 1938-

1273 San Pasqual Street

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, 1928-1929. 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, 1929-1939. 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, Altadena

Arié 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-

351 South Parkwood Avenue

William Huse, M.A.

Associate 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. Assistant Professor, California Institute, 1929-1938; Associate Professor, 1938-

3676 Yorkshire Road

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, 1936-. Instructor, California Institute, 1922-1930; Assistant Professor, 1930-1936; Associate Professor, 1936-

549 East California Street

IRVING PARKHURST KRICK, PH.D.
Associate 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, 1935-1938; Associate Professor, 1938-

2174 San Pasqual Street

FREDERICK CHARLES LINDVALL, PH.D.
Associate Professor of Electrical and Mechanical 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-

95 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

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

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

ERNEST HAYWOOD SWIFT, PH.D.

Associate 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, 1928-1938; Associate Professor, 1938-

3140 East California Street

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

Associate Professor of Economics and History
Dean of Freshmen

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-

265 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-

1025 San Pasqual 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

DONALD PORTER BARNES, M.S.
Resident Engineer at the California Institute
(U. S. Bureau of Reclamation)

B.S., Oregon State College, 1928; M.S., California Institute of Technology, 1930. Designer, Pasadena Water Department, 1930-1931; Instructor in Civil Engineering, Missouri School of Mines and Metallurgy, 1931-1932; American Society of Civil Engineers Freeman Scholar in Europe, 1932-1933. Assistant Engineer, Metropolitan Water District of Southern California, 1933-1934; Assistant Engineer, U. S. Bureau of Reclamation (Denver), 1934-1936; Associate Engineer, U. S. Bureau of Reclamation (Denver), 1936-1937; Resident Engineer, U. S. Bureau of Reclamation, California Institute, 1937-

223 West Laurel, Sierra Madre

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

JAMES FREDERICK BONNER, PH.D.

Assistant Professor of 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, 1936-1938; Assistant Professor, 1938-

406 South Chester Avenue

A. PERRY BANTA, M.S.

Assistant Professor of Sanitary Engineering

A.B. in Civil Engineering, Stanford University, 1926; M.S., California Institute of Technology, 1928. Assistant in Surveying and Structural Design, Stanford University, 1924-1926; Teaching Fellow, California Institute, 1926-1927; Designer with Quinton, Code & Hill, 1927; Assistant Engineer, Los Angeles County Sanitation Districts, 1927-. Assistant Professor, California Institute, 1939-

159 Sierra View Road

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. Trustee, American Society for Metals, 1938-. Assistant and Teaching Fellow, California Institute, 1929-1934; Instructor, 1934-1937; Assistant Professor, 1937-

Dabney 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

HORACE J. FRASER, PH.D.

Assistant Professor of Mineralogy and Metalliferous Geology

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

WILLIAM ALFRED FOWLER, PH.D.

Assistant Professor of Physics

B.Eng.Physics, Ohio State University, 1933; Ph.D., California Institute of Technology, 1936. Research Fellow, California Institute, 1933-1939; Assistant Professor, 1939-

Athenæum

*On leave of absence, 1937-1940.

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

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

ROBERT MINSSEN KLEINPELL, PH.D.
Assistant Professor of Micropaleontology

A.B., Occidental College, 1926; A.M., Stanford University, 1928; Ph.D., 1934. Field geologist, Richfield Oil Company, 1928-1931. Assistant Geologist, United States Geological Survey, 1931-1937. Consulting Geologist, 1937-. Assistant Professor, California Institute, 1939-

ALBERT EATON LOMBARD, JR., PH.D.
Assistant Professor of Aeronautics and Mechanical Engineering

B.S., California Institute, 1928; M.S., 1929; Ph.D., 1939. Assistant in Mathematics, California Institute, 1928-1929. Structural, Aerodynamics, Research and Consulting Engineer, Curtiss-Wright Corporation, 1929-1939. Teaching Fellow in Applied Mechanics and Aeronautics, California Institute, 1937-1939; Assistant Professor of Aeronautics and Mechanical Engineering, 1939-

765 S. Hudson Avenue

GEORGE EBER MACGINITIE, M.A.
Assistant Professor of Biology
In charge of William G. Kerckhoff Marine Laboratory

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

JOHN H. MAXSON, PH.D.
Assistant Professor of Geology

B.S., California Institute of Technology, 1927; M.S., 1928; Ph.D., 1931. Teaching Fellow, California Institute, 1928-1931; Instructor, 1931-1938, Assistant Professor, 1938-. Geologist, Petrol Grubu, Maden Tetkik ve Arama Enstitusu, Republic of Turkey, 1936-1937; Research Associate, Carnegie Institution of Washington, 1933-. California Institute, 1928-

1965 Galbreth Road, Altadena

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

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, 1933-1937; Assistant Professor, 1937-

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 of the General Education Board at the Rockefeller Institute for Medical Research, 1935-1936; Assistant in Chemistry, 1936-1937; Fellow of the Rockefeller Foundation at the University College Hospital Medical School, 1937-1938. Assistant Professor, California Institute, 1937-

Johannes van Overbeek, Ph.D.

Assistant Professor of Plant Physiology

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, 1937-1939; Assistant Professor, 1939-

863 North Sunset Boulevard, Arcadia

Dwight L. Palmer, Ph.D.

*Visiting Assistant Professor of Industrial Relations**

A.B., Pomona College, 1925; M.A. in Business Administration, University of Chicago, 1926; Ph.D., Stanford University, 1935. Laura Spelman Fellow, School of Commerce and Administration, University of Chicago, 1925-1926; Research Department, Bullock's, Los Angeles, 1927-1928; Instructor in Economics and Sociology, Beloit College, 1928-1930; Instructor in Economics, Stanford University, 1930-1935; Economist, California State Unemployment Commission, 1932; Staff Economist, National Longshoreman's Board, 1934; Research Fellow of the Social Science Research Council, 1936-1938; Assistant Professor of Economics, Massachusetts Institute of Technology, 1938-. California Institute, 1939-

528 South Hudson Avenue

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

Robert Ross, Ph.D.

Visiting Lecturer in Psychology

B.S., California Institute of Technology, 1927; A.M., University of Southern California, 1930; Ph.D., Yale University, 1934. Graduate Assistant in Public Address, Pomona College, 1928-1929; Instructor, 1929-1930; Resident Assistant to the Dean, 1930-1931; Instructor in Psychology, 1930-1932; University Fellow in Psychology, Yale University, 1933-1934; Instructor, 1934-1936; Assistant Professor of Psychology, Stanford University, 1936-. California Institute, 1938-

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 Drive, Altadena

---

*On leave from the Massachusetts Institute of Technology.

WILLIAM REES SEARS, PH.D.

Assistant Professor of Aeronautics

B.Aero.E., University of Minnesota, 1934; Ph.D., California Institute of Technology, 1938. Assistant in Aeronautics, California Institute, 1934-1937; Instructor, 1937-1939; Assistant Professor, 1939-

1320 Fay Place

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, PH.D.*

Assistant Professor of History

B.A., University of Toronto, 1927; M.A., University of Alberta, 1930; Ph.D., Stanford University, 1938. 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

JOHN DONOVAN STRONG, PH.D.

Assistant Professor of Physics in Astrophysics

A.B., University of Kansas, 1926; M.S., University of Michigan, 1928; Ph.D., 1930. National Research Fellow, California Institute of Technology, 1932-1935; Research Fellow, 1932-1935; Senior Fellow in Research, 1935-1938; Assistant Professor, 1938-

1427 Monte Vista Street

JAMES HOLMES STURDIVANT, PH.D.

Assistant Professor of Chemistry

B.A., University of Texas, 1926; M.A., 1927; Ph.D., California Institute of Technology, 1930. Instructor, University of Texas, 1926-1927. Teaching Fellow, California Institute of Technology, 1927-1930; Research Fellow, 1930-1935; Senior Fellow in Research, 1935-1938; Assistant Professor, 1938-

Athenæum

ALBERT TYLER

Assistant Professor of Embryology

A.B., Columbia University, 1926; A.M., 1927; Ph.D., California Institute of Technology, 1929. Assistant in Zoology, Columbia University, 1927-1928; National Research Fellow in Biology at Berlin and Naples, 1932-1933; Teaching Fellow, California Institute of Technology, 1928-1929; Instructor, 1929-1938; Assistant Professor, 1938-

896 Granite Drive

---

*On leave of absence, 1939-1940.

HOWELL NEWBOLD TYSON, B.S.

Assistant Professor of Mechanical Engineering and Engineering Drafting

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, 1936-1939; Assistant Professor, 1939-

505 South Wilson Avenue

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

MARSHALL YATES KREMERS, M.D.

Assistant to the Consulting Physician

A.B., Occidental College, 1930; M.A., University of California, 1932; M.D., 1935.

1510 Harding Avenue

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; in charge of field explorations for Vertebrate Paleontology, 1935-1936; Geologist, Foreign Service, Standard Oil Company of California, in Abyssinia, Eritrea, Somalia, Egypt, Italy, 1937-1939. Instructor in Geology, California Institute, 1936-

2066 Galbreth Road, Altadena

ROBERT B. COREY, PH.D.

Senior Fellow in Chemical 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, 1930-1937. California Institute, 1937-

352 South Parkwood 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-

1755 Orangewood Street

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-

515 South El Molino Avenue

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

RAYMOND ALFRED PETERSON, PH.D.
Instructor in Geophysics

B.S., California Institute of Technology, 1931; Ph.D., 1935. Geophysical Engineering Corp., 1935-1938; United Geophysical Co., 1938-. California Institute, 1931-

1813 Euclid Avenue, San Marino

WILLIAM HAYWARD PICKERING, PH.D.
Instructor in History and Electrical Engineering and Research Fellow in Physics

B.S., California Institute of Technology, 1932; M.S., 1933; Ph.D., 1936. Lecturer in Physics, University of Southern California, 1938. Graduate Assistant and Teaching Fellow, California Institute, 1932-1936; Instructor, 1936-

KERMIT ROOSEVELT, JR., A.B.
Instructor in History

A.B., Harvard College, 1937 (as of 1938). Assistant in History, Harvard University, 1937-1939. California Institute, 1939-

717 South Catalina Avenue

PAUL E. RUCH, B.S.
Instructor in Synoptic Meteorology

B.S. in Engineering Administration, Massachusetts Institute of Technology, 1928; M.S. in Meteorology, California Institute of Technology, 1939. Instructor, California Institute, 1938-

2244 North Craig Avenue

FRANCES HALSEY SPINING
Librarian

California Institute, 1914-

1067 North Catalina Avenue

HOMER JOSEPH STEWART, B.Aero.E.
Instructor in Dynamic Meteorology

B.Aero.E., University of Minnesota, 1936. Assistant in Aeronautics, California Institute of Technology, 1936-1938; Instructor, 1938-

314 South Michigan Avenue

VICTOR V. VEYSEY, M.B.A.

Instructor in Economics and Accounting
Research Fellow in Industrial Relations; Resident Associate in Fleming House

B.S., California Institute of Technology, 1936; M.B.A., Harvard University, 1938. Instructor, California Institute, 1938-

Fleming House

NATHANIEL W. WILCOX, A.B.

Instructor in Engineering Drawing

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

369 South Lake Avenue

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. Assistant Professor of Physics, Occidental College, 1936-. Research Fellow, California Institute, 1933-

1600 Campus Road, Los Angeles

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-. Research Fellow, California Institute, 1935-

412 South Chevy Chase Drive, Glendale

ROLAND A. BUDENHOLZER, PH.D.

Research Fellow in Chemical Engineering[1]

B.S., New Mexico State College, 1935; M.S., California Institute of Technology, 1937; Ph.D., 1939. Research Fellow, California Institute, 1939-

177 South Mentor Avenue

JAMES WALLACE DAILY, M.S.

Research Fellow in Hydraulic Machinery

A.B., Stanford University, 1935; M.S., California Institute of Technology, 1937. Graduate Assistant, California Institute, 1936-1938; Research Assistant, 1938-1939; Research Fellow, 1939-. Manager, Hydraulic Machinery Laboratory, 1937-

518 North Madison Avenue

THOMAS HARRISON DAVIES, PH.D.

National Research Fellow in Medicine

B.A., Johns Hopkins University, 1935; Ph.D., Johns Hopkins University School of Medicine, 1938. Research Fellow, California Institute, 1938-

115 North El Molino Avenue

---

[1]American Petroleum Institute Fellow.

ALEXIS A. B. DEMBER, D.SC.

Research Fellow in Physics[1]

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

1459 Rose Villa Street

WALTER M. ELSASSER, PH.D.

Research Fellow in Meteorology

Ph.D., University of Göttingen, 1927. Assistant in Theoretical Physics, University of Frankfurt (Germany), 1930-1933; Research Fellow, Institut Henri Poincaré, Sorbonne, Paris, 1933-1936; Research Division, United States Weather Bureau, 1938. Research Fellow, California Institute, 1937-

124 El Nido Avenue

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; Resident Doctor, 1931-1937. California Institute, 1937-

1491 North Holliston Avenue

EDWARD H. HUGHES, PH.D.

Research Fellow in Chemistry

B.Chem., Cornell University, 1924; Ph.D., 1935. Resident Doctor, 1935-1938. Research Fellow, California Institute, 1938-

Athenæum

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

HERMAN M. KALCKAR, M.D.

International Research Fellow of the Rockefeller Foundation in Biology

M.D., University of Copenhagen, 1939. Instructor in Physiology, University of Copenhagen, 1935-1939. California Institute, 1939-

Athenæum

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, Occidental College, 1929-1930; Teaching Fellow, California Institute of Technology, 1930-1931; Assistant Professor, University of Hawaii, 1931-1935; Assistant Professor, Occidental College, 1935-1936; Acting Head of Department, 1936-1937; Associate Professor and Head of Department, 1937-. California Institute, 1936-

1555 North Avenue Forty-Six, Los Angeles

SPIRO KYROPOULOS, PH.D.

Research Fellow in Physics[1]

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-

1936 Mill Road, South Pasadena

[1]Rare Metals Research Fund.

RUDOLPH M. LANGER, PH.D.
Research Fellow in Physics

B.S., College of the City of New York, 1920; M.A., Columbia University, 1921; Ph.D., California Institute of Technology, 1927. Assistant Physicist, Naval Research Laboratory, 1926-1927; National Research Fellow in Physics, Bureau of Standards, 1927-1929; University of Berlin, 1929-1930; Assistant Professor of Physics, Massachusetts Institute of Technology, 1930-1931; Professorial Lecturer in Physics, University of Minnesota, 1931-1932. Research Fellow in Physics, California Institute, 1932-

496 Astabula Street

HENRI A. LÉVY, PH.D.
Research Fellow in Chemistry

B.S., California Institute of Technology, 1935; Ph.D., 1938. Research Fellow, California Institute, 1938-

2016 Edgewood Drive, South Pasadena

HANS WOLFGANG LIEPMANN, D.PHIL.
Research Fellow in Aeronautics

Dr.Phil., University of Zurich, 1938. Research Fellow, University of Zurich, 1938-1939. Recipient of the prize in physics of the Philosophical Faculty, Zurich, 1939. California Institute, 1939-

123 North Michigan Avenue

PAUL EUGENE LLOYD, PH.D.
Research Fellow in Physics

B.A., Stanford University, 1929; Ph.D., California Institute of Technology, 1937. Instructor, Oberlin College, 1938. Research Fellow, California Institute, 1938-

3311 Lowry Road, Los Angeles

CHIA-SI LU, PH.D.
Sino-British Boxer Indemnity Fund Scholar in Chemistry

B.Sc., University of Amoy, 1934; Ph.D., University of London, 1939. California Institute, 1939-

420 South Wilson Avenue

GEORGE MARMONT, B.S.
Hixon Fund Fellow in Neurology

B.S., California Institute, 1934. California Institute, 1939-

Athenæum

SETH HENRY NEDDERMEYER, PH.D.
Research Fellow in Physics

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

306 South El Molino Avenue

DARRELL WAYNE OSBORNE, PH.D.
Arthur A. Noyes Fellow in Chemistry

A.B., University of California at Los Angeles, 1935; Ph.D., California Institute of Technology, 1938. California Institute, 1938-

5130 Coringa Drive, Los Angeles

ARTHUR N. PRATER, PH.D.
Hawaiian Pineapple Producers Cooperative Association Fellow in Bio-Organic Chemistry

B.A., University of California at Los Angeles, 1932; M.S., California Institute of Technology, 1933; Ph.D., 1935. Research Assistant, California Institute, 1938-1939; Research Fellow, 1939-
565 South Wilson Avenue

JOHN R. RAPER, PH.D.
National Research Fellow in Botany

A.B., University of North Carolina, 1933; M.A., University of North Carolina, 1936; M.A., Harvard University, 1939; Ph.D., Harvard University, 1939. California Institute, 1939-
1148 Constance Street

VERNER SCHOMAKER, PH.D.
George Ellery Hale Fellow in Chemistry

B.S., University of Nebraska, 1934; M.S., 1935; Ph.D., California Institute of Technology, 1938. California Institute, 1938-
2016 Edgewood Drive, South Pasadena

DAVID P. STEVENSON, PH.D.
Research Fellow in Chemistry[1]

B.S., University of California, 1934; Ph.D., Princeton University, 1938. California Institute, 1938-
2016 Edgewood Drive, South Pasadena

ARTHUR J. STOSICK, PH.D.
Research Fellow in Chemistry

B.S., University of Wisconsin, 1936; Ph.D., California Institute of Technology, 1939. Research Fellow, California Institute, 1939-
241 South Holliston Avenue

RALPH L. TRACY, PH.D.
Research Fellow in Bio-Physics[2]

A.B., Stanford University, 1930; M.A., University of California, 1932; Ph.D., University of Southern California Medical School, 1937. Research Assistant, California Institute, 1938-1939, Research Fellow, 1939-
258 South Hudson Avenue

HSUE-SHEN TSIEN, PH.D.
Research Fellow in Aeronautics

B.S. in M.E., Chiao-Tung University, 1934; M.S. in A.E., Massachusetts Institute of Technology, 1936; Ph.D., California Institute of Technology, 1939. 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

---

[1]Asphalt Institute Fellow.
[2]Rare Metals Research Fund.

RICHARD ERNEST VOLLRATH, PH.D.
Research Fellow in Astrophysics

B.A., Johns Hopkins University, 1926; Ph.D., 1929. National Research Fellow in Physics, California Institute of Technology, 1929-1931; Associate Professor of Physics, University of Southern California, 1931-. California Institute, 1938-

1818 Mission Street, South Pasadena

HAROLD WAYLAND, PH.D.
Research Fellow in Physics

B.S., University of Idaho, 1931; M.S., California Institute of Technology, 1935; Ph.D., 1937. Teaching Fellow, California Institute, 1931-1934; Instructor, University of Idaho, 1934-1935; American-Scandinavian Foundation Fellow, University of Copenhagen, 1936-1937; Assistant Professor of Physics, University of Redlands, 1938-. Research Assistant, California Institute, 1938-1939; Research Fellow, 1939-

937 College Avenue, Redlands

SIDNEY WEINBAUM, PH.D.
Research Fellow in Chemistry

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

1171 Steuben Street

J. NORTON WILSON, PH.D.
Research Fellow in Chemistry

B.A., University of British Columbia, 1934; M.A., 1936; Ph.D., California Institute of Technology, 1939. California Institute, 1939-

2016 Edgewood Drive, South Pasadena

REUBEN E. WOOD, PH.D.
Research Fellow in Chemistry

B.S., California Institute of Technology, 1936; M.S., University of Chicago, 1937; Ph.D., California Institute of Technology, 1939. California Institute, 1939-

338 Highland Place, Monrovia

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, 1919-1932. California Institute, 1932-

1477 North Holliston Avenue

LLOYD ZUMWALT, PH.D.
Arthur A. Noyes Fellow in Chemistry

B.S., University of California, 1936; Ph.D., California Institute of Technology, 1939. California Institute, 1939-

2016 Edgewood Drive, South Pasadena

RESEARCH ASSISTANTS

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 Co-operative 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 of Technology, 1932; M.S., in Aero., 1938. California Institute, 1932-

2067 Paloma Street

Samuel J. Broadwell, Ph.D.
Research Assistant in Physics

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

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-

111 Harkness Avenue

Emory L. Ellis, Ph.D.
Research Assistant in Biology

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

432 North San Marino Avenue, San Gabriel

Andrew Fejer, M.E.
Research Assistant in Hydraulic Machinery

M.E., Technische Hochschule at Prague, Czechoslovakia, 1936; B.S., California Institute of Technology, 1938. California Institute, 1939-

615 South El Molino Avenue

George Alexander Feigen, A.B.
Research Assistant in Pharmacology

A.B., University of California Medical School, 1938. California Institute, 1939-

658 South Hudson Avenue

---

[1]Soil Conservation Service, Department of Agriculture.

EDWARD SEYMOUR FORMAN
Research Assistant in Aeronautics

Repair and Maintenance, United Aviation and Parachute Service, 1934-1936; Plant Maintenance Engineer, Halifax Explosives Company, 1936-1937; in charge of Skin Department, Lockheed Aircraft Corporation, 1937-1938. California Institute, 1939-

1165 Summit Avenue

SIDNEY FOX, B.A.
Research Assistant in Chemistry

B.A., University of California at Los Angeles, 1938. California Institute, 1935-

1100 East Del Mar Street

EUSTACE L. FURLONG
Curator in Vertebrate Paleontology

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

270 South Roosevelt Avenue

JOHN BURTON HATCHER, M.S.
Research Assistant in Biology

B.S., California Institute of Technology, 1937; M.S., 1938. California Institute, 1939-

105B South Mentor Avenue

ERIK HEEGAARD, B.S.
Research Assistant in Chemistry

B.S., Danmarks Tekniske Hjskole, Copenhagen, 1936. Research Chemist, Danmarks Tekniske Hjskole, 1937. California Institute, 1938-

290 South Michigan Avenue

ROBERT GEORGE HELFER, B.S.
Research Assistant in Biology

B.S., Baldwin-Wallace College, 1936. Graduate Assistant, California Institute, 1936-1939; Research Assistant, 1939-

1150 South Los Robles Avenue

GEOFFREY KEIGHLEY, B.A.
Research Assistant in Biology

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

237 West Las Flores Drive, Altadena

JUSTUS G. KIRCHNER, PH.D.
Research Assistant in Organic Chemistry

B.S., Creighton University, 1935; Ph.D., Iowa State University, 1939. California Institute, 1939-

120 North Mentor Avenue

HENRY LANZ, JR., A.B.
Research Assistant in Microanalysis

A.B., Stanford University, 1936. Research Fellow, Carlsberg Laboratory, Copenhagen, 1936-1938; Medeziniche-Chemiches Institut der Universität, Graz, Austria, 1938; Research Assistant, Stanford University, 1938-1939. California Institute, 1939-

68 North Hill Avenue

JOSEPH LEVY, M.S.
Research Assistant in Hydraulic Machinery

B.S., University of California, 1937; M.S., 1939. California Institute, 1939-
314 South Hill Avenue

FRANK JOSEPH MALINA, M.S.
Research Assistant in Hydraulics[1]

B.S., Texas Agricultural and Mechanical College, 1934; M.S., California Institute of Technology, 1935 and 1936. Assistant and Teaching Fellow, California Institute, 1936-1939; Research Assistant, 1939-
1288 Cordova Street

WALTER L. MOORE, M.S.
Research Assistant in Hydraulics[1]

B.S., California Institute, 1937; M.S., 1938. Designer, U. S. Army Engineering Office, 1938. California Institute, 1939-
246 South Grand Oaks Avenue

GEORGE MORIKAWA, B.S.
Research Assistant in Hydraulic Machinery

B.S., California Institute of Technology, 1939. California Institute, 1939-
Dormitory

BROOKS T. MORRIS, C.E.
Research Assistant in Hydraulic Machinery[1]

A.B., Stanford University, 1934; C.E., 1938. Research Assistant, California Institute, 1938-
2059 Navarro 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-
157 South Wilson Avenue

JOHN WHITESIDE PARSONS
Research Assistant in Aeronautics

Chief Chemist, Halifax Explosives Company, 1935-1938; Explosives Expert, Los Angeles District Attorney's Office, 1938-1939. California Institute, 1939-
168 Terrace Drive

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

[1]Soil Conservation Service, Department of Agriculture.

C. Ernst Redemann, B.A.
Research Assistant in Chemistry

B.A., University of California at Los Angeles, 1931. Associate, University of California at Los Angeles, 1931-1939; Graduate Student, California Institute, 1936-1939. California Institute, 1939-

8306 Melrose Avenue, Los Angeles

Alf Reims, Ch.E.
Research Assistant in Chemistry

Ch.E., Abo Akademi, Finland, 1937. Assistant in Chemistry, Abo Akademi, 1937. California Institute, 1938-

940 Del Mar Street

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

Robert A. Ruehrwein, Ph.D.
Research Assistant in Biology

A.B., University of Montana, 1936; Ph.D., University of California, 1939. California Institute, 1939-

1148 Constance Street

Peter V. H. Serrell, M.S.
Research Assistant in Aeronautics

B.S., California Institute of Technology, 1936; M.S., 1939. California Institute, 1938-

907 Cornell Road

Solomon Shankman, Ph.D.
Research Assistant in Biology

B.A., University of Toronto, 1936; M.A., 1937; Ph.D., 1939. California Institute, 1939-

4449 Clarissa Street, Los Angeles

Edward E. Simmons, Jr., M.S.
Research Assistant in Mechanical Engineering[2]

B.S., California Institute of Technology, 1934; M.S., 1936. Research Assistant, California Institute, 1936-

211 North Dillon Street, Los Angeles

Carl L. Thiele, M.S.
Research Assistant in Aeronautics

B.S., California Institute of Technology, 1932; M.S., 1933. Research Assistant, California Institute, 1938-

423 South Chester Avenue

Kenichi Watanabe, B.S.
Research Assistant in Astrophysics

B.S., California Institute of Technology, 1936. Graduate Assistant, California Institute, 1936-1939; Research Assistant, 1939-

320 Bueno Loma Court, Altadena

---

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

CECIL Z. WAWRA, B.S.
Research Assistant in Chemistry

B.S., Sorbonne, Paris, 1934. Chemical Engineer, University of Geneva, 1934-1938. California Institute, 1939-

664 South Lake Avenue

JOHN L. WEBB, B.S.
Research Assistant in Bio-Organic Chemistry

B.S., California Institute of Technology, 1936. Research Assistant, California Institute, 1938-

124 West Glenarm Street

DAVID P. WILLOUGHBY
Scientific Illustrator in Vertebrate Paleontology

Medical Artist and Illustrator in Vertebrate Paleontology, 1929-1936; Scientific Artist, Federal Art Project, Los Angeles County Museum, 1936-1937. California Institute, 1938-

1516 Camden Avenue, West Los Angeles

FLOYD L. HANES, D.O.
Physical Trainer

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

2115 Layton Avenue

LEON V. METCALF, M. MUS.
Director of Orchestra and Glee Club; Assistant Director of Institute Band

Graduate of Music, University of Wisconsin, 1925; B. Mus. Ed., Northwestern University, 1928; M. Mus. (composition), University of Michigan, 1934. Instructor of Music, Grand Rapids Public Schools, 1925-1927; Gary Public Schools, 1928-1930; Director of Instrumental Music, Hartland Area Project (Michigan), 1930-1937; Instructor, Northwestern University, summers of 1928 and 1929; Instructor, National Music Camp, Interlochen, Michigan, summer, 1930; Professor, University of Montana, summers of 1936 and 1937. Director of Orchestra and Glee Club, Assistant Director of Band, California Institute, 1938-

395 South Carmelo Avenue

AUDRE L. STONG, M.S.
Director of Institute Band

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

2051 Jefferson Drive

TEACHING FELLOWS AND GRADUATE ASSISTANTS

Lewis Harry Abraham . . . . Aeronautics
B.S., State College of the University of North Carolina, 1938

Carl Odman Alexis . . . . Geology
A.B., University of Nebraska, 1937; M.S., University of Arizona, 1940

O'Dean Anderson . . . . Civil Engineering
B.S., Utah State Agricultural College, 1938

John Shoichi Atsumi . . . . Aeronautics
B.S., University of Southern California, 1932; M.S.E., University of Michigan, 1935

Sherwin Parker Avann . . . . Mathematics
B.S., University of Washington, 1938

Joseph M. Axelrod . . . . Chemistry
B.S., California Institute, 1937; M.S., 1938

Howland Haskell Bailey . . . . Physics
A.B., Haverford College, 1932

Robert Adolph Becker . . . . Physics
B.S., College of Puget Sound, 1935; M.S., California Institute, 1937

Francis Wendell Beichley . . . . Electrical Engineering
B.S., Kansas State College of Agriculture and Applied Arts, 1937

Richard William Bell . . . . Aeronautics
B.A., Oberlin College, 1939

Steven Eric Belsley . . . . Aeronautics
B.S., Purdue University, 1938; B.S. in AE., California Institute, 1939

Andrew Alm Benson . . . . Chemistry
B.S., University of California, 1939

David Joseph Bohm . . . . Physics
B.S., Pennsylvania State University, 1939

David Mahlon Bonner . . . . Biology
B.A., University of Utah, 1936

Neil Erasmus Borgquist . . . . Civil Engineering
B.S., University of Arizona, 1939

Daniel Funderburg Botkin . . . . Chemistry
B.S., New Mexico College of Agriculture and Mechanical Arts, 1939

Hugh Bradner . . . . Physics
A.B., Miami University, 1936

James William Braithwaite . . . . Aeronautics
B.S., California Institute, 1939

Frederick Martin Brasch . . . . Meteorology
A.B., Nebraska Wesleyan University, 1939

Emil Joseph Burcik . . . . Chemistry
B.S., Carnegie Institute of Technology, 1937

Ralph Edward Byrne, Jr. . . . . Civil Engineering
B.S., California Institute, 1933; M.S., 1934

John Bell Cabell . . . . Civil Engineering
B.S., Virginia Military Institute, 1937

Richard Bruce Canright . . . . Physics
A.B., Miami University, 1939

Charles Frederick Carstarphen . . . . Mechanical Engineering
B.S., California Institute, 1939

Robert Trissel Carter . . . . Chemistry
B.S., California Institute, 1939

Robert Little Caswell . . . . Chemistry
B.S., University of California, 1939

Robert Alonzo Cooley . . . . Chemistry
B.S., University of California, 1938

James Vaile Crawford . . . . Mechanical Engineering

Harold Brown Crockett . . . . Aeronautics
B.S. and M.S., University of Texas, 1939

Leverett Davis, Jr. . . . . Physics
B.S., Oregon State College, 1936; M.S., California Institute, 1938

Philip Sarkis Devirian . . . . Mechanical Engineering
B.S., California Institute, 1939

Barry Dibble, Jr. . . . . Physics
B.S., California Institute, 1939

John Andrew Dilworth, III . . . . Aeronautics
B.S., Louisiana State University, 1939

Russell Nimtz Doescher . . . . Chemistry
B.S., California Institute, 1933; M.S., 1934

Louis Gerhardus Dunn . . . . Aeronautics
B.S., California Institute, 1936; M.A., 1938

Paul Oscar Engelder . . . . Electrical Engineering
B.S., California Institute, 1939

John C. Evvard . . . . Physics
B.S., California Institute, 1939

Charles Fink Fischer . . . . Aeronautics
B.S., United States Naval Academy, 1934

Harold Fischer . . . . Aeronautics
B.A., University of California at Los Angeles, 1938; B.S. in AE., California Institute, 1939

Joseph Louis Fredrick . . . . Aeronautics
B.S., Louisiana State University, 1938; B.S. in AE., California Institute, 1939

Hugo Gabriel . . . . German
Ph.D., University of Cologne, 1928

Walter Henry Gage . . . . Physics
B.A., University of British Columbia, 1925; M.A., 1926

Edward Victor Gant . . . . Civil Engineering
B.E., Vanderbilt University, 1939

Wendell Oliver Gould, Jr. . . . . Physics
B.S. and M.S., Washington State College, 1930

William Jeffrey Green . . . . Meteorology
B.A., University of Manitoba, 1938

Chris Gregory . . . . Physics
B.S., California Institute, 1938; M.S., 1939

Isaac Gringorten . . . . Meteorology
B.A., University of Toronto, 1935; M.A., 1936

Forrest Holt Hall . . . . Civil Engineering
B.S., Colorado State College, 1939

Byron Luther Havens . . . . Electrical Engineering
B.S., University of Washington, 1938; M.S., California Institute, 1939

John Thomas Hays, Jr. . . . . Chemistry
B.S., Montana State College, 1935; B.A., Oxford University, 1937; B.Sc., 1938

Paul Carrington Henshaw . . . . Geology
A.B., Harvard College, 1936; M.S., California Institute, 1938

Eustace Plumb Hetzel . . . . Aeronautics
B. of AE., Rensselaer Polytechnic Institute, 1939

Harold Elston Heywood . . . . Mechanical Engineering
B.S., Oklahoma Agricultural and Mechanical College, 1939

John Marshall Holloway . . . . Geology
B.S., University of Manitoba, 1937

Pierre Marcel Honnell . . . . Electrical Engineering
B.Sc., Agricultural and Mechanical College of Texas, 1930; E.E., 1938; M.Sc., Massachusetts Institute, 1939

George William Housner . . . . Civil Engineering
B.S. in CE. and B.S. in Ma., University of Michigan, 1933; M.S., California Institute, 1934

Benjamin Franklin Howell . . . . Geology
A.B., Princeton University, 1939

William Jasper Howell, Jr. . . . . Chemistry
B.A., Swarthmore College, 1938

Robert Beck Hoy . . . . Geology
B.S., Lafayette College, 1937; M.S., California Institute, 1939

Chao-Wang Hsueh . . . . Physics
B.S., National University of Peking, 1931; M.S., California Institute, 1939

Donald Ellis Hudson . . . . Mechanical Engineering
B.S., California Institute, 1938; M.S., 1939

John Warren Jackson . . . . Mechanical Engineering
B.S., University of Cincinnati, 1934; ME., 1937

Leon Katz . . . . Physics
B.Sc., Queen's University, 1934; M.Sc., 1937

Harold Francis Kleckner . . . . Aeronautics
B.S., University of Illinois, 1939

Ellis Lapin . . . . Aeronautics
B.S., Drexel Institute of Technology, 1939

Joseph Pierre LaSalle . . . . Physics
B.S., Louisiana State University, 1937

John Jacob Lentz . . . . Electrical Engineering
B.S., California Institute, 1938; M.S., 1939

Edward Butts Lewis, Jr. . . . . Biology
B.A., University of Minnesota, 1939

Lloyd Alan Lewis . . . . Geology
E.M., University of Minnesota, 1938

Richard Newton Lewis . . . . Chemistry
A.B., University of California, 1937; B.A., Oxford University, 1938

William Dabney Lewis . . . . Geology
A.B., Denison University, 1938

James Ellis LuValle . . . . Chemistry
B.A., University of California at Los Angeles, 1936; M.A., 1937

Channing Bruce Lyon . . . . Biology
B.S., University of Nebraska, 1938; M.S., University of Chicago, 1939

Don Stanley Martin, Jr. . . . . Chemistry
B.S., Purdue University, 1939

William James McGill . . . . Geology
B.Sc., Queen's University, 1937; M.Sc., 1939

Willard Lee McRary . . . . Biology
B.S., California Institute, 1936; M.S., 1938

James Franklyn Mead . . . . Chemistry
A.B., Princeton University, 1938

Charles Baker Metz . . . . Biology
A.B., Johns Hopkins University, 1939

A. Boyd Mewborn . . . . Mathematics
B.S., University of Arizona, 1927; M.S., 1933

Dwight Dana Miller . . . . Biology
A.B., Whittier College, 1937

Walter Heinrich Munk . . . . Modern Languages
B.S., California Institute, 1939

Henry Takeshi Nagamatsu . . . . Aeronautics
B.S., California Institute, 1938; B.S. in AE., 1939

William Francis Nash, Jr. . . . . Mechanical Engineering
B.S., California Institute, 1938; M.S., 1939

Peter L. Nichols, Jr. . . . . Chemistry
B.A., Texas Christian University, 1938

Edward E. Novitski . . . . Biology
B.S., Purdue University, 1938

Richard Macy Noyes . . . . Chemistry
A.B., Harvard College, 1939

Robert Horner Olds . . . . Chemistry
B.S., California Institute, 1938; M.S., 1939

Justus Axel Olsson . . . . Civil Engineering
B.S., University of California, 1935

Guy Clifton Omer, Jr. . . . . Physics
B.S., University of Kansas, 1936; M.S., 1937

John William Otvos . . . . Chemistry
B.S., Harvard College, 1939

Wolfgang Kurt Hermann Panofsky . . . . Physics
A.B., Princeton University, 1938

Simon Pasternack . . . . Physics
B.Sc., University of Alberta, 1935; Ph.D., California Institute, 1939

Edmund Joy Pinney . . . . Mathematics
B.S., California Institute, 1939

Walter Brown Powell . . . . Aeronautics
B.A., Stanford University, 1937; B.S. in AE., California Institute, 1939

David Pressman . . . . Chemistry
B.S., California Institute, 1937; M.A., University of California at Los Angeles, 1938

William Duncan Rannie . . . . Aeronautics
B.A., University of Toronto, 1936; M.A., 1937

Robert Severin Rasmussen . . . . Chemistry
S.B., University of Chicago, 1938

Louis John Regan, Jr. . . . . Geology
B.S., California Institute, 1939

Ellis Earl Roberts . . . . Geology
B.S., Michigan College of Mining and Technology, 1937

Max Tofield Rogers . . . . Chemistry
B.Sc., University of Alberta, 1937; M.Sc., 1938

Edward Rosenthall . . . . Mathematics
B.Sc., McGill University, 1937; M.Sc., 1938

Sylvan Rubin . . . . Physics
B.S., California Institute, 1939

George Thomas Rudkin . . . . Biology
B.S., California Institute, 1938; A.M., Stanford, 1939

Lewis Benning Rumph, Jr. . . . . Aeronautics
B.S., Georgia School of Technology, 1933; M.S., 1936

Robert Eugene Rundle . . . . Chemistry
B.S., University of Nebraska, 1937; M.S., 1938

John Joseph Rupnik . . . . Geology
Geolog. Engineer, Colorado School of Mines, 1933

Horace Russell, Jr. . . . . Chemistry
B.S., Duke University, 1938

Paul Rome Saunders . . . . Biology
B.S., University of California, 1939

Maurice Jay Schlatter . . . . Chemistry
B.S., California Institute, 1938

Charles William Seekins . . . . Mathematics
A.B., Occidental College, 1938

Philip Anderson Shaffer, Jr. . . . . Chemistry
B.S., Harvard College, 1937

Alexander Smith . . . . Geology
B.A., University of British Columbia, 1932; M.A., 1933

Clay Taylor Smith . . . . Geology
B.S., California Institute, 1938

Jack Carlton Smith . . . . Physics
B.E., Ohio State University, 1935; M.Sc., 1936

Josiah Edward Smith . . . . Aeronautics
B.S., California Institute, 1939

Robert Beaton Smith . . . . Aeronautics
B.A., Ohio State University, 1936; M.S., California Institute, 1938

William Eugene Snow . . . . Geology
B.A.Sc., University of British Columbia, 1935; M.A.Sc., 1936

Ralph William Spitzer . . . . Chemistry
A.B., Cornell University, 1938

John Spizizen . . . . Biology
B.A., University of Toronto, 1939

Robert Anton Spurr . . . . Chemistry
A.B., Rollins College, 1936; B.S., 1937; M.S., Harvard University, 1938

Charles Edward Stearns . . . . Geology
A.B., Tufts College, 1939

Horton Guyford Stever . . . . Physics
B.A., Colgate University, 1938

William Thomas Stewart . . . . Chemistry
B.S., University of Arizona, 1937; M.S., 1938

Fred W. Stoltz . . . . Mechanical Engineering
B.S., Washington State College, 1937

John Frederick Streib, Jr. . . . . Physics
B.S., California Institute, 1936

Martin Summerfield . . . . Physics
B.S., Brooklyn College, 1936; M.S., California Institute, 1937

Herbert Clark Sumner . . . . Mechanical Engineering
B.A., Stanford University, 1939

Harold H. Sweberg . . . . Aeronautics
B.S., Louisiana State University, 1939

Jonathan Dean Swift . . . . Mathematics
A.B., University of California, 1939

Stanley Morse Swingle . . . . Chemistry
B.S., Montana State College, 1939

Robert Fulton Tangren . . . . Aeronautics
B.S., California Institute, 1939

J. Earl Thomas . . . . Physics
A.B., Johns Hopkins University, 1939

Everett Parsons Tomlinson . . . . Physics
B.S., Yale University, 1936

Karl Unholtz . . . . Electrical Engineering
B.S., California Institute, 1936; M.S., 1939

Edward Reginald Van Driest . . . . Civil Engineering
B.S., Case School of Applied Science, 1936; M.S., State University of Iowa, 1937

James Benson Vernon . . . . Aeronautics
B.S., University of Iowa, 1938; M.S., 1939

Charles Daniel Wagner . . . . Chemistry
A.B., Grinnell College, 1939

Austin Levy Wahrhaftig . . . . Chemistry
A.B., University of California, 1938

Robert Earl Wallace . . . . Geology
B.S., Northwestern University, 1938

Dana Bushnell Waring . . . . Mechanical Engineering
M.E., Cornell University, 1939

Jurg Heinrich Ernst Waser . . . . Chemistry
Federal Certificate of Maturity, University of Zurich, 1935

Waterman, Alan Tower, Jr. . . . . Meterology
A.B., Princeton University, 1939

Robert Lynn Wells . . . . Mechanical Engineering
B.S., University of Rochester, 1939

John Oswald Wessale . . . . Aeronautics
B.S., University of Iowa, 1939

William Owen Wetmore . . . . Mechanical Engineering
B.S., California Institute, 1937; M.S., 1939

Donald Bingham Wheeler, Jr. . . . . Physics
B.S., Lehigh University, 1938

John Shearon Wiggins . . . . Physics
A.B., Earlham College, 1936; M.S., California Institute, 1938

John Meincke Wild . . . . Aeronautics
B.S., Purdue University, 1937

Harry David Bruce Wilson . . . . Geology
B.Sc., University of Manitoba, 1936; M.S., California Institute, 1939

John Robert Woolson . . . . Mathematics
Ph.B., Gonzaga University, 1936; B.S., California Institute, 1938

Willis George Worcester . . . . Electrical Engineering
B.S., University of Colorado, 1939

Frederick Hamilton Wright . . . . Physics
B.A., Haverford College, 1934

Max Wyman . . . . Mathematics
B.Sc., University of Alberta, 1937

Russell Raymond Yost, Jr. . . . . Physics
B.S., Haverford College, 1939

Luke Chia-liu Yuan . . . . Meteorology
B.S., Yenching University, 1932; M.S., 1934

Abe Mordecai Zarem . . . . Electrical Engineering
B.S., Armour Institute of Technology, 1939

VISITORS FROM OTHER INSTITUTIONS FOR THE ACADEMIC YEAR 1939-1940

Henri Frederic Bohnenblust, Ph.D., Associate Professor of Mathematics, Princeton University.

Dan H. Campbell, Ph.D., Assistant Professor of Bacteriology, University of Chicago.

David N. Dennison, Ph.D., Professor of Physics, University of Michigan.

Henry E. Hartig, Ph.D., Associate Professor of Commercial Engineering, University of Minnesota.

Milton S. Plesset, Ph.D., Instructor in Physics, University of Rochester.

Tokitaro Saita, D.Eng., Member Earthquake Research Institute, Imperial University, Tokyo.

C. K. Sundarachar, M.A., Professor of Physics, Central College, Bangalore, India.

Roland R. Tileston, D.Sc., Professor of Physics, Pomona College.

STAFF OF INSTRUCTION AND RESEARCH SUMMARY

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

ROBERT A. MILLIKAN, *Chairman*

PROFESSORS

CARL D. ANDERSON	Physics
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
ARISTOTLE D. MICHAL	Mathematics
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

ASSOCIATE PROFESSORS

JESSE W. M. DUMOND	Physics
ALEXANDER GOETZ	Physics
FREDERICK C. LINDVALL	Electrical and Mechanical Engineering
S. STUART MACKEOWN	Electrical Engineering
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
WILLIAM A. FOWLER	Physics
FRANCIS W. MAXSTADT	Electrical Engineering
H. VICTOR NEHER	Physics
JOHN STRONG	Physics

INSTRUCTOR

William H. Pickering . . . . Electrical Engineering

RESEARCH FELLOWS IN PHYSICS

Verne L. Bollman
L. Reed Brantley
Alexis Dember[1]
Frederick R. Hirsh, Jr.
Harry A. Kirkpatrick
Spiro Kyropoulos[1]
Rudolph M. Langer
Paul Eugene Lloyd
Seth H. Neddermeyer
William H. Pickering
Ralph L. Tracy
Harold Wayland
J. Paul Youtz

TEACHING FELLOWS AND ASSISTANTS

Sherwin P. Avann
Howland H. Bailey[2]
Robert A. Becker[2]
Francis W. Beichley[2]
David J. Bohm
Hugh Bradner
Richard B. Canright
Leverett Davis, Jr.[2]
Barry Dibble, Jr.
Paul O. Engelder
John C. Evvard
Walter H. Gage[2]
Wendell O. Gould, Jr.[3]
Chris Gregory
Byron L. Havens[2]
Pierre M. Honnell[2]
Chao-Wang Hsueh
Leon Katz
Joseph P. LaSalle[3]
John J. Lentz
A. Boyd Mewborn
Guy C. Omer, Jr.
Wolfgang K. H. Panofsky[3]
Simon Pasternack
Edmund J. Pinney
Edward Rosenthall
Sylvan Rubin
Charles W. Seekins
Jack C. Smith[4]
Horton G. Stever[5]
John F. Streib, Jr.[2]
Martin Summerfield
Jonathan Dean Swift
J. Earl Thomas
Everett P. Tomlinson
Karl Unholtz
Donald B. Wheeler, Jr.[3]
John S. Wiggins
John R. Woolson
Willis G. Worcester
Frederick H. Wright[2]
Max W. Wyman[3]
Russell R. Yost
Abe M. Zarem

RESEARCH ASSISTANTS IN PHYSICS

Samuel J. Broadwell
Franklin S. Harris, Jr.[1]

[1]Rare Metals Research Fund.
[2]Caroline W. Dobbins Fellow.
[3]Henry Laws Fellow.
[4]Bridge Fellow.
[5]Cosmic Ray Fund Fellow.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

LINUS PAULING, *Chairman*

PROFESSORS

STUART J. BATES	Physical Chemistry
JAMES E. BELL	Chemistry
ROSCOE G. DICKINSON	Physical Chemistry
WILLIAM N. LACEY	Chemical Engineering
LINUS PAULING	Chemistry
RICHARD C. TOLMAN	Physical Chemistry, Mathematical Physics
LÁSZLÓ ZECHMEISTER	Organic Chemistry

ASSOCIATE PROFESSORS

RICHARD M. BADGER	Chemistry
HOWARD J. LUCAS	Organic Chemistry
ERNEST H. SWIFT	Analytical Chemistry
DON M. YOST	Inorganic Chemistry

RESEARCH ASSOCIATES

EDWIN R. BUCHMAN	Organic Chemistry
JOSEPH B. KOEPFLI	Chemistry

ASSISTANT PROFESSORS

ARNOLD O. BECKMAN	Chemistry
CARL G. NIEMANN	Organic Chemistry
BRUCE H. SAGE	Chemical Engineering
JAMES H. STURDIVANT	Chemistry

SENIOR FELLOW IN RESEARCH

ROBERT B. COREY . . . . . Structural Chemistry

INSTRUCTOR

LINDSAY HELMHOLZ . . . . . Chemistry

NATIONAL RESEARCH FELLOW

THOMAS HARRISON DAVIES . . . . . Medicine

GEORGE ELLERY HALE FELLOW

VERNER F. H. SCHOMAKER

ARTHUR A. NOYES FELLOWS

DARRELL W. OSBORNE — LLOYD ZUMWALT

RESEARCH FELLOWS

Roland A. Budenholzer[1]
Edward H. Hughes
Chia-Si Lu[9]
Henri A. Lévy
Reuben E. Wood
David P. Stevenson[2]
Arthur J. Stosick
Sidney Weinbaum
J. Norton Wilson

RESEARCH ASSISTANTS

Sidney Fox
Erik Heegaard
Justus G. Kirchner
Cecil Z. Wawra
Henry Lanz, Jr.
C. Ernst Redemann
Alf Reims

TEACHING FELLOWS AND ASSISTANTS

Joseph M. Axelrod
Andrew A. Benson
Daniel F. Botkin
Emil J. Burcik
Robert T. Carter[3]
Robert L. Caswell
Robert A. Cooley
Russell N. Doescher
John T. Hays, Jr.
William J. Howell, Jr.
Richard N. Lewis
James E. LuValle[4]
Don S. Martin, Jr.
James F. Mead
Peter L. Nichols, Jr.
Richard M. Noyes[5]
Robert H. Olds[8]
John W. Otvos
David Pressman
Robert S. Rasmussen
Max T. Rogers
Robert E. Rundle
Horace Russell, Jr.
Maurice J. Schlatter
Philip A. Shaffer, Jr.[6]
Ralph W. Spitzer
Robert A. Spurr[7]
William T. Stewart
Stanley M. Swingle
Charles D. Wagner
Austin L. Wahrhaftig
Jurg Waser

---

[1]American Petroleum Institute Fellow.
[2]Asphalt Institute Fellow.
[3]Standard Oil Company of California Fellow.
[4]Rosenwald Fellow.
[5]Drake Fellow.
[6]Elizabeth Thompson Stone Scholar.
[7]Henry Laws Fellow.
[8]Polymerization Process Corporation Fellow.
[9]Sino-British Boxer Indemnity Fund Fellow.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING, AERONAUTICS, AND METEOROLOGY

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 PROFESSORS

FRED J. CONVERSE . . . . Civil Engineering
ARTHUR L. KLEIN . . . . Aeronautics
ROBERT T KNAPP . . . . Hydraulic Engineering
IRVING P. KRICK . . . . Meteorology
FREDERICK C. LINDVALL . . . . . . Electrical and Mechanical Engineering
WILLIAM W. MICHAEL . . . . Civil Engineering
CLARK B. MILLIKAN . . . . Aeronautics

ASSISTANT PROFESSORS

A. PERRY BANTA . . . . Sanitary Engineering
DONALD P. BARNES . . . . . . Resident Engineer, Bureau of Reclamation
DONALD S. CLARK . . . . Mechanical Engineering
ALBERT E. LOMBARD, JR. . . . . . Aeronautics and Mechanical Engineering
WILLIAM R. SEARS . . . . Aeronautics
ERNEST E. SECHLER . . . . Airplane Structures
HOWELL N. TYSON . . . . Mechanical Engineering and Engineering Drafting

INSTRUCTORS

PAUL E. RUCH . . . . Synoptic Meteorology
HOMER J. STEWART . . . . Dynamic Meteorology
NATHANIEL W. WILCOX . . . . Engineering Drawing

RESEARCH FELLOWS

JAMES W. DAILY . . . . Hydraulic Machinery
WALTER M. ELSASSER[1] . . . . Meteorology
HANS W. LIEPMANN . . . . Aeronautics
HSUE-SHEN TSIEN[2] . . . . Aeronautics
VITO A. VANONI[3] . . . . Hydraulics

[1]Cooperative Agent, U. S. Weather Bureau.
[2]Civil Aeronautics Authority, Research Fund Fellow.
[3]Soil Conservation Service, Department of Agriculture.

RESEARCH ASSISTANTS

Hugh S. Bell[1]	Hydraulics
William H. Bowen	Aeronautics
Andrew Fejer	Hydraulic Machinery
Edward S. Forman	Aeronautics
Joseph Levy	Hydraulic Machinery
Frank J. Malina[1]	Aeronautics
Walter L. Moore[1]	Hydraulics
George Morikawa	Hydraulic Machinery
Brooks T. Morris[1]	Hydraulics
J. Pat O'Neill[1]	Hydraulics
George H. Otto[1]	Hydraulics
John W. Parsons	Aeronautics
Harold F. Richards[1]	Hydraulics
Peter v. H. Serrell	Aeronautics
Edward E. Simmons, Jr.[2]	Hydraulic Machinery
Carl L. Thiele[2]	Aeronautics

TEACHING FELLOWS AND ASSISTANTS

Lewis H. Abraham
O'Dean Anderson
John S. Atsumi
Steven E. Belsley
Richard W. Bell
Neil E. Borgquist
James W. Braithwaite
Frederick Martin Brasch
Ralph E. Byrne, Jr.
John B. Cabell
Charles F. Carstarphen
James V. Crawford
Harold B. Crockett
Philip S. Devirian[5]
John A. Dilworth, III
Louis G. Dunn
Charles F. Fischer
Harold Fischer
Joseph L. Fredrick
Edward V. Gant
William J. Green
Isaac Gringorten
Forrest H. Hall
Eustace P. Hetzel
Harold E. Heywood
George W. Housner
Donald E. Hudson
John W. Jackson
Harold F. Kleckner
Ellis Lapin
Henry Nagamatsu
William F. Nash, Jr.[4]
Justus A. Olsson
Walter B. Powell
W. Duncan Rannie
L. Benning Rumph, Jr.
Josiah E. Smith
Robert B. Smith
Fred W. Stoltz
Herbert C. Sumner
Harold H. Sweberg
R. Fulton Tangren
Edward R. Van Driest[3]
James B. Vernon
Dana B. Waring
Alan T. Waterman, Jr.
Robert L. Wells
John O. Wessale
William O. Wetmore[4]
John M. Wild
Luke C. L. Yuan

[1]*Soil Conservation Service, Department of Agriculture.*
[2]Impact Research Fund Fellow.
[3]Caroline W. Dobbins Fellow.
[4]Rare Metals Research Fellow.
[5]Shell Fellow in Mechanical Engineering.

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
Gennady W. Potapenko . . . . Geophysics

ASSISTANT PROFESSORS

Horace J. Fraser . . . . Mineralogy and Metalliferous Geology
Robert M. Kleinpell . . . . Micropaleontology
John H. Maxson . . . . Geology
Charles F. Richter . . . . Seismology

INSTRUCTORS

Francis D. Bode . . . . Geology
Raymond A. Peterson . . . . Geophysics

CURATORS

Eustace L. Furlong . . . . Vertebrate Paleontology
Willis P. Popenoe . . . . Invertebrate Paleontology

SCIENTIFIC ILLUSTRATOR

David P. Willoughby

TEACHING FELLOWS AND ASSISTANTS

Carl O. Alexis
Paul C. Henshaw[1]
John M. Holloway
Benjamin F. Howell, Jr.
Robert B. Hoy[2]
Lloyd A. Lewis[3]
William D. Lewis
William J. McGill
Louis J. Regan, Jr.
Ellis E. Roberts
John J. Rupnik
Alexander Smith
Clay T. Smith[1]
William E. Snow
Charles E. Stearns
Robert E. Wallace[2].
H. D. Bruce Wilson

[1]Drake Fellow.
[2]Blacker Fellow.
[3]Standard Oil Company of California 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

VISITING LECTURER

G. R. STRICKLAND	Protozoology

RESEARCH ASSOCIATE

GORDON ALLES	Biology

ASSOCIATE PROFESSORS

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

ASSISTANT PROFESSORS

JAMES F. BONNER	Plant Physiology
ROBERT EMERSON[1]	Biophysics
ANTHONIE VAN HARREVELD	Physiology
HUGH M. HUFFMAN	Biochemistry
GEORGE E. MACGINITIE	Biology
JOHANNES VAN OVERBEEK	Plant Physiology
ALBERT TYLER	Embryology

INTERNATIONAL RESEARCH FELLOW IN BIOLOGY OF THE ROCKEFELLER FOUNDATION

HERMAN M. KALCKAR

NATIONAL RESEARCH FELLOW

JOHN R. RAPER

RESEARCH FELLOW

ARTHUR N. PRATER[2]

HIXON FUND FELLOW

GEORGE MARMONT

[1]On leave of absence.
[2]Hawaiian Pineapple Producers Cooperative Association Fellow.

RESEARCH ASSISTANTS

Jacob Dubnoff
Emory L. Ellis
George A. Feigen
John B. Hatcher
Robert G. Helfer
Geoffrey Keighley
R. A. Ruehrwein
Solomon Shankman
John L. Webb

TEACHING FELLOWS AND ASSISTANTS

David M. Bonner
Edward B. Lewis, Jr.
Channing B. Lyon
Willard L. McRary
Charles B. Metz
Dwight D. Miller
Edward E. Novitski
George T. Rudkin
Paul R. Saunders
John Spizizen

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

VISITING PROFESSOR

CHARLES G. OSGOOD	English Literature

ASSOCIATES

GODFREY DAVIES	History
EDWIN F. GAY	Economic History
EDWARD A. WHITNEY	English and History
LOUIS B. WRIGHT	English Literature

ASSOCIATE PROFESSORS

HARVEY EAGLESON	English Language and Literature
PHILIP S. FOGG	Business Economics
HORACE N. GILBERT	Business Economics
WILLIAM HUSE	English Language and Literature
GEORGE R. MACMINN	English Language and Literature
RAY E. UNTEREINER	Economics and History

LECTURERS

GEORGE H. EDGELL	Art and Architecture
VLASTIMIL KYBAL	History and Economics
ROBERT ROSS	Psychology
ARCHIBALD B. YOUNG	Business Law
ARTHUR H. YOUNG	Industrial Relations

ASSISTANT PROFESSORS

L. WINCHESTER JONES	English Language and Literature
DWIGHT L. PALMER[1]	Industrial Relations
ROGER STANTON	English Language and Literature
J. E. WALLACE STERLING[2]	History

INSTRUCTORS

HARDIN CRAIG, JR.	History
WILLIAM H. PICKERING	History
KERMIT ROOSEVELT	History
VICTOR V. VEYSEY[3]	Economics and Accounting

TEACHING FELLOWS AND GRADUATE ASSISTANTS

HUGO GABRIEL	Modern Languages
WALTER H. MUNK	German

[1]On leave of absence from Massachusetts Institute of Technology.
[2]On leave of absence, 1939-1940.
[3]Research Fellow in Industrial Relations.

DIVISION OF PHYSICAL EDUCATION

R. W. SORENSEN, *Chairman*

PHYSICAL DIRECTOR

WILLIAM L. STANTON

ASSISTANT DIRECTOR AND ATHLETIC MANAGER

HAROLD Z. MUSSELMAN

CONSULTING PHYSICIAN

EDWARD D. KREMERS

ASSISTANT TO THE CONSULTING PHYSICIAN

MARSHALL Y. KREMERS

PHYSICAL TRAINER

FLOYD L. HANES

ASSISTANTS

HUGH BRADNER
CLAUDE BROWN
ROBERT G. COOPER
JOSEPH P. LASALLE
PAUL ENGELDER
MELVIN N. LEVET
JOHN W. PRICE
STUART L. SEYMOUR
CLAY T. SMITH

ASTROPHYSICS

OBSERVATORY COUNCIL

MAX MASON, *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*

POLICY COMMITTEE

MAX MASON, *Chairman*

WALTER S. ADAMS
EDWIN HUBBLE
IRA S. BOWEN
RICHARD C. TOLMAN

CONSTRUCTION COMMITTEE

JOHN A. ANDERSON, *Chairman*

WALTER S. ADAMS
EDWIN HUBBLE
IRA S. BOWEN
MAX MASON

ASSOCIATES IN OPTICS AND INSTRUMENT DESIGN

JOHN A. ANDERSON
RUSSELL W. PORTER

IN CHARGE OF INSTRUMENT SHOP

GARDNER W. SHERBURNE

IN CHARGE OF OPTICAL SHOP

MARCUS H. BROWN

FRITZ ZWICKY . . . . Associate Professor of Physics
JOHN D. STRONG . . . . . . Assistant Professor of Physics in Astrophysics
JOSEF J. JOHNSON . . . . Research Fellow in Astrophysics
RICHARD E. VOLLRATH . . . . Research Fellow in Astrophysics
KENICHI WATANABE . . . . Research Assistant in Astrophysics

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.

ARCHIBALD B. YOUNG
2nd Vice-Pres.

SEELEY G. MUDD
3rd Vice-Pres.

R. R. BUSH
4th Vice-Pres.

PRESTON HOTCHKIS
Secretary

DONALD O'MELVENY
Treasurer

EDWARD C. BARRETT
Asst. Secy.-Asst. Treas.

DIRECTORS

C. F. Braun
Scott Brown
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
Archibald B. Young

MEMBERS

Fred S. Albertson
George W. H. Allen
William H. Allen, Jr.
Mrs. James G. Bailey
Allan C. Balch
Mrs. Allan C. Balch
Franklin Baldwin
Mrs. Russell H. Ballard
John E. Barber
Harry J. Bauer
Garner A. Beckett
Arnold O. Beckman
A. Elmer Belt
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
Carl 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
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
Mrs. 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
Mrs. Edith A. English
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
Mrs. Stanton W. Forsman
Stuart W. French
Robert N. Frick
Mrs. Robert N. Frick
Mrs. John Gaffey
Mrs. Charles W. Gates
Robert L. Gifford
Robert C. Gillis
E. S. Gosney
Mrs. Herbert J. Goudge
Claude M. Griffeth
Mrs. George E. Hale
Mrs. Girard van B. Hale
Miss Evelyn Hamburger
Mrs. F. A. Hardy
Mrs. Edward C. Harwood
Arnold D. Haskell
S. M. Haskins
William C. Hay
Mrs. Arthur Hill
Mrs. Frank P. Hixon
Mrs. Joseph M. Hixon
George Grant Hoag
Collis H. Holladay
Mrs. W. I. Hollingsworth
Webster B. Holmes
Herbert B. Holt
William L. Honnold
Mrs. William L. Honnold
Louis J. Hopkins
Preston Hotchkis
Mrs. William F. Howard
Rupert Hughes
Myron Hunt
Willis G. Hunt
Willard C. Jackson
John E. Jardine
Mrs. W. P. Jeffries
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
Richard C. Lilly
Ralph B. Lloyd
Edward D. Lyman
Leonard S. Lyon
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
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
I. Graham Pattinson
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
Thomas N. St. Hill
Howard J. Schoder
Frank R. Seaver
Keith Spalding
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
A. L. Weil
Frederick W. Williamson
P. G. Winnett
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, presented 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 Research Laboratory 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, instruction 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, 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, 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, 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 a separate entry 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 will be given only when there are reasons of emergency or when there are no longer any vacancies in the Houses. Since the demand for rooms may exceed the supply, students newly entering the Institute must file room applications as soon as they are notified by the Registrar of admission to the Institute.

EXTRA-CURRICULAR OPPORTUNITIES

STUDENT ORGANIZATIONS AND ACTIVITIES

The undergraduate students are organized as the "Associated Students of the California Institute of Technology, Incorporated," of which all students who pay their student body fees are members, to deal with affairs of general student concern, and with such matters as may be delegated to them by the faculty. Membership in the corporation entitles each student to (a) admission to all regular athletic or forensic contests in which Institute teams participate, (b) a subscription to THE CALIFORNIA TECH, (c) a subscription to the BIG T, (d) one vote in each corporate election, and (e) the right to hold a corporate office. The executive body of the corporation is the Board of Directors, which is elected by the members in accordance with the provisions of the By-Laws. The Board conducts and supervises all student activities, makes awards for athletic and other extra-curricular activities, and has the sole power to authorize expenditure of corporation funds.

The honor system is the fundamental principle of conduct of all students; it applies to all scholastic and extra-curricular activities, and to relations between students and faculty as well as between students. To protect the honor system the members elect the 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 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 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 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 course in journalism 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.

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 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 exhibited there.

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.

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 AND VACCINATION

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.

Every student of the Institute (undergraduate and graduate) must be vaccinated upon admission or bring a certificate from a physician that he has been vaccinated not earlier than one month before admission.

Those students who refuse to be vaccinated will be denied admission to the Institute.

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.

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 four dollars ($4.00) 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. The Emergency Hospitalization Fund is not applicable to accidents away from the grounds of the Institute. This rule does not apply, i.e., the Fund is applicable, to accidents away from the Institute when these occur in authorized activities connected with regular curricular work.

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 in excess of the maximum amounts prescribed in Section 2 above 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 at least five units 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, additional English, Mathematics, Laboratory Science, History, Drawing, Commercial subjects, etc.	5

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.

The Admissions Committee recommends that the applicant's high school course include at least two years of a foreign language, preferably Latin, a year of basic elementary shop work, and as much extra instruction in English grammar and composition as is available in the high school curriculum.

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 March or April 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.

[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 1940 is as follows: Tuesday, September 17, 9:00 a.m., mathematics; Wednesday, September 18, 9:00 a.m., history and foreign languages.

Regular entrance examinations will be held at the Institute Saturday, March 9, and Saturday, March 16, 1940. Applicants should report in the Lounge of Dabney Hall March 9, at 8:30 a.m. The examinations on March 9 will be chemistry and English and on March 16 mathematics and physics. The examinations in chemistry and English for high school juniors will be held in Dabney Hall on June 8, 1940.

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. Every student entering the Institute for the first time must be vaccinated upon admission or bring a certificate from a physician that he has been vaccinated not earlier than one month before admission. Those students who refuse to be vaccinated will be denied admission to the Institute.

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 17, 1940, 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 permitted to take the entrance examinations.

A student who is admitted to the upper classes pursues a full course in one of the options in engineering or in science, leading to the degree of Bachelor of Science. The Institute has no special students. Men are admitted either as freshmen in accordance with the regulations set forth on pages 82 to 85, or as upper classmen in the manner described below. Those who have pursued college work elsewhere, but whose preparation is such that they have not had the substantial equivalent of any two of the following freshman subjects, English, mathematics, physics and chemistry, will be classified as freshmen and must be admitted as such. They may, however, receive credit for the subjects which have been completed in a satisfactory manner.

A minimum residence at the Institute of one scholastic year is required of all candidates for the degree of Bachelor of Science. See page 101.

Because of the very thorough, intensive study of mathematics and science 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 174-187), 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 includes certain topics in differential and integral calculus. It is possible, however, for an exceptionally able student to cover outside of class, the necessary work in integral calculus and thus prepare himself for the entrance examination and the sophomore course in mathematics.

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. Applicants should not come to the Institute expecting to be admitted to the examinations, without first receiving definite permission to take them.

In 1940 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 1940 is as follows:

June 1, 9 a.m.	Chemistry	Sept. 13, 9 a.m.	Mathematics
June 7, 9 a.m.	Mathematics	Sept. 14, 9 a.m.	Physics
June 8, 9 a.m.	Physics	Sept. 14, 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.

Those who write upon the June examinations will be notified of their admission or rejection about July 1; those taking the September examinations will be notified in time for registration. Upon the 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.

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 99 and 100. 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 100.

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.

Students transferring to any of the undergraduate classes (i.e., sophomore year and beyond) are required to pay a registration fee of $10 upon notification of admission to the Institute. This fee is automatically applied on the first term's tuition.

EXPENSES

The following is a list of student expenses at the California Institute of Technology for the academic year 1939-40, together with the dates on which the various fees are due. These charges are subject to change, at the discretion of the Institute, for 1940-41. 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	Amount: 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. 4, 1939	1st instalment of Room and Board, payable in advance		
	15 meals a week	58.50	
	21 meals a week	69.00	
Sept. 19, 1939: Freshmen; Sept. 22, 1939: Upperclassmen	Tuition, 1st term	100.00†	100.00†
	Associated Student Body Dues, 1st term	4.45	4.45
	Emergency Hospitalization Fee, 1939-40	4.00	4.00
	Subscription to the California Tech	.55	.55
	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	
Nov. 6, 1939	2nd instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	

*This fee is paid by Freshmen and by undergraduate students transferring from other institutions, and is automatically applied on the first term's tuition.

**Optional.

†For those who have already paid the Registration Fee, the Tuition balance due is $90.

Date	Fee	Amount: Resident Student	Amount: Non-Resident Student
Jan. 2, 1940	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	
Feb. 12, 1940	4th instalment of Room and Board		
	15 meals a week	48.75	
	21 meals a week	57.50	
Mar. 25, 1940	Tuition, 3rd term	100.00	100.00
	Associated Student Body Dues, 3rd term	5.00	5.00
	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	
May 6, 1940	6th instalment of Room and Board		
	15 meals a week	48.75	
	21 meals a week	57.50	

TOTAL

For student taking 15 meals	$699.00†	
For student taking 21 meals	758.50†	
For non-resident student		$347.00†

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.
†*This total does not include optional items.*

scribed by the Board of Trustees and administered by the Institute Physician and the Faculty Committee on Student Health (see pages 79-81).

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee of $14.45 is payable by all undergraduate students. Of this fee $5.50 is used for the support of athletics, $3.00 is a subscription to the BIG T, and the remainder is budgeted by the Board of Directors of the Associated Student Body for other student activities. The subscription to the CALIFORNIA TECH, 55 cents a year, is collected from every undergraduate.

GENERAL DEPOSIT

Beginning with the Fall Term, 1940, each undergraduate student will be required to make a general deposit of $25, to cover possible loss and/or damage of Institute property used in connection with his work in regular courses of study. Upon his graduation or withdrawal from the Institute, any remaining balance of the deposit will be refunded.

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 (see page 74).

SCHOLARSHIPS, PRIZES, AND STUDENT AID

FRESHMAN PRIZE SCHOLARSHIPS

Twelve or more freshman scholarships carrying stipends of $150 or $300 are awarded each year to members of the incoming freshman class. The recipients of these scholarships are selected by the Committee on Freshman Admission from the candidates who have passed the entrance examinations and otherwise satisfied the entrance requirements of the Institute.

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 101 of this Catalogue. In addition, a smaller number of tuition grants may be awarded to students of exceptionally 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 the late Mrs. Emily A. Humphry 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.

LA VERNE NOYES SCHOLARSHIPS

Under the will of the late La Verne Noyes, of Chicago, funds are provided for paying the tuition, in part or in full, of deserving students needing this assistance to enable them to procure a university or college training. This is to be done without regard to differences of race, religion, or political party, but only for those who shall be citizens of the United States of America and either

First, shall themselves have served in the army or navy of the United States of America in the war into which our country entered on the 6th day of April, 1917, and were honorably discharged from such service, or

Second, shall be descended by blood from some one who has served in the army or navy of the United States in said war, and who either is still in said service or whose said service in the army or navy was terminated by death or an honorable discharge.

The recipients are designated La Verne Noyes Scholars.

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 $15,000 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 1939-40 the sum of $1125 per month, which represents 75 units of $15 each per month during the academic year 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, 1939-1940, will take place January 2, 1940 (9 a.m. to 3 p.m.); for the third term, March 25, 1940 (9 a.m. to 3 p.m.). Registration for the first term, 1940-1941, will take place, for freshmen, September 17, 1940 (1:30 p.m.), for transfers from other colleges, September 19, 1940 (9 a.m. to 3 p.m.), and for other students, September 20, 1940 (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:

A denotes Excellent,
B denotes Good,
C denotes Satisfactory,
D denotes Poor,
E denotes Conditioned,
F denotes Failed,
inc denotes Incomplete.

In giving the grade *incomplete* the "inc" must be followed by a letter indicating the grade of work and by a 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 "D" 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. *Credits* are awarded on the basis of the number of units multiplied by four if the grade received is "A," three if "B," two if "C" and one if "D": thus, a student receiving a grade of "B" in a twelve unit course receives 36 credits for this course.

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

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 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.

Deficiency. Any freshman, sophomore, or new transfer student who fails to receive at least 72 credits during any one term will be required to report to the Dean before registering and may be requested to withdraw from all extra-curricular activities and outside employment or reduce the number of subjects he is carrying sufficiently to enable him to meet the scholastic requirements in succeeding terms.

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, Aeronautics, and Meteorology.
Division of the Geological Sciences.
Division of Biology.
Division of the Humanities.

†Any student whose grade-point average is less than 1.9 in freshman and sophomore physics and chemistry may, at the discretion of the Division of the Geological Sciences, be refused permission to register for the junior course in the Geological Sciences Option.

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 no longer be subject to the scholastic regulation requiring that he make at least 270 credits during the school year, except that a student who is *reinstated* to enter the junior or senior year is subject to this requirement during his junior or senior year.

All undergraduate and fifth- and sixth-year Master's candidates are subject to the requirement that they must receive at least 54 credits each term to be eligible for subsequent registration. (Special note should be made of the graduation requirement in the following paragraph.)

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.

Residence requirement. All transfer students who are candidates for the Bachelor of Science degree must complete at least one full year of residence in the undergraduate school at the Institute immediately preceding the completion of the requirements for graduation. At least ninety of the units taken must be in subjects in professional courses. A full year of residence is interpreted as meaning the equivalent of registration for three terms of not less than 49 units each.

Honor standing. At the close of each school-year the Committee on Honor Students awards *honor standing* to approximately fifteen students who have completed the freshman year, and to ten to fifteen 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 "B" 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 "A" and "B," 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 100) shall be prorated on the basis of 40 as a standard. For example, any student carrying 30 units of work shall be expected to obtain three-fourths of 54, or 41 credits, to be eligible for registration.

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 and sophomores should make application, shortly before the close of the school year, for admission to the second and third years of the Course in Engineering or 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

THE SCIENCES

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. The organization of the Observatory Council and the personnel of its advisory committees are shown on page 61 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 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.

BIOLOGICAL SCIENCES

The William G. Kerckhoff Laboratories of the Biological Sciences consist of two units, erected in 1928 and 1938, respectively. These provide research laboratories, undergraduate laboratories, private research rooms, several lecture rooms, seminar rooms, shops, and a large library which is a memorial to Mr. William G. Kerckhoff for his generous gift to the Institute.

Adjacent to the campus there is a laboratory for plant physiology, with two greenhouses. Here is special equipment allowing for the exact control of temperature, light, and humidity that is necessary for much of the research in this field.

At Arcadia, about five miles from the Institute, there is a ten-acre farm, with greenhouse and laboratory, for work in plant genetics. At Corona del Mar there is a marine laboratory. 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.

INSTRUCTION AND RESEARCH

The undergraduate option is designed to give the student an understanding of the outlines of modern Biology, especially on the physiological side. The course serves as a basis for graduate study leading to an advanced degree (M.S. or Ph.D.), or for admission to medical school.

The graduate work is chiefly in the fields of biochemistry, bioorganic chemistry, biophysics, animal physiology, plant physiology, genetics, and embryology. These subjects are grouped in a single division, rather than in the traditionally separate ones (Botany, Zoölogy, etc.), in order to encourage the coöperation of investigators with different backgrounds and methods of attack, and in the hope that general and fundamental properties common to animals and plants may be emphasized and studied.

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 was completed in 1937 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, physical, and organic 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 laboratories for inorganic, physical, and organic chemical research, providing space for about eighty research fellows and advanced students.

With the Gates and Crellin Laboratories is associated the Research Laboratory of Applied Chemistry, which is located in the Engineering Research Building. This laboratory has available equipment for carrying on chemical reactions on a fifty or hundred pound scale. The laboratory is especially well equipped for the investigation of the phase relations and thermodynamic properties of fluids at moderately high pressures. Research equipment is provided for intensive study of transfers of matter and energy in systems involving fluids.

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 and as chemists in charge of the operation and control of manufacturing processes, and, in the case of the fifth and sixth year Chemical Engineering Course, for positions involving 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 on both the scientific and applied sides, opportunities for more specialized study and research leading to the degree of Doctor of Philosophy are provided at the Institute in the fields of inorganic, analytical, 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 subject centers around the chemistry of acids, bases, salts, metals, and non-metals. The third term is devoted to elementary qualitative analysis, accompanied by special lectures in various fields of chemistry given by staff members of the division. Provision is made for the execution in the laboratory of interesting and fruitful experiments closely coordinated with the lectures and classroom discussions.

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 laboratory 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. Problems are a feature in the subjects of organic and applied chemistry also.

The supervision of the research work of graduate students is distributed among the members of the staff of the Division of Chemistry and Chemical Engineering. In physical chemistry the lines of research now being actively pursued by graduate students in cooperation with the staff include the following: thermodynamic studies including low temperature calorimetry; 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 investigations on plant hormones; studies of the Walden inversion; work on unsaturated compounds, with especial reference to isomerism, hydration, and complex formation; studies on the constitution of the phosphotides and cerebrosides; the synthesis of disaccharides and alkylated monosaccharides; configurational studies on the mono- and di-hydroxy amino acids; the investigation of the α-hydroxy and α-alkoxy amines; and the study of the chemistry of blood.

The fifth-year course in Chemical Engineering leads to the degree of Bachelor of Science in Chemical Engineering in distinction to the Bachelor of Science degree without designation received for completion of the four-year course in Applied Chemistry. This fifth-year course contains an intensive problem study of chemical engineering, a laboratory course in the fundamentals of engineering measurement, a course in business economics, and elective studies in science and engineering. Upon completion of the fifth-year course the student becomes eligible to pursue sixth-year work leading to the degree of Master of Science in Chemical Engineering. Approximately one-half of the work of the sixth year is devoted to research either in Chemical Engineering or in Applied Chemistry, the other half being occupied with graduate course work arranged with the approval of the Division of Chemistry and Chemical Engineering.

Although Chemical Engineering is not offered as a major subject for the degree of Doctor of Philosophy, it may be presented as a minor subject in connection with the doctorate in Chemistry or in Mechanical Engineering. The lines of research being pursued in applied chemistry include the study of applications of the molecular still and the glass electrode to industrial processes, and those in chemical engineering include engineering thermodynamics, phase equilibrium of hydrocarbons at elevated pressures, thermal transfer, and fluid flow.

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 have recently been completed on the Institute campus for the geological sciences. Both structures are memorials to men who were very active in the mining industry. The eastern one of the two is 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 was 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 is 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, additional graduate work and research should 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 five members, devoting themselves to different phases of the subject. Instruction is given in seismic, gravity, electrical, magnetic and other methods of prospecting. The design and construction of geophysical instruments in the shop of the seismological laboratory receive attention. Geophysical researches of various types are in progress.

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 164-168.

MATHEMATICS

Study and research in pure mathematics leading to the degree of Doctor of Philosophy were 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 for mathematical work beyond the bachelor's degree.

PHYSICS

UNDERGRADUATE WORK

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 WORK

Graduate students should complete as soon as possible the courses required for admission to candidacy for the doctor's degree. (See pages 156-164.) 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 both laboratories important work in nuclear physics and various phases of high-voltage x-rays is 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 pages 127-144 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.

ENGINEERING

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

The plan of instruction in Engineering 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 in Civil, Electrical, or Mechanical Engineering. The fifth year in Aeronautics or Meteorology leads to the degree of Bachelor of Science in Aeronautics or Meteorology; the sixth year, to the degree of Master of Science in Aeronautics or Meteorology. 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. Subjects 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.

AERONAUTICS AND METEOROLOGY

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 intensive 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.

CHEMICAL ENGINEERING

(See pp. 108 to 110.)

CIVIL ENGINEERING

The branches of Civil Engineering in which advanced work is offered include the control, development and conservation and treatment 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 treatment and disposal works; the location, design, construction and operation of railroads and highways; the study of properties and economical utilization of construction materials; and the study of soil mechanics as related to foundations, earth dams, stability of slopes, and other earthwork problems.

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. A 2,000,000 volt surge generator supplemented by cathode-ray oscillographs and other apparatus used in the study of electric surges (artificial lightning) and its effect upon electrical apparatus provides ample facility for the study of high voltage transients. 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.

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. 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 Bureau of Reclamation of the United States Department of the Interior, the Los Angeles County Flood Control District, and the Soil Conservation Service of the United States Department of Agriculture.

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. It is provided with a wave machine 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 constructed in cooperation with the Los Angeles Gas and Electric Corporation and the Los Angeles County Flood Control District. (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.

HYDRAULIC MACHINERY RESEARCH LABORATORY. The hydraulic machinery laboratory 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.

SOIL CONSERVATION LABORATORY. The Soil Conservation Laboratory is a cooperative undertaking with the Soil Conservation Service of the United States Department of Agriculture. Its objective is the study of the mechanism of the entrainment, transportation, and deposition of solid materials by flowing streams. 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 circulating type of flume for the study of rate of reduction of bed load. (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.

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 is 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 (including industrial relations) 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 room for the exhibition of pictures and other works of art, a library—reading room, a large senior room, conference rooms, and offices, 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 for the same purpose 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 Mr. Godfrey Davies, Dr. Edwin F. Gay, Mr. Edward A. Whitney, Dr. Louis B. Wright, of the Huntington Library, Professor Charles G. Osgood, of Princeton University, and Dr. George Howard Edgell, Director of the Boston Museum of Fine Arts, formerly Dean of the Harvard Graduate School of Architecture. 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, 1938 TO SEPTEMBER 30, 1939

Books and Pamphlets

The Internal Constitution of the Earth (Vol. VII of *The Physics of the Earth*).
Beno Gutenberg, editor, 401 pages, McGraw-Hill Book Company, Inc., New York, 1939.

The Old Faith and the New Philosophy.
William B. Munro, Phi Beta Kappa Address at Stanford University, 18 pages, June 17, 1939.

Static and Dynamic Electricity.
William R. Smythe, 560 pages, McGraw-Hill Book Company, Inc., 1939.

An Introduction to Genetics.
A. H. Sturtevant and G. W. Beadle, 391 pages, W. B. Saunders Company, 1939.

Rooting of Cuttings with Indole Acetic Acid and Vitamin B_1.
George C. Warner and F. W. Went, 19 pages, Castle Press, Pasadena, 1939.

Articles

I. Science

Astrophysics

Astrophysical Laboratory

The 200-Inch Telescope.
J. A. Anderson, *Pub. A. S. P.*, 51, 24-26, February, 1939.

Photographic Light-Curves of the Two Supernovae in IC 4182 and NGC 1003.
W. Baade and F. Zwicky, *Astrophys. J.*, 88, 411-421 (1938).

Foundations, Research and Colleges.
Max Mason, *Proc. 1938-39 Meetings of Association of Colleges and Universities of the Pacific Southwest*, pp. 6-9.

Our Red Neighbor.
Max Mason, *Collier's Weekly*, Dec. 17, 1938.

†Oil-Pad Bearings and Driving Gears of 200-Inch Telescope.
M. B. Karelitz, *Mechanical Engineering*, 60, 541-544 (1938).

On Collapsed Neutron Stars.
F. Zwicky, *Astrophys. J.*, 88, 522-525 (1938).

Endnu Fire Supernouvae.
Fritz Zwicky, *Nordisk Astronomisk Tidsskrift*, 20, 51-54 (1939).

Four More Supernovae.
F. Zwicky, *Pub. A. S. P.*, 51, 1-4 (1939).

On the Frequency of Supernovae.
F. Zwicky, *Astrophys. J.*, 88, 529-541 (1938).

†Not previously reported.

Biology

William G. Kerckhoff Laboratories of the Biological Sciences

Vitamin B_1 in Relation to Meristematic Activity of Isolated Pea Roots.
Frederick T. Addicott, *Bot. Gaz.*, 100, 836-843 (1939).

Nicotinic Acid and the Growth of Isolated Pea Roots.
Frederick T. Addicott and James Bonner, *Science*, 88, 577-578 (1938).

Translocations in Maize Involving Chromosome 8.
E. G. Anderson, *Genetics*, 24, 385-390 (1939).

Chemical Changes in the Adductor Muscle of the Cheliped of the Crayfish in Relation to the Double Motor Innervation.
W. R. Bergren and C. A. G. Wiersma, *J. Gen. Phys.*, 22, 193-206 (1938).

Nicotinic Acid and the Growth of Isolated Pea Embryos.
James Bonner, *Plant Phys.*, 13, 865-868 (1938).

Relation of Environment and of the Physical Properties of Synthetic Growth Substances to the Growth Relation.
David M. Bonner, *Bot. Gaz.*, 100, 200-214 (1938).

Leaf Growth Factors II. The Activity of Pure Substances in Leaf Growth.
David M. Bonner and A. J. Haagen-Smit, *Proc. Nat. Acad. Sci.*, 25, 184-188 (1939).

The Hormones and Vitamins of Plant Growth.
James Bonner, *Scient. Month.*, 47, 439-448 (1938).

Syntheses carried out in Vivo by Isolated Pea Roots: I.
James Bonner and Edwin R. Buchman, *Proc. Nat. Acad. Sci.*, 24, 431-438 (1938).

The Phycomyces Assay for Thiamin (Vitamin B_1): The Method and Its Chemical Specificity.
James Bonner and James Erickson, *Am. J. Bot.*, 25, 685-692 (1938).

Vitamin B_1 and the Growth of Green Plants.
James Bonner and Jesse Greene, *Bot. Gaz.*, 100, 226-237 (1938).

The Synthesis and Destruction of Vitamin B_1 by Phycomyces.
James Bonner and Edwin R. Buchman, *Proc. Nat. Acad. Sci.*, 25, 164-171 (1939).

The Inhibition of Root Growth by Auxins.
James Bonner and J. B. Koepfli, *Am. J. Bot.*, 26, 557-566 (1939).

Vitamins.
Henry Borsook, *Bulletin of the California Institute of Technology*, 47, 4, 3-15 (1938).

The Relief of Symptoms in Major Trigeminal Neuralgia (Tic Douloureux) following the Administration of Massive Doses of Vitamin B_1 supplemented in Some Instances by Concentrated Liver Extract.
H. Borsook, M. Y. Kremers, and C. G. Wiggins, *Science*, 89, 439-440 (1939).

Cytological and Genetic Basis of Sex (Chap. II of *Sex and Internal Secretions*).
Calvin B. Bridges.

Genetic Structure of Natural Populations.
Th. Dobzhansky, *Carn. Inst. Wash. Yr. Bk.*, 37, 323-325 (1938).

Genetics of Natural Populations IV. Mexican and Guatemalan Populations of Drosophila Pseudoobscura.
Th. Dobzhansky, *Genetics*, 24, 391-412 (1939).

***Fatti e Problemi della Condizione "Rapporto Sessi" (Sex-Ratio) in Drosophila.**
Th. Dobzhansky, *Scientia Genetica*, 1, 67-75 (1939).

---

*Not available for distribution.

An Experimental Study of Sexual Isolation in Drosophila.
Th. Dobzhansky and P. Ch. Koller, *Biol. Zentralblatt,* 58, 589-607 (1938).

***Sexual Isolation between Two Species of Drosophila—a Study of the Origin of an Isolating Mechanism.**
Th. Dobzhansky and P. Ch. Koller, *Genetics,* 24, 97-98 (1939).

Structure and Variation of the Chromosomes in Drosophila Azteca.
Th. Dobzhansky and D. Sokolov, *J. Heredity,* 30, 3-16 (1939).

A Preliminary Survey of the Oenothera Organensis Population.
Sterling Emerson, *Genetics,* 24, 524-537 (1939).

The Wound Hormones of Plants II. The Isolation of a Crystalline Active Substance.
James English, Jr., James Bonner, and A. J. Haagen-Smit, *Proc. Nat. Acad. Sci.,* 25, 323-329, (1939).

Uber die Physiologie und Chemie der pflanzlichen Wuchshormone.
A. J. Haagen-Smit, *Ergebnisse der Vitamin-und Hormonforschung,* Band II, 347-380 (1939).

Photoperiodism in Relation to Hormones as Factors in Floral Initiation and Development.
Karl C. Hamner and James Bonner, *Bot. Gaz.,* 100, 388-431 (1938).

Doubly-, Triply-, Quadruply-, and Quintuply Innervated Crustacean Muscle.
A. van Harreveld, *J. Comp. Neur.,* 70, 285-296 (1939).

The Nerve Supply of Doubly and Triply Innervated Crayfish Muscles Related to their Function.
A. van Harreveld, *J. Comp. Neur.,* 70, 267-284 (1939).

Influence of Asphyxia on Reciprocal Innervation.
A. van Harreveld, *Proc. Soc. Exp. Biol. and Med.,* 40, 561-562 (1939).

Asphyxia of the Spinal Cord of the Cat.
A. van Harreveld and George Marmont, *Proc. Soc. Exp. Biol. and Med.,* 39, 437-438 (1938).

The Course of Recovery of the Spinal Cord from Asphyxia.
A. van Harreveld and George Marmont, *J. Neurophysiology,* 2, 101-111 (1939).

The Function of the Quintuple Innervation of a Crustacean Muscle.
A. van Harreveld and C. A. G. Wiersma, *J. Exp. Biol.,* 16, 121-133 (1939).

Transplantation Experiments with Peas II.
H. E. Hayward and F. W. Went, *Bot. Gaz.,* 100, 788-801 (1939).

***The Effects of High Temperature on Bristle Frequencies in Scute and Wild-Type Males of Drosophila Melanogaster.**
Philip Truman Ives, *Genetics,* 24, 315-331 (1939).

***Genetics of Natural Populations III. Gene Arrangements in Populations of Drosophila pseudoobscura from Contiguous Localities.**
P. Ch. Koller, *Genetics,* 24, 22-33 (1939).

Is Agglutination an Explanation for the Occurrence and for the Chromomere-to-Chromomere Specificity of Synapsis?
Carl C. Lindegren and C. B. Bridges, *Science,* 87, 510-511 (1938).

Experiments which cause Inhibition of the Function, but not the Activity, of Sperms of Urechis Caupo.
G. E. MacGinitie, *J. Exp. Zool.,* 79, 237-242 (1938).

The Method of Feeding of Chaetopterus.
G. E. MacGinitie, *Biol. Bull.,* 72, 115-118 (1939).

The Natural History of the Blind Goby, Typhlogobius californiensis Steindachner.
G. E. MacGinitie, *Am. Mid. Nat.,* 21, 489-505 (1939).

*Not available for distribution.

Littoral Marine Communities.
G. E. MacGinitie, *Am. Mid. Nat.*, 21, 28-55 (1939).

Some Effects of Fresh Water on the Fauna of a Marine Harbor.
G. E. MacGinitie, *Am. Mid. Nat.*, 21, 681-686 (1939).

Morphological Differences between the "Races" of Drosophila Pseudoobscura.
K. Mather and Th. Dobzhansky, *Am. Nat.*, 73, 5-25 (1939).

*The Action of Ethylene on Plant Growth.
H. David Michener, *Am. J. Bot.*, 25, 711-720 (1938).

The Effects of Centrifuging on the Polar Spindles of the Egg of Chaetopterus and Cumingia.
T. H. Morgan, *Biol. Bull.*, 76, 339-358 (1939).

Calvin Blackman Bridges (Obituary).
T. H. Morgan, *Science*, 89, 118-119 (1939).

The Genetics and the Physiological Problems of Self-sterility in Ciona III. Induced Self-Fertilization.
T. H. Morgan, *J. Exp. Zool.*, 80, 19-54 (1939).

The Genetic and the Physiological Problems of Self-sterility in Ciona IV. Some Biological Aspects of Fertilization.
T. H. Morgan, *J. Exp. Zool.*, 80, 55-80 (1939).

Constitution of the Germinal Material in Relation to Heredity.
T. H. Morgan, C. B. Bridges, and Jack Schultz, *Carn. Inst. Wash. Yr. Bk.*, 37, 304-310 (1938).

"Laziness" in Maize due to Abnormal Distribution of Growth Hormone.
J. van Overbeek, *J. Heredity*, 29, 339-341 (1938).

Auxin Distribution in Seedlings and its Bearing on the Problem of Bud Inhibition.
J. van Overbeek, *Bot. Gaz.*, 100, 133-166 (1938).

Is Auxin Produced in Roots?
J. van Overbeek, *Proc. Nat. Acad. Sci.*, 25, 245-248 (1939).

*The Influence of Centrifugal Force on the Bilateral Determination of the Spirally-Cleaving Egg of Urechis.
Daniel C. Pease, *Biol. Bull.*, 75, 409-424 (1938).

A Plant Growth Inhibitor.
Wm. S. Stewart, Wm. Bergren, and C. E. Redemann, *Science*, 89, 185-186 (1939).

Essays on Evolution III. On the Origin of Interspecific Sterility.
A. H. Sturtevant, *Quart. Rev. Biol.*, 13, 333-335 (1938).

On the Subdivision of the Genus Drosophila.
A. H. Sturtevant, *Proc. Nat. Acad. Sci.*, 25, 137-141 (1939).

High Mutation Frequency Induced by Hybridization.
A. H. Sturtevant, *Proc. Nat. Acad. Sci.*, 25, 308-310 (1939).

Plant Growth Hormones.
Kenneth V. Thimann and James Bonner, *Phys. Rev.*, 18, 524-553 (1938).

Extraction of an Egg Membrane-Lysin from Sperm of the Giant Keyhole Limpet (Megathura Crenulata).
Albert Tyler, *Proc. Nat. Acad. Sci.*, 25, 317-323 (1939).

Increasing the Life Span of Unfertilized Urechis Eggs by Acid.
Albert Tyler and Frank W. Dessel, *J. Exp. Zool.*, 81, 459-472 (1939).

The Activities of Various Substituted Phenols in Stimulating the Respiration of Sea Urchin Eggs.
Albert Tyler and N. H. Horowitz, *Biol. Bull.*, 75, 209-223 (1938).

Remarks about Two Auxin Problems.
F. W. Went, *Chronica Botanica*, 4, 503-505 (1938).

---

*Not available for distribution.

The Dual Effect of Auxin on Root Formation.
F. W. Went, *Am. J. Bot.*, 26, 24-29 (1939).

A Case of Correlative Growth Inhibition in Plants.
F. W. Went, *Am. J. Bot.*, 26, 505-512 (1939).

Some Experiments on Bud Growth.
F. W. Went, *Am. J. Bot.*, 26, 109-117 (1939).

Further Analysis of the Pea Test for Auxin.
F. W. Went, *Bull. Torrey Bot. Club*, 66, 391-410 (1939).

Transport of Inorganic Ions in Polar Plant Tissues.
F. W. Went, *Plant Phys.*, 14, 365-369 (1939).

Growth Hormones in the Higher Plants.
F. W. Went, *An. Rev. Biochemistry*, 8, 521-540 (1939).

Experiments on the Transport of Auxin.
F. W. Went and Ralph White, *Bot. Gaz.*, 100, 465-484 (1939).

Interactions of the Slow and the Fast Contraction of Crustacean Muscle.
C. A. G. Wiersma and A. van Harreveld, *Phys. Zool.*, 12, 43-49 (1939).

Chemistry and Chemical Engineering

Gates and Crellin Laboratories of Chemistry

No. 637. Phase Equilibria in Hydrocarbon Systems. XXII. Equilibrium Constants for Methane in a Number of Hydrocarbon Systems.
B. H. Sage and W. N. Lacey, *Ind. and Eng. Chem.*, 30, 1296-1304 (1938).

No. 652. An Attempted Exchange of Phosphorus between Phosphorous and Phosphoric Acids.
J. Norton Wilson, *J. Am. Chem. Soc.*, 60, 2697-2699 (1938).

No. 653. The Band Envelopes of Unsymmetrical Rotator Molecules. I. Calculation of the Theoretical Envelopes.
Richard M. Badger and Lloyd Zumwalt, *J. Chem. Phys.*, 6, 711-717 (1938).

No. 654. A Note on the Unit Cell and Probable Space Group of Strontium Hydroxide Octohydrates, $Sr(OH)_2 \cdot 8H_2O$.
D. P. Mellor, *Zeit. f. Krist.*, 100, 441-442 (1939).

No. 655. The Electron Diffraction Investigation of Sulfur Monochloride, Sulfur Dichloride, Sulfur Trioxide, Thionyl Chloride, Sulfuryl Chloride, Vanadium Oxytrichloride, and Chromyl Chloride.
K. J. Palmer, *J. Am. Chem. Soc.*, 60, 2360-2369 (1938).

No. 656. Phase Equilibria in Hydrocarbon Systems. XXIII. Joule-Thomson Coefficient of Methane.
R. A. Budenholzer, B. H. Sage, and W. N. Lacey, *Ind. and Eng. Chem.*, 31, 369-374 (1939).

No. 657. The Structure of Ammonium Heptafluozirconate and Potassium Heptafluozirconate and the Configuration of the Heptafluozirconate Group.
G. C. Hampson and Linus Pauling, *J. Am. Chem. Soc.*, 60, 2702-2707 (1938).

No. 658. The Spectrum of Allene in the Photographic Infrared.
Eugene H. Eyster, *J. Chem. Phys.*, 6, 580-585 (1938).

No. 659. The Absorption Spectra of Cyclopropane, Ethylene Oxide, Ethylene Sulfide, and Ethylene Imine in the Photographic Infrared.
Eugene H. Eyster, *J. Chem. Phys.*, 6, 576-579 (1938).

No. 660. A Comparative Method of Measuring Vapor Pressure Lowering with Application to Solutions of Phenol in Benzene.
Edwin N. Lassettre and Roscoe G. Dickinson, *J. Am. Chem. Soc.*, 61, 54-57 (1939).

No. 661. Phase Equilibria in Hydrocarbon Systems. XXIV. Latent Heat of Vaporization of Propane and n-Pentane.
B. H. Sage, H. D. Evans, and W. N. Lacey, *Ind. and Eng. Chem.*, 31, 763-767 (1939).

No. 663. The Diamagnetism of Nitrosyl Chloride.
Carrol M. Beeson and Charles D. Coryell, *J. Chem. Phys.*, 6, 656-657 (1938).

No. 664. Effect of Pressure upon Viscosity of n-Butane and Isobutane.
B. H. Sage, W. D. Yale, and W. N. Lacey, *Ind. and Eng. Chem.*, 31, 223-226 (1939).

No. 667. Partial Volumetric Behavior of the Lighter Hydrocarbons in the Liquid Phase.
B. H. Sage, B. L. Hicks, and W. N. Lacey, *Drilling and Production Practice*, 1938, p. 402.

No. 668. The Crystal Structure of Ammonium Cadmium Chloride, NH_4CdCl_3.
Henri Brasseur and Linus Pauling, *J. Am. Chem. Soc.*, 60, 2886-2890 (1938).

No. 669. The Equilibrium Dissociation and Thermodynamic Constants of Nitrosyl Chloride. Comparison with Spectroscopic Data.
Carrol M. Beeson and Don M. Yost, *J. Chem. Phys.*, 7, 44-52 (1939).

No. 670. Syntheses Carried out in Vivo by Isolated Pea Roots: I.
James Bonner and Edwin R. Buchman. (Jointly with William G. Kerckhoff Laboratories of the Biological Sciences.) *Proc. Nat. Acad. Sci.*, 24, 431-438 (1938).

No. 671. A Quantum Mechanical Discussion of the Carbon-Chlorine Bond in the Substituted Ethylenes and Benzenes.
J. Sherman and J. A. A. Ketelaar, *Physica*, VI, 572-580 (1939).

No. 672. The Raman Spectra of Volatile Fluorides. Applications of Raman Spectra to Chemical Problems.
Don M. Yost, *Proc. of the Indian Academy of Sci.*, VIII, 333-340 (1938).

No. 673. Gravitational Concentration Gradients in Static Columns of Hydrocarbon Fluids.
B. H. Sage and W. N. Lacey, *Trans. A.I.M.M.E., Petrol. Div.*, 132, 120 (1939).

No. 675. The Chemistry of Protein Structure.
Carl Niemann, *Symposium Monograph*, Long Island Biological Assn., Cold Spring Harbor, Long Island, 1938, Vol. VI, 58-66.

No. 676. The Nature of the Interatomic Forces in Metals.
Linus Pauling, *Phys. Rev.*, 54, 899-904 (1938).

No. 678. The Electron Diffraction Investigation of Methylacetylene, Dimethylacetylene, Dimethyldiacetylene, Methyl Cyanide, Diacetylene, and Cyanogen.
Linus Pauling, H. D. Springall, and K. J. Palmer, *J. Am. Chem. Soc.*, 61, 927-937 (1939).

No. 680. *Structure of the O-H Bands in the Vapors of Halogen Substituted Alcohols.
Lloyd R. Zumwalt, and Richard M. Badger, *J. Chem. Phys.*, 7, 87 (1939).

No. 681. An Absorption Band of Formaldoxime at λ9572.
Lloyd R. Zumwalt and Richard M. Badger, *J. Chem. Phys.*, 7, 235-237 (1939).

No. 682. The Thermodynamic Functions of Cyanogen and the Cyanogen Halides.
D. P. Stevenson, *J. Chem. Phys.*, 7, 171-174 (1939).

No. 683. The Unit Cell and Space Group of Cs_2CuCl_4.
D. P. Mellor, *Zeit. f. Krist.*, 101, 160-161 (1939).

No. 684. Internal Rotation in Ethylene Chloride.
J. Y. Beach and K. J. Palmer, *J. Chem. Phys.*, 6, 639-644 (1938).

---

*Not available for distribution.

No. 686. The Electron Diffraction Investigation of the Structure of Benzene, Pyridine, Pyrazine, Butadiene, Cyclopentadiene, Furan, Pyrrole, and Thiophene.
V. Schomaker and L. Pauling, *J. Am. Chem. Soc.*, 61, 1769-1780 (1939).

No. 687. The Crystal Structure of Glycine.
Gustav Albrecht and Robt. B. Corey, *J. Am. Chem. Soc.*, 61, 1087-1103 (1938).

No. 688. The Determination of the Molecular Structure of Tetranitromethane by the Electron Diffraction Method.
A. J. Stosick, *J. Am. Chem. Soc.*, 61, 1127-1130 (1939).

No. 689. The Electron Diffraction Investigation of Phosphorus Sulfoxide, $P_4O_6S_4$.
A. J. Stosick, *J. Am. Chem. Soc.*, 61, 1130-1132 (1939).

No. 691. Thiamin Analogs. I. β-(4-Methylthiazolyl-5)-alanine.
Edwin R. Buchman and Edwin M. Richardson, *J. Am. Chem. Soc.*, 61, 891-893 (1939).

No. 692. The Magnetic Study of the Equilibrium between Ferrohemoglobin and Cyanide Ion.
Fred Stitt and Charles D. Coryell, *J. Am. Chem. Soc.*, 61, 1263-1266 (1939).

No. 693. The Reduction of α-Bromocyclohexanone with Aluminum Isopropoxide.
S. Winstein, (Note) *J. Am. Chem. Soc.*, 61, 1610 (1939).

No. 694. Phase Behavior of the Methane-n-Pentane System.
H. S. Taylor, G. W. Wald, B. H. Sage, and W. N. Lacey, *Oil and Gas Journal*, 38, 46, 48, 50 (1939).

No. 695. The Thermodynamic Constants of Bromine Chloride. The Equilibrium Reaction between Nitric Oxide, Bromine, Chlorine, Nitrosyl Bromide and Chloride, and Bromine Chloride.
Carrol M. Beeson and Don M. Yost, *J. Am. Chem. Soc.*, 61, 1432-1436 (1939).

No. 696. Investigations on the Stereoisomerism of Unsaturated Compounds. V. A Mechanism for the Formation of Butenes from 2,3-Dibromobutanes by the Action of Iodide Ion.
Saul Winstein, David Pressman, and William G. Young, *J. Am. Chem. Soc.*, 61, 1645-1647 (1939).

No. 697. Infrared Bands and Association of Some Hydroxylic Compounds.
H. W. Thompson, *J. Am. Chem. Soc.*, 61, 1396-1400 (1939).

No. 698. Vibration-rotation Bands of Some Polyatomic Molecules in the Photographic Infrared.
H. W. Thompson, *J. Chem. Phys.*, 7, 441-447 (1939).

No. 699. The Infrared Spectrum of Methylamine.
H. W. Thompson, *J. Chem. Phys.*, 7, 448-452 (1939).

No. 700. The Infrared Band of Formic Acid at 7525 A.
H. W. Thompson, *J. Chem. Phys.*, 7, 453-455 (1939).

No. 701. Retention of Configuration in the Reaction of 3-Bromo-2-Butanols with Hydrogen Bromide.
Saul Winstein and Howard J. Lucas, *J. Am. Chem. Soc.*, 61, 1576-1581 (1939).

No. 702. The Reaction Steps in the Conversion of 2,3-Diacetoxybutane to 2,3-Dibromobutane.
S. Winstein and H. J. Lucas, *J. Am. Chem. Soc.*, 61, 1581-1584 (1939).

No. 703. The Solvolysis of Tertiary Butyl Chloride. Solvolytic Reactions and the Walden Inversion.
Saul Winstein, *J. Am. Chem. Soc.*, 61, 1635-1640 (1939).

No. 704. The Synthesis and Destruction of Vitamin B_1 by Phycomyces.
James Bonner and Edwin R. Buchman. (Jointly with William G. Kerckhoff Laboratories of the Biological Sciences.) *Proc. Nat. Acad. Sci.*, 25, 164-171 (1939).

No. 705. The Crystal Structure of Neodymium Bromate Enneahydrate, $Nd(BrO_3)_3 \cdot 9H_2O$.
Lindsay Helmholz, *J. Am. Chem. Soc.*, 61, 1544-1550 (1939).

No. 706. The Compression of Hydrocarbon Gases.
B. H. Sage and W. N. Lacey, *California Oil World*, 32, No. 8, 22 (1939).

No. 707. Absorption Factor in Crystal Spectroscopy.
G. Albrecht, *Review of Scientific Instruments*, 10, 221-222 (1939).

No. 708. The Structure of Proteins.
Linus Pauling and Carl Niemann, *J. Am. Chem. Soc.*, 61, 1860-1867 (1939).

No. 709. The Hydration of Unsaturated Compounds. VII. The Rate of Hydration of Crotonic Acid; the Rate of Dehydration of β-Hydroxybutyric Acid; the Equilibrium between Crotonic Acid and β-Hydroxybutyric Acid in Dilute Aqueous Solution.
D. Pressman and H. J. Lucas, *J. Am. Chem. Soc.*, 61, 2271-2277 (1939).

No. 710. The Constitution of Secretin.
Carl Niemann, *Proc. Nat. Acad. Sci.*, 25, 267-269 (1939).

No. 711. The Magnetic Properties of Myoglobin and Ferrimyoglobin, and their Bearing on the Problem of the Existence of Magnetic Interactions in Hemoglobin.
Donald S. Taylor, *J. Am. Chem. Soc.*, 61, 2150-2154 (1939).

No. 714. The Wound Hormones of Plants. II. The Isolation of a Crystalline Active Substance.
James English, Jr., James Bonner, and A. J. Haagen-Smit. (Jointly with William G. Kerckhoff Laboratories of the Biological Sciences.) *Proc. Nat. Acad. Sci.*, 25, 323-329 (1939).

No. 717. The N-H Harmonic Bands of Pyrrole at λ9900, and the Structure of the Pyrrole Molecule.
Lloyd R. Zumwalt and Richard M. Badger, *J. Chem. Phys.*, 7, 629-630 (1939).

No. 718. The Structure of Formaldehyde from Electron Diffraction.
D. P. Stevenson, James E. LuValle, and Verner Schomaker, *J. Am. Chem. Soc.*, 61, 2508-2510 (1939).

A Recent Advance in Immunology.
Carl G. Niemann, *Bulletin of the California Institute of Technology*, 47, 4, 16-19 (1938).

Geology

Balch Graduate School of the Geological Sciences; Charles Arms and Seeley W. Mudd Laboratories of the Geological Sciences

Dedication of the Seeley W. Mudd and the Charles Arms Laboratories of the Geological Sciences, Bull. Calif. Inst. of Tech., 48, 2, April, 1939. Addresses as follows:

The Geological Laboratories. Structural Geology. John P. Buwalda, pp. 5-9.
Petrology. Ian Campbell, pp. 9-12.
Problems of Metalliferous Geology. Horace J. Fraser, pp. 12-15.
Geology and Physiography. John H. Maxson, pp. 15-16.
Paleontology. Chester Stock, pp. 16-18.
Geophysics. Beno Gutenberg, pp. 18-21.
The Instrument-Development Program of the Seismological Laboratory. Hugo Benioff, pp. 22-23.

Scope of Activities in the Geological Sciences.
John P. Buwalda, *Bull. Calif. Inst. of Tech.*, 48, 37-42 (1939).

The Mammoth "Earthquake Fault" and Related Features in Mono County, California.
Hugo Benioff and Beno Gutenberg, *Bull. Seis. Soc. Amer.*, 29, 333-340 (1939).

Observations with the Electro-Magnetic Microbarograph.
Hugo Benioff and Beno Gutenberg, *Nature,* 144, 478 (1939).

Earth History of a Portion of the Pacific Northwest.
John P. Buwalda, *Carn. Inst. of Washington Publ. 501, Cooperation in Research,* 695-710 (1938).

Geological Studies of the Archean Rocks at Grand Canyon, Arizona.
Ian Campbell and John H. Maxson, *Carn. Inst. of Washington Year Book 37,* 359-364 (1938).

A New Pliocene Badger from Mexico.
Arthur B. Drescher, *Bull. So. Calif. Acad. of Sci.,* 38, 57-62 (1939).

Darkening of Cinnabar in Sunlight.
Robert M. Dreyer, *Amer. Min.,* 24, 457-460 (1939).

The Velocity of Sound Waves from Gunfire in Southern California.
Beno Gutenberg, *Trans. Amer. Geophys. Union, 19th Ann. Meeting* (1938).

Internal Constitution of the Earth. *(Physics of the Earth,* Vol. VII.)
McGraw-Hill Book Company, 1939. Beno Gutenberg, editor, and author of the following chapters:
I Introduction, pp. 3-10.
VII The Cooling of the Earth and the Temperature in Its Interior, pp. 153-164.
VIII Forces in the Earth's Crust, 165-176.
IX Hypotheses on the Development of the Earth's Crust and Their Implications, pp. 177-218.
XIV The Elastic Constants in the Interior of the Earth, pp. 345-360.
XV Viscosity, Strength and Internal Friction in the Interior of the Earth, pp. 361-384.
XVI Summary, pp. 385-390.
Beno Gutenberg and C. F. Richter:
XI Evidence from Deep-Focus Earthquakes, pp. 291-300.
XII Structure of the Crusts. Continents and Oceans, pp. 301-328.

The Velocity of Sound Waves and the Temperature in the Stratosphere in Southern California.
Beno Gutenberg, *Bull. Amer. Meteor. Soc.,* 20, 192-201 (1939).

Zur Entwicklung der Seismischen Aufschlussmethoden.
Beno Gutenberg, *Ergebnisse der Kosmischen Physik,* Bd. IV, 169-218 (1939).

On Seismic Waves, 4th Paper.
B. Gutenberg and C. F. Richter, *Gerlands Beiträge zur Geophysik,* 54, 94-136 (1939).

A Tertiary Mammalian Fauna from the Avawatz Mountains, San Bernardino County, California.
Paul C. Henshaw, *Carn. Inst. of Washington Publ.,* 514, 1-30 (1939).

Clerici Solution for the Specific Gravity Determination of Small Mineral Grains.
Richard H. Jahns, *Amer. Mineralogist,* 24, 116-122 (1939).

Geology and Ore Deposits of the Darwin Silver-Lead Mining District, Inyo County, California.
Vincent C. Kelley, *Calif. Jour. Mines and Geol., Report 34 of the State Mineralogist,* 503-562 (1938).

Structural and Petrofabric Study of the Val Verde Tonalite.
E. F. Osborn, *Bull. Geol. Soc. Amer.,* 50, 921-950 (1939).

Eocene Amynodonts in Southern California.
Chester Stock, *Proc. Natl. Acad. Sci.,* 25, 270-275 (1939).

John Campbell Merriam, Scientist and Philosopher.
Chester Stock, *Carn. Inst. of Washington Publ. 501, Cooperation in Research,* 765-778 (1938).

The McKittrick Tar Seeps of California.
Chester Stock, *Carn. Inst. of Washington, News Service Bulletin,* Vol. IV, No. 32, November 20, 1938.

Nature's Etchings in Stone.
Chester Stock, *Westways,* 30, 12, 20-21 (1938).

Our Earliest Relatives in California.
Chester Stock, *Westways,* 31, 9, 20-21 (1939).

A Titanothere from the Type Sespe of California.
Chester Stock, *Proc. Natl. Acad. Sci.*, 24, 507-512 (1938).

Rodents and Lagomorphs of the Late Tertiary Avawatz Fauna, California.
Robert W. Wilson, *Carn. Inst. of Washington Publ.*, 514, 31-38 (1939).

Mathematics

Correction of Sample Moment Bias Due to Lack of High Contact and to Histogram Grouping.
Dinsmore Alter, *Ann. Math. Statistics*, 10, 192-195 (1939).

A Periodogram Investigation of Short-Period Sunspot Cycles.
Dinsmore Alter, *Monthly Weather Review*, July, 1938. (Issued Oct. 12, 1938.)

Paraboloidal Coordinates.
H. Bateman, *Phil. Mag.*, 26, 1063-1068 (1938).

Review of *Elementary Matrices* by R. A. Frazer, W. J. Duncan and A. R. Couar.
H. Bateman, *Rev. of Sc. Instruments*, 10, 116 (1939).

The Transformation of a Legrangian Series into a Newtonian Series.
H. Bateman, *Proc. Nat. Acad. Sci.*, 25, 262-265 (1939).

A Duality for Certain Difference Equations.
E. T. Bell, *Bull. Am. Math. Soc.*, 45, 145-151 (1939).

Euler's Concordant Forms.
E. T. Bell, *Proc. Nat. Acad. Sci.*, 25, 46-48 (1939).

Legrange and Wilson Theorems for the Generalized Stirling Numbers.
E. T. Bell, *Edinburgh Math. Soc.*, 5, 171-173 (1938).

Reducible Ternary Arithmetical Cubics.
E. T. Bell, *Travaux de L'Institut Mathematique De Tiflis*, 5, 135-142 (1938).

Non-Commutative Arithmetic.
R. P. Dilworth, *Duke Math. J.*, 5, 270-280 (1939).

General Differential Geometries and Related Topics.
A. D. Michal, *Bull. Am. Math. Soc.*, 45, 529-563 (1939).

Differential Invariants in a General Differential Geometry.
A. D. Michal and D. H. Hyers, *Math. Annalen*, 116, 310-333 (1939).

Abstract Flat Projective Geometry.
A. D. Michal and A. B. Mewborn, *Proc. Nat. Acad. Sci.*, 25, 440-443 (1939).

Géométrie différentielle projective générale des géodésiques généralisées.
A. D. Michal and A. B. Mewborn, *Comptes Rendus*, 209, 392-394 (1939).

The Algebra of Lattice Functions.
Morgan Ward, *Duke Math. J.*, 5, 357-371 (1939).

A Characterization of Dedekind Structures.
Morgan Ward, *Bull. Am. Math. Soc.*, 45, 448-451 (1939).

A Note on Divisibility Sequences.
Morgan Ward, *Bull. Am. Math. Soc.*, 45, 334-335 (1939).

Note on the General Rational Solution of the Equation $ax^2 - by^2 = z^3$.
Morgan Ward, *Am. J. Math.*, 41, 788-790 (1939).

Residuated Lattices.
Morgan Ward and R. P. Dilworth, *Trans. Am. Math. Soc.*, 335-354 (1939).

Ring Homomorphisms which are also Lattice Homomorphisms.
Morgan Ward, *Am. J. Math.*, 41, 783-787 (1939).

A Characterization of Boolean Algebras.
Morgan Ward and Garrett Birkhoff, *Ann. of Math.*, 40, 609-610 (1939).

Evaluations over Residuated Structures.
Morgan Ward and R. P. Dilworth, *Ann. of Math.*, 40, 328-339 (1939).

The Lattice Theory of Ova.
Morgan Ward and R. P. Dilworth, *Ann. of Math.*, 40, 600-608 (1939).

Physics

Norman Bridge Laboratory of Physics

Free Charges, Polarization and Polarization Charges, Especially those produced when an Insulator moves in a Magnetic Field.
S. J. Barnett, *Am. Phys. Teacher*, 7, 28-35 (1939).

Review of *Electromagnetics* by Alfred O'Rahilly.
H. Bateman, *Science*, 90, 300-302 (1939).

Exploratory Study of Plural X-Ray Reflection Methods Applied to the Problem of the Diffraction Pattern of Calcite.
V. L. Bollman, H. H. Bailey, and J. W. M. DuMond, *Phys. Rev.*, 54, 792-802 (1938).

Further Tests of the Validity of X-Ray Crystal Methods of Determining e.
V. L. Bollman and J. W. M. DuMond, *Phys. Rev.*, 54, 1005-1010 (1938).

Effect of Collisions on the Intensities of Nebular Lines.
I. S. Bowen and R. Minkowski, *Nature*, 142, 1079-1081 (1938).

Forbidden Lines of Fe VII in the Spectrum of Nova RR Pictoris (1925).
I. S. Bowen and B. Edlen, *Nature*, 143, 374 (1939).

Fine Structure of the Line $\lambda 4686$ of Ionized Helium.
Djen Chu, *Phys. Rev.*, 55, 175-180 (1939).

Change of Resistance in a Magnetic Field.
Leverett Davis, Jr., *Phys. Rev.*, 56, 93-98 (1939).

A Note on the Wave Functions of the Relativistic Hydrogenic Atom.
Leverett Davis, Jr., *Phys. Rev.*, 56, 186-187 (1939).

Our Present Dilemma Regarding the Values of the Natural Constants e, m and h. A New Graphical Method of Presentation.
Jesse W. M. DuMond, *Phys. Rev.*, 56, 153-164 (1939).

Approximate Method of Cutting Short Circular Cylindrical Arcs with Very Large Radii of Curvature in the Milling Machine.
Jesse W. M. DuMond, *R. S. I.*, 9, 329 (1938).

Resumés of Recent Research.
Jesse W. M. DuMond, *J. of App. Phys.*, 10, 609-611 (1939).

Origin of the Earth's Magnetic Field.
Walter M. Elsasser, *Nature*, 143, 374-375 (1939).

On the Origin of the Earth's Magnetic Field.
Walter M. Elsasser, *Phys. Rev.*, 55, 489-498 (1939).

Normal Modes of Vibration of a Body-Centered Cubic Lattice.
Paul Charles Fine, *Phys. Rev.*, 56, 355-359 (1939).

*†Preuves expérimentales de l'existence de propriétés de "Groupes" dans les métaux a l'etat solide.
A. Goetz, *Congres International de Physique*, London, 1934.

Vitrification and Crystallization of Organic Cells at Low Temperatures.
Alexander Goetz and S. Scott Goetz, *J. App. Phys.*, 9, 718-729 (1938).

The Living State of Matter in the Range of Low Temperatures.
Alexander Goetz, *Science*, 88, 501-502 (1938).

Death by Devitrification in Yeast Cells.
A. Goetz and S. Scott Goetz, *Biodynamica*, 43 (1938).

The Graininess of Photographic Emulsions III.
A. Goetz and W. O. Gould, *Agfa Mot. Pic. Topics*, Nov.-Dec., 1938.

The Graininess of Photographic Emulsions IV.
A. Goetz and W. O. Gould, *Agfa Mot. Pic. Topics*, March-April, 1939.

*Not available for distribution.
†Not previously reported.

*An Instrument for the Absolute Measurement of the Graininess of Photographic Emulsions.
A. Goetz, W. O. Gould, and A. Dember, *Jour. S. M. P. E.*, 32, 469, 1939.

Tieftemperaturkonservierung lebender Zellen durch Verglasung.
A. Goetz, *Umschau*, 43, 489-491 (1939).

The Possible Use of Superconductivity for Radiometric Purposes.
Alexander Goetz, *Phys. Rev.*, 55, 1270-1271 (1939).

Graininess of Photographic Emulsions.
A. Goetz, *Photo Technique*, 1, 21-29 (1939).

*The Practical Applicability of Low Temperature Phenomena.
A. Goetz, *Papers, 98th Meeting Am. Chem. Soc. P.*, 11-12, 1939.

*Intensity Profiles of Bragg Reflections between 300° and 4.2° K.
A. Dember and A. Goetz, *Papers, 98th Meeting Am. Chem. Soc. P.*, 12-13, 1939.

X-Ray Evidence on the Nature of the Surface Layers of Thin Ground Quartz Crystals Secured with the Cauchois Spectrograph.
F. R. Hirsh, Jr., and J. W. M. DuMond, *Phys. Rev.*, 54, 789-792 (1938).

Resonance Broadening of Spectral Lines.
W. V. Houston, *Phys. Rev.*, 54, 884-888 (1938).

Conservation of Momentum in Electrical Conductivity.
W. V. Houston, *Phys. Rev.*, 55, 1255-1261 (1939).

Electrons in Metals.
W. V. Houston, *Proc. Am. Phil. Soc.*, 81, 525-532 (1939).

Shape of the Modified Compton Line for Hydrogen and Ceylon Graphite Scatterers.
H. A. Kirkpatrick and J. W. M. DuMond, *Phys. Rev.*, 54, 802-808 (1938).

Contact Electric Phenomena in the Flow of Oil.
S. Kyropoulos, *Bull. Amer. Phys. Soc.*, 14, 10 (1939).

Experimental Studies on Non-Fluid Lubrication. I.
S. Kyropoulos, *Refiner and Natural Gasoline Manufacturer*, 18, 274 (1939).

Experimental Studies on Non-Fluid Lubrication II. A.
S. Kyropoulos, *Refiner and Natural Gasoline Manufacturer*, 18, 320 (1939).

On the Viscosity of Nonpolar Liquids.
S. Kyropoulos, *J. Chem. Phys.*, 7, 52-57 (1939).

*Lord Rutherford of Nelson (Obituary).
Robert A. Millikan, *Am. Philosophical Soc. Year Book*, 1939, pp. 386-388.

*Science and Social Justice.
Robert A. Millikan, *Vital Speeches*, 5, 98-101 (1938).

*Science and the World of Tomorrow.
Robert A. Millikan, *Scient. Month.*, 49, 210-214 (1939); *Vital Speeches*, 5, 446-448 (1939).

*The Place of the Private Secondary School in Modern Life.
R. A. Millikan, *Thacher School Semicentennial Addresses*, 85-93 (1939).

Studies of Cosmic Rays.
Robert A. Millikan, *Carnegie Institution Year Book No. 37*, 1937-1938, pp. 378-380.

†The Progress of the Institute.
Robert A. Millikan. Published by the Institute, August, 1938; 11 pages.

Address at Dedication of the Seeley W. Mudd and the Charles Arms Laboratories of the Geological Sciences.
Robert A. Millikan, *Bulletin of the California Institute of Technology*, 48, 2, 29-35 (1939).

The Progress of the Institute.
Robert A. Millikan, *Bulletin of the California Institute of Technology*, 48, 2, 21-28 (1939).

---

*Not available for distribution.
†Not previously reported.

Seasonal Effects in Cosmic Ray Intensities from Sea Level up to the Top of the Atmosphere.
R. A. Millikan and H. Victor Neher, *Science*, 89, 398 (1939).

Albert Abraham Michelson.
Robert A. Millikan, *Biographical Memoirs of National Academy of Sciences*, XIX, 121-147 (1938); also *Sci. Monthly*, 48, 16-27 (1939).

Seasonal Cosmic-Ray Effects at Sea Level.
R. A. Millikan, H. V. Neher, and D. O. Smith, *Phys. Rev.*, 56, 487-490 (1939).

New Evidence for a Change with Time of the Total Energy Brought into the Earth by Cosmic Rays.
R. A. Millikan and H. V. Neher, *Phys. Rev.*, 56, 491-493 (1939).

A High Speed Mechanical Recorder.
H. Victor Neher, *R. S. I.*, 10, 29-31 (1939).

Two Voltage Regulators.
H. Victor Neher and William H. Pickering, *R. S. I.*, 10, 53-56 (1939).

Note on the Fine Structure of Hα and Dα.
Simon Pasternack, *Phys. Rev.*, 54, 1113 (1938).

Transition Probabilities of some Forbidden Lines of Astrophysical Interest.
Simon Pasternack, *Pub. A. S. P.*, 51, 160-162 (1939).

A Generalization of the Polynomial $F_n(x)$.
Simon Pasternack, *Phil. Mag.*, 28, 209-226 (1939).

Dispersion und Absorption kurzer elektrischer Wellen und Molekulstrüktur.
E. Keutner and G. Potapenko, *Physik. Zeit.*, 40, 100-104 (1939).

Cosmic Rays and Radioactive Potassium.
W. R. Smythe, *Phys. Rev.*, 55, 316 (1939).

Pressure Shifts of the High Terms of the Absorption Series of Na, Rb and Cs Produced by Hydrogen and Nitrogen.
Ny Tsi-Ze and Ch'en Shang-Yi, *Phys. Rev.*, 54, 1045-1047 (1938).

Anomalous Scattering of Neutrons by Helium.
H. Staub and W. E. Stephens, *Phys. Rev.*, 55, 131-139 (1939).

Neutrons from the Breakup of He^5.
H. Staub and W. E. Stephens, *Phys. Rev.*, 55, 845-850 (1939).

Remarks on the Doctor of Philosophy Degree.
Richard C. Tolman, *J. of Proc. and Addresses of the Assn. of Am. Universities*, November, 1938, pp. 77-84.

Static Solutions of Einstein's Field Equations for Spheres of Fluid.
Richard C. Tolman, *Phys. Rev.*, 55, 364-373 (1939).

Greaseless Vacuum Valves.
Charles H. Townes, *R. S. I.*, 9, 428-429 (1938).

The Angular Distribution of Cosmic-Ray Particles Scattered in 1 Cm. of Platinum.
J. A. Vargus, Jr., *Phys. Rev.*, 56, 480-481 (1939).

Reproductions of Prints, Drawings and Paintings of Interest in the History of Physics. 4. Trinity College, Cambridge, at the Time of Newton.
E. C. Watson, *Am. Phys. Teacher*, 6, 319-320 (1938).

Reproductions of Prints, Drawings and Paintings of Interest in the History of Physics. 5. Portraits and Caricatures of Joseph Black, and Prints of Edinburgh and Glasgow in His Day.
E. C. Watson, *Am. Phys. Teacher*, 7, 123-129 (1939).

Reproductions of Prints, Drawings and Paintings of Interest in the History of Physics. 6. Eminent Men of Science of Great Britain Living in the Years 1807-1808.
E. C. Watson, *Am. Phys. Teacher*, 7, 185-187 (1939).

Reproductions of Prints, Drawings and Paintings of Interest in the History of Physics. 7. A Meeting of the Académie Royale des Sciences in the King's Library in Paris on the Occasion of a Visit by Louis XIV in 1671.
E. C. Watson, *Am. Phys. Teacher*, 7, 238-240 (1939).

Edme Mariotte (c.1620-1684).
E. C. Watson, *Am. Phys. Teacher*, 7, 230-232 (1939).

A Possible Portrait of Arthur Cayley as an Undergraduate at Cambridge.
E. C. Watson, *Scripta Mathematica*, 6, 31-36 (1939).

The Early Days of the Académie des Sciences as portrayed in the Engravings of Sebastien Le Clerc.
E. C. Watson, *Osiris*, 7, 556-587 (1939).

A Device to Protect Large Vacuum Systems against Accidental Interruptions of the Mechanical Pump.
J. Paul Youtz, *R. S. I.*, 9, 420-421 (1938).

On the Theory and Observation of Highly collapsed Stars.
F. Zwicky, *Phys. Rev.*, 55, 726-743 (1939).

Cosmic Rays from Supernovae.
F. Zwicky, *Phys. Rev.*, 55, 986 (1939).

Production of Atomic Rays and of Cosmic Rays in Supernovae.
F. Zwicky, *P. N. A. S.*, 25, 338-344 (1939).

W. K. Kellogg Laboratory of Radiation

Scattering of Fast Electrons.
W. A. Fowler, *Phys. Rev.*, 54, 773 (1938).

The Gamma-radiation from Boron Bombarded by Deuterons.
E. Gaerttner, W. A. Fowler, and C. C. Lauritsen, *Phys. Rev.*, 55, 27 (1939).

Half-value Layer Measurements with a 1,000 kv. Roentgen Tube.
Thomas Lauritsen, *Am. J. Roent. & Rad. Therapy*, 41, 999-1002 (1939).

Depth Dose Measurements with a 1,000 kv. Roentgen Tube.
Thomas Lauritsen, *Am. J. Roent. & Rad. Therapy*, 41, 1003-1006 (1939).

Short Range Alpha-Particles from $F^{19} + H^{1}$.
W. B. McLean, R. A. Becker, W. A. Fowler, and C. C. Lauritsen, *Phys. Rev.*, 55, 796 (1939).

Clinical Application of Super-hard X-Rays in the Treatment of Cancer.
Seeley G. Mudd. Chapter in *The Treatment of Cancer and Allied Diseases;* editors, George T. Pack, M.D., and Edward M. Livingston, M.D.

Vertebrate Zoology

The Arizona Broad-billed Hummingbird.
Robert T. Moore, *The Auk.*, 56, 313-319 (1939).

Discovery of the Nest and Eggs of the Tufted Jay.
Robert T. Moore, *The Condor*, 40, 233-241 (1938).

A New Race of Cyanthus Latirostris from Guanajuato.
Robert T. Moore, *Proc. Biol. Soc. Wash.*, 52, 57-60 (1939).

New Races of the Genera Sialia and Carpodacus from Mexico.
Robert T. Moore, *Proc. Biol. Soc. Wash.*, 52, 125-130 (1939).

Two New Races of Carpodacus Mexicanus.
Robert T. Moore, *Proc. Biol. Soc. Wash.*, 52, 105-112 (1939).

A Review of the House Finches of the Subgenus Burrica.
Robert T. Moore, *The Condor*, 41, 177-205 (1939).

The Genus Otus of Mexico and Central America.
Robert T. Moore and James L. Peters, *The Auk*, 56, 38-56 (1939).

The Authority for the Name of the Long-tailed Chat.
A. J. van Rossem, *The Auk,* 56, 87 (1939).

A Colorado Desert Race of the Summer Tanager.
A. J. van Rossem, *Trans. of San Diego Soc. of Nat. Hist.,* 9, 13-14 (1938).

Descriptions of Three New Birds from Western Mexico.
A. J. van Rossem, *Trans. of San Diego Soc. of Nat. Hist.,* 9, 9-12 (1938).

Descriptions of Two New Subspecies of Birds from Western Mexico.
A. J. van Rossem, *Proc. Biological Soc. of Wash.,* 52, 11-12 (1939).

Four New Races of Sittidae and Certhidae from Mexico.
A. J. van Rossem, *Proc. Biological Soc. of Wash.,* 52, 3-6 (1939).

The Identity of Forpus Cyanopygius (Souancé).
A. J. van Rossem, *The Auk,* 56, 70 (1939).

The Identity of Garrulus Sordidus Swainson.
A. J. van Rossem, *The Auk,* 56, 86-87 (1939).

A New Race of Becard from Northeastern Mexico.
A. J. van Rossem, *The Condor,* 40, 262-263 (1938).

A New Race of Sharp-Shinned Hawk from Mexico.
A. J. van Rossem, *The Auk,* 56, 127-128 (1939).

A New Spotted Screech Owl from Guerreto, Mexico.
A. J. van Rossem, *The Condor,* 40, 258 (1938).

Notes on some Mexican and Central American Wrens of the Genera Heleodytes, Troglodytes, and Mannorchilus; and Four New Races.
A. J. van Rossem, *B. O. C. Bull.,* 59, 10-15 (1938).

Notes on Two Woodhewers from Mexico.
A. J. van Rossem, *Proc. Biological Soc. of Wash.,* 52, 15-16 (1939).

An Overlooked Race of the California Quail.
A. J. van Rossem, *The Auk,* 56, 68 (1939).

A Race of the Rivoli Humming Bird from Arizona and Northwestern Mexico.
A. J. van Rossem, *Proc. Biological Soc. of Wash.,* 52, 7-8 (1939).

A Dimorphic Subspecies of the Bush-Tit from Northwestern Mexico.
A. J. van Rossem and the Marquess Hachisuka, *Trans. San Diego Soc. of Nat. Hist.,* 9, 7-8 (1938).

A New Race of Cliff Swallow from Northwestern Mexico.
A. J. van Rossem and the Marquess Hachisuka, *Trans. of San Diego Soc. of Nat. Hist.,* 9, 5-6 (1938).

A Northwestern Race of the Mexican Cormorant.
A. J. van Rossem and the Marquess Hachisuka, *Proc. Biological Soc. of Wash.,* 52, 9-10 (1939).

A Race of the Military Macaw from Sonora.
A. J. van Rossem and the Marquess Hachisuka, *Proc. Biological Soc. of Wash.,* 52, 13-14 (1939).

II. Engineering

Aeronautics and Meteorology

Daniel Guggenheim Aeronautical Laboratory

108. Supersonic Flow over an Inclined Body of Revolution.
Hsue-Shen Tsien, *Jour. Aero. Sci.,* 5, 480-483 (1938).

109. Flight Analysis of a Sounding Rocket with Special Reference to Propulsion by Successive Impulses.
Hsue-Shen Tsien and Frank J. Malina, *Jour. Aero. Sci.,* 6, 50-58 (1938).

110. *Use of Orthogonal Functions in Structural Problems.
Th. von Kármán, "Contributions to the Mechanics of Solids," *Stephen Timoshenko 60th Anniversary Volume*, 114-124 (1938).

111. A Non-Linear Wing Theory and Its Application to Rectangular Wings of Small Aspect Ratio.
William Bollay, *Zeitschrift für angewandte Mathematik und Mechanik*, 19, 21-35 (1939).

112. Some Remarks on the Statistical Theory of Turbulence.
Th. von Kármán, *Proceedings of the Fifth Inter. Congr. for Applied Mechanics*, pp. 347-351 (1938).

113. A Contribution to the Airfoil Theory for Non-Uniform Motion.
William R. Sears, *Proceedings of the Fifth Inter. Congr. for Applied Mechanics*, pp. 483-487 (1938).

114. A Critical Discussion of Turbulent Flows in Channels and Circular Tubes.
Clark B. Millikan, *Proceedings of the Fifth Inter. Congr. for Applied Mechanics*, pp. 386-392 (1938).

115. A Method of Determining End Fixity.
W. Lavern Howland, *Jour. of Aero. Sci.*, 6, 284-288 (1939).

116. An Investigation of the Conditions for the Occurrence of Flutter in Aircraft and the Development of Criteria for the Prediction and Elimination of Such Flutter.
A. E. Lombard, (1939).

117. A Correction to the Yawing Moment due to Ailerons for Circular Wind Tunnels.
H. J. Stewart, *Jour. Aero. Sci.*, 6, 329-331 (1939).

118. The Analogy between Fluid Friction and Heat Transfer.
Th. von Kármán, *Transactions of the A. S. M. E.*, pp. 1-6 (1939).

119. The Growth of the Circulation of an Airfoil Flying through a Gust.
W. R. Sears and A. M. Kuethe, *Jour. Aero. Sci.*, 6, 376-378 (1939).

120. Two-Dimensional Subsonic Flow of Compressible Fluids.
Hsue-Shen Tsien, *Jour. Aero. Sci.*, 6, 399-407 (1939).

121. General Airplane Performance.
W. C. Rockefeller, *N. A. C. Tech. Rep.*, 654 (1939).

122. The Aerodynamics of Reacting Substances.
H. Bateman, *Proc. Nat. Acad. Sci.*, 25, 388-391 (1939).

Atmospheric Radiation Charts.
Walter M. Elsasser. (Privately printed.) (1939).

A Technique for the Preparation of Monthly Weather Predictions.
Irving P. Krick, *Abstract of Memoirs of the International Union of Geodesy and Geophysics*, Washington, pp. 26-27 (1939).

Civil, Electrical, and Mechanical Engineering

Discussion to the Article: Hard-Surfacing Processes and Material.
Donald S. Clark, *Mechanical Engineering*, 61, 395 (1939).

Results of Lamella Roof Tests Reported.
Frederick J. Converse, *Building Standards Monthly*, 7, 6-7 (1938).

Curvilinear Flow of Liquids with Free Surfaces at Velocities above that of Wave Propagation.
Robert T. Knapp and Arthur T. Ippen, *Proceedings of the 5th International Congress of Applied Mechanics*, 531-536 (1938).

Forced Air Circulation for Refrigerator Cars.
F. C. Lindvall, *Refrigerating Engineering*, 32, 297-301 (1939).

*Not available for distribution.

A Modified Logarithmic Probability Graph for the Interpretation of Mechanical Analyses of Sediments.
George H. Otto, *Jour. of Sedimentary Petrology*, 9, 62-76 (1939).

Wind-Tunnel Classifier for Sand and Silt.
George H. Otto and Hunter Rouse, *Civil Engineering*, 9, 414-415 (1939).

Multiple-Stage Sewage Sludge Digestion.
A. M. Rawn, A. Perry Banta, and Richard Pomeroy, *Trans. A. S. C. E.*, 104, 93-132 (1939).

Experiments on the Mechanics of Sediment Suspension.
Hunter Rouse, *Proceedings of the 5th International Congress for Applied Mechanics*, 550-554 (1938).

An Analysis of Sediment Transportation in the Light of Fluid Turbulence.
Hunter Rouse, *U. S. Dept. of Agric., Soil Conservation Service, Sedimentation Division*, SCS-TP-25, July (1939).

Author's Closure: The Economic Status of the Engineer.
R. W. Sorensen, *Trans. A. I. E. E.*, 57, 790 (1938).

Test Barrel Devised for Surge Tests in Oil.
R. W. Sorensen, *Electrical Engineering*, 58, 15 (1939).

Discussion to the Article: The Paradox of Social Progress.
R. W. Sorensen, *Electrical Engineering*, 58, 89-90 (1939).

The Student Engineer and Electrical Engineering.
R. W. Sorensen, *Electrical Engineering*, 58, 181-182 (1939).

III. HUMANITIES

The Treatment of Constitutional History in Macaulay's *History of England*.
Godfrey Davies, *Huntington Library Quarterly*, January, 1939.

Edited, *The Regimental History of Cromwell's Army*, by C. H. Firth.
Godfrey Davies.

The Temples of Stowe and their Debts: Sir Thomas Temple and Sir Peter Temple, 1603-1653.
Edwin F. Gay, *Huntington Library Quarterly*, July, 1939.

*Refugees from the Dust Bowl (a review of *The Grapes of Wrath*, by John Steinbeck, and *Factories in the Field*, by Carey McWilliams).
William Huse, *Alumni Review, California Institute of Technology*, Sept., 1939.

Review of *John of the Mountains. The Unpublished Journals of John Muir.*
G. R. MacMinn, *Frontier and Midland*, 19, 135-6 (1938).

*The Bryce That I Knew.
William B. Munro, in *Bryce's American Commonwealth*, Fiftieth Anniversary Volume, pp. 204-220, The Macmillan Company, 1939.

*Schools, Standards and Moral Stamina.
William B. Munro, *Thacher School Semi-centennial addresses*, 21-25 (1939).

Influence of Age on Employment.
Dwight Livingston Palmer and J. A. Brownell, *Monthly Labor R.*, 48, 765-780 (1939).

The Price of Security.
D. L. Palmer, *Mech. Eng.*, 61, 463-464 (1939).

Industrial Relations in the United States.
Dwight L. Palmer, *Occupational Psych.*, 13, 178-199 (1939).

*A Review of Taylor Caldwell's *Dynasty of Death*.
Roger Stanton, *Alumni Review*, California Institute of Technology, March, 1939.

*The Spiritual Quality of Democracy.
Theodore Gerald Soares, *Official Report of American Association of School Administration*, 7-16 (1939).

---

*Not available for distribution.

***The Role of the Teacher.**
Theodore Gerald Soares, *Proceedings of Association of Colleges and Universities of the Pacific Southwest,* 20-22 (1939).

Humanitarianism and Romanticism.
Edward A. Whitney, *Huntington Library Quarterly,* January, 1939.

Erastianism and Divine Right.
Edward A. Whitney, *Huntington Library Quarterly,* July, 1939.

The Retreat of the Humanities.
Louis B. Wright, *The English Journal,* XXVIII.

Richard Lee II, a Belated Elizabethan in Virginia.
Louis B. Wright, *Huntington Library Quarterly,* October, 1938.

A Shorthand Diary of William Byrd of Westover.
Louis B. Wright, *Huntington Library Quarterly,* July, 1939.

Some Early "Friends" of Libraries.
Louis B. Wright, *Huntington Library Quarterly,* April, 1939.

---

*Not available for distribution.

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 the following degrees: the higher degree of Bachelor of Science with designation, in Aeronautics, in Meteorology, or in Chemical Engineering, for a fifth year of work in those departments (see pages 189-191), 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 the above degrees 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 *only to 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*. Applications received at a later date may be given delayed consideration, and admission may have to be refused solely on the basis of limited facilities in the department concerned. Students applying for admission may be required in advance to give evidence of their ability to pay the necessary tuition fees and support themselves during the proposed period of study. Students

applying for assistantships or fellowships need not make separate application for admission to graduate standing, but should make application for appointment by February 15. See pages 164-165.

3. Admission to graduate standing does not of itself admit to candidacy for the degree of Bachelor of Science with designation, or Master of Science or Doctor of Philosophy.

II. TUITION FEES

The tuition fee for graduate students in regular attendance at the Institute will be \$300 a year, payable in three equal installments of \$100 at the beginning of each term. Graduate students who cannot devote full time to their studies are allowed to register only under special circumstances. Students desiring permission to register for less than 33 units should petition therefor on a blank to be obtained from the Registrar. If such reduced registration is permitted, the tuition will be at the rate of \$75 a term for 25 to 32 units, and at the rate of \$3 a unit for less than 25 units, with a minimum of \$30 a term. If the courses registered for do not correspond to the full educational facilities made available to the student, additional tuition will be charged.

The payment of tuition by graduate students is required (a) without reference to the character of the work of the student, which may consist in the prosecution of research, in independent reading, or in the writing of a thesis or other dissertation, as well as in attendance at regular classes; (b) without reference to the number of terms in which the student has already been in residence; and (c) without reference to the status of the student as an appointee of the Institute, except that members of the academic staff of rank of Instructor or higher are not required to pay tuition. Graduate students who continue their researches during the summer are not required to pay tuition fees therefor.

An annual fee of \$4 to assist in the defraying of expenses in cases of emergency requiring hospitalization is required.* No other fees

---

*See page 80.

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 at the beginning of the school year to cover such charges. Such a deposit is also required of students working for a degree in the Division of the Geological Sciences. No degrees are awarded until all bills due the Institute have been paid.

In regard to *fellowships and assistantships*, see pages 164-169 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 CONCERNING WORK FOR THE DEGREES OF BACHELOR OF SCIENCE WITH DESIGNATION AND MASTER OF SCIENCE

I. GENERAL REQUIREMENTS

To receive the degree of Bachelor of Science with designation or of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of fifth-year and sixth-year courses (see pages 188-193) as well as in the schedule of the Four-Year Course in Science or in Engineering (see pages 174-187), 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 higher 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 degrees of Bachelor of Science with designation and 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, Geophysics, 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 the degree shall be made by the appropriate committee, 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 Bachelor of Science with designation or 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 these degrees may be obtained from the Registrar, and must be submitted not later than November fifteenth of the school 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 pages 97-102 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. Students registering for more than 50 units but less than 63 units in any term must have the approval of their department. Registration for more than 62 units must in addition have the approval of the Registration Committee.

III. SCHOLASTIC REQUIREMENTS

1. A minimum of 150 units of residence work is required for a fifth-year degree.

2. Scholastic requirements given on pages 99-102 of the catalogue for undergraduate students also apply to fifth-year students.

3. In the case of a student registered for the higher bachelor's or 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.

4. A fifth-year student who has completed his senior year at the Institute is subject to the same regulations as are juniors and seniors, as listed on page 101.

Candidates for a fifth-year degree who have completed their undergraduate work at other institutions are subject to the same scholastic regulations applying to new transfer students as listed on page 100.

IV. THESIS

In the case of a required thesis two final copies 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 a thesis presented in partial fulfilment 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 primarily 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 period 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.

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 for.

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, after consultation with the chairman of the division, shall 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: "A" excellent, "B" good, "C" satisfactory, "D" poor, "E" conditioned, "F" 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. GENERAL 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.

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 fulfilment 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 fulfilment 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 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. For special departmental regulations concerning admission to candidacy, see Section VI.

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 registration of students transferring from other colleges, 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.

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. For special departmental regulations concerning candidacy and final examinations, see Section VI.

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. For special departmental regulations concerning theses, see Section VI.

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 Fulfilment 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 REQUIREMENTS FOR THE DOCTOR'S DEGREE

In agreement with the general requirements for the doctor's degree adopted by the Committee on Graduate Study, as set forth in Section V (pages 152-156), the various divisions and departments of the Institute have adopted the following supplementary regulations.

A. PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

1a. *Physics.* To be recommended for candidacy for the doctor's degree in Physics the applicant must pass the following subjects with a grade of C or better:

Ph. 101 a b	Electricity and Magnetism
Ph. 105 a b	Analytical Mechanics
Ph. 105 a b	Optics

and 45 units selected from the following courses:

Ph. 101 c	Electricity and Magnetism
Ph. 103 c	Analytical Mechanics
Ph. 105 c	Optics
Ph. 107 a b c	Atomic Physics
Ph. 110 a	Kinetic Theory
Ph. 114	Principles of Quantum Mechanics
Ph. 115	Applications of Quantum Mechanics
Ph. 211	Thermodynamics
Ph. 236 a b c	Theory of Relativity
Ch. 224 a b c	Statistical Mechanics

1b. *Mathematics.* To be recommended for candidacy for the doctor's degree in Mathematics the applicant must pass the following subjects with a grade of C or better:

Ma. 101 a b c	Modern Algebra
Ma. 201	Modern Analysis
	or
Ma. 205	Theory of Functions
Ma. 256 a b c	Modern Differential Geometry
Ma. 102 a b c	Introduction to Higher Geometry

and any *one* of the following subjects:

Ph. 101 a b c	Electricity and Magnetism
Ph. 103 a b c	Analytical Mechanics
Ph. 105 a b	Optics
	and
Ph. 114	Quantum Mechanics

One of the year sequences given by Professor Epstein.

1c. *Electrical Engineering.* To be recommended for candidacy for the doctor's degree in Electrical Engineering the applicant must pass the following subjects with a grade of C or better:

Ph. 101 a b c	Electricity and Magnetism

and one of the following subjects:

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 subjects:

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 subjects 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 any of the course requirements described above by taking an examination in the subject with the instructor in charge. Every examination of this type will cover the *whole* of the course specified and the student will not be permitted

to take it either in parts (e.g. term by term) or more than twice. These so-called candidacy examinations will be given early in the fall term of each year and the student must apply for permission to take them before the end of the second week of the term. Such application must be in writing and, if approved, will be regarded as one of the two permitted trials, whether or not the student actually takes the examination. (Note: The above regulations are not to be interpreted as preventing the student, with the permission of the instructor in charge, from satisfying the candidacy requirements by taking the term examinations in a course without actual class attendance.)

No course which has been taken more than twice will be counted towards the fulfilment of the above candidacy requirements, nor will the student be permitted a total of more than three trials at the removal of any part of the candidacy requirements.

Students are advised to satisfy the conditions for admission to candidacy in their respective departments as rapidly as possible.

Students registered for the Ph.D. degree who fail to meet at least two-thirds of the candidacy requirements by the end of their first year of graduate study will not be allowed to register for further work without special permission 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 and the final doctoral examination will be based upon this work rather than upon the candidacy courses.

4. Candidates for the degree of Doctor of Philosophy with a major in Physics or Mathematics must take the final examination some time before the beginning of the term in which they expect the degree to be conferred.

5. 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.

6. 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.

B. CHEMISTRY*

1. To be recommended for candidacy for the doctor's degree in Chemistry 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 a candidate.

3. The forty-five units of study offered for satisfaction of a minor requirement are to consist in general of graduate courses other

*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 Mechanical Engineering.

than research; however, the Division of Chemistry and Chemical Engineering may, by special action, permit up to twenty-three units to consist of appropriate research.

4. After admission to candidacy a student must in general pursue advanced study and research for not less than four terms (counting equivalent summer work) before he will be recommended by the Division of Chemistry and Chemical Engineering for the final examination for the doctor's degree.

5. 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 ten in number, of which about four should relate to the minor subject and 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 defense of them. It is recommended that the candidate begin the formulation of his set of propositions early in his course of graduate study.

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.

C. CIVIL AND MECHANICAL ENGINEERING, AERONAUTICS, AND METEOROLOGY

1a. *Civil Engineering.* To be recommended for candidacy for the doctor's degree in Civil Engineering the applicant must pass with a grade of C or better, the subjects prescribed and elected for the fifth year, or equivalent substitutions satisfactory to the department, and such other advanced subjects related to the contemplated direction of study as the department may require, and must pass special comprehensive oral or written examinations in the fields covered by these subjects.

1b. *Mechanical Engineering.* To be recommended for candidacy for the doctor's degree in Mechanical Engineering the applicant must pass the following subjects with a grade of C 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	Fluid Mechanics
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 subjects.

1c. *Aeronautics.* To be recommended for candidacy for the doctor's degree in Aeronautics the applicant must pass the following subjects with a grade of C 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 was taken elsewhere than at the Institute, the candidate will be required to pass special examinations indicating an equivalent knowledge of the subject.

1d. *Meteorology.* To be recommended for candidacy for the doctor's degree in Meteorology the applicant must pass the following subjects with a grade of C or better:

Ma. 14	Vector Analysis
AE. 266 a b	Theoretical Aerodynamics I
Ph. 211	Thermodynamics

and one of the following subjects:

Ma. 114 a b	Introduction to Mathematical Analysis
EE. 226 a b	Engineering Mathematical Physics

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.

D. GEOLOGICAL SCIENCES

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 doctoral 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 doctoral 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.

E. BIOLOGY

1. To be recommended for candidacy for the doctor's degree in Biology a student must pass a comprehensive written examination covering advanced work in the major and minor fields at least two terms before the degree is to be conferred. A final oral examination covering principally the work of the thesis will be held at least two weeks before the degree is to be conferred.

2a. *Animal Physiology.* For a major in Animal Physiology, the subjects in this field and other supplementary subjects of graduate rank must be taken. If there is one minor, it must be taken in Biology; if there are two minors, the second may be taken outside the Division of Biology.

2b. *Biochemistry.* Either the Biology or the Chemistry Option or its equivalent is prerequisite. In either case, examinations in Chemical Principles and Organic Chemistry, set by the Division of Chemistry, must be passed satisfactorily; and an examination on Biochemistry (based on Bi. 7a, b) must also be passed. Later, more advanced work (Bi. 110 and 102) will be required before the examination for admission to candidacy is taken. At least one of the minors must be in another department of the Division of Biology.

2c. *Bio-organic Chemistry.* For a major in Bio-organic Chemistry, either the Biology or the Chemistry Option or its equivalent is prerequisite. Those who take the Biology Option should include Ch. 46a, b (Organic Chemistry Laboratory) either as an undergraduate or graduate subject. For graduate work in bio-organic chemistry, the subjects Bi. 115 (Chemistry of Bio-organic Substances) and Bi. 141 (Plant Chemistry) are both required. For the minor some field of biology or chemistry should be chosen.

2d. *Embryology.* For a major in Embryology, the Biology Option or its equivalent is prerequisite. In addition to the subjects and the research in the major and minor fields, advanced work in at least one other department of the Division of Biology will be required. The program of work will depend upon the preliminary training of the student and will be subject to the approval of those in charge of the major work.

2e. *Genetics.* For a major in Genetics the Biology Option or its equivalent is prerequisite. As a part of the major, Bi. 125 should be taken for at least two years, and other subjects in related fields. For a minor, some other subject or subjects, either in the Division of Biology or in some other division of the Institute, should be taken, subject to the approval of those in charge of the major.

2f. *Plant Physiology.* For a major in Plant Physiology the Biology Option or its equivalent is prerequisite. The major should include Bi. 140, Bi. 141, and related subjects. For a minor, one or two other subjects in the Division should be chosen, with the approval of those in charge of the major.

3. A minor in the Division of Biology must be taken in *one* of the departments of study listed above, unless special arrangements are made otherwise.

D. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

I. 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 73 and 169) 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.

Students from any university or college, who have completed their undergraduate work satisfactorily (see page 145), are eligible to apply for graduate assistantships and fellowships. In the award of such appointments 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 or department 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. In using these forms it is not necessary to make separate application for admission to graduate standing. When possible, these applications should reach the Institute by February 15. Successful applicants for appointment may expect to receive notification thereof sometime in March or April. 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

The character of various fellowships and scholarships available at the Institute is described below, but in making application graduate students should not designate any particular appointment.

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 further 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 units, 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, United States Bureau of Reclamation, United States Soil Conservation Service, Metropolitan Water District of Southern California, Los Angeles County Flood Control District, Los Angeles City Harbor Board, Los Angeles County seismological interests, American Petroleum Institute, General Petroleum Corporation, Polymerization Process Corporation, Shell Oil Company, Standard Oil Company of California, Texaco Development Corporation, Union Oil Company of California, Consolidated Aircraft Corporation, Curtiss-Wright Corporation, Douglas Aircraft Co., Inc., Lockheed Aircraft Corporation, North American Aviation, Inc., Vultee Aircraft Division, Aviation Mfg. Corporation, Agfa-Ansco Corporation, Allis-Chalmers Manufacturing Company, Asphalt Institute, Caterpillar Tractor Co., Geo-Frequenta Corporation, Hughes Tool Company, Kelco Company, Lane-Wells Company, National Supply Company, Rare Metals Institute, Research Corporation of New York, A. O. Smith Corporation, Submarine Signal Company, Mr. Arnold Pfau, Dr. W. M. White, and the Mudd and Kellogg funds for research 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 already holding the doctor's degree, who desire to carry on special investigations, may be invited to make use of the facilities of the Institute. 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 73) 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.

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 development departments of the larger chemical, metallurgical, and electrical companies.

The Option in Applied Chemistry and the fifth-year and sixth-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, Paleontology and Geophysics Options and the graduate courses in these fields prepare students for teaching and research positions in colleges and universities, for Government posts in connection with geological and mining surveys, for places as investigators and field explorers of museums and, above all, for professional work as geologists, paleontologists and geophysicists in the petroleum or 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 187-257. 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
Drafting and 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

FIRST YEAR, ALL THREE TERMS

		Units per Term
Ma 1 abc	Mathematics* (4-0-8)	12
Ph 1 abc	Physics* (3-3-6)	12
Ch 1 abc	Chemistry* (3-6-3)	12
En 1 abc	English* (3-0-3)**	6
H 1 abc	History (3-0-2)	5
D 1, 3 ab	Drafting*** (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 100.

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 Drafting (0-6-0)	6 or	6	..
D 6b	Engineering Drafting (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 174 and 175)

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 100.

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 2a	Electrical Machinery (3-0-6)	..	9	..
EE 3a	Electrical Machinery Laboratory (0-3-3)	..	6	..
EE 2b	Electrical Machinery (3-0-6)	..	..	9
EE 3b	Electrical Machinery Laboratory (0-3-3)	..	..	6
A: Ma 11	Differential Equations (3-0-6)	..	9	..
ME 15	Heat Engineering (3-3-6)	12	..	..
Hy 5	Hydraulics (3-3-6)	..	..	12
B: Ph 5 abc	Mathematical Physics (4-0-8)	12	12	12

FOURTH YEAR

		1st	2nd	3rd
	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	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
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 5	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 174 and 175)

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 100.

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

		1st	2nd	3rd
	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 6	Transportation Engineering	6	..	..
CE 7	Curves and Earthwork (2-0-4)	..	6	..
CE 8	Route Surveying (0-6-0)	..	..	6
CE 10 ab	Theory of Structures (3-3-6) (3-0-6)	12	..	9
CE 11	Design of Structures (3-3-6)	..	12	..
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 110	Engineering Geology (2-2-5)	..	..	9

*See first footnote on page 176.

COURSE IN ENGINEERING
MECHANICAL ENGINEERING OPTION

(For First and Second Years, see pages 174 and 175)

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 100.

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 ab	Hydraulics (3-3-6) (3-0-6)	12	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

		1st	2nd	3rd
	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 abc	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	..	..	6
CE 9	Structures (3-3-5)	..	11	
ME 5 abc	Machine Design (3-0-6) (3-3-3) (3-3-3)	9	9	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 Current Laboratory (0-3-2)	5	..	..
Ec 2	Economics (4-0-6)	..	10	..
EE 10	Alternating Currents (3-0-4)	..	..	7
EE 11	Alternating Current Laboratory (0-3-2)	..	..	5
	Elective	..	..	9

Men who expect to attend the graduate school of aeronautics should substitute Ma. 11 (9 units) and ME 50c (2 units) for ME 16 in the third term of the third year and in the fourth year should substitute:

		1st	2nd	3rd
Ma 15 abc	Higher Mathematics for Engineers (3-0-6)	9	9	9
ME 8	Machine Design (3-3-6)	12	..	..
AE 2 ab	Aircraft Structures	..	12	12
AM 3	Testing Materials Laboratory (0-3-3)	..	6	..
	Elective	..	..	6

for ME 5 abc, ME 17, ME 50 abc, CE 9, and the 9 unit Elective.

*See first footnote on page 176.

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 174)

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 100.

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 Bi 2 Ay 1	Paleontology (4-1-4) or Biology (3-4-2) or Astronomy (3-1-5) } (Except Ph., Ap. Ph., and Geol. Op. C)	..	..	9
	Options as below	..	..	10

OPTIONS

PHYSICS AND APPLIED PHYSICS

(Students in these options do not take Ch 12 ab or Ay 1)

Ch 11	Analytical Chemistry (2-6-2)	..	..	10
L 32 abc	German (4-0-6)	10	10	10

MATHEMATICS

(Students in this option do not take Ch 12 ab)

L 32 abc	German (4-0-6)	10	10	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 (Options A, B, and C)**

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 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 majoring in the Geological Sciences, Options A (Geology) and B (Paleontology), do not take mathematics the third term. Students in Option C (Geophysics) take Ma 2 c d.

***All students are required to pass a comprehensive examination in English and History at the end of the sophomore year.

COURSE IN SCIENCE
PHYSICS OR ASTRONOMY OPTION

(For First and Second Years, see pages 174 and 179)

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 100.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ch 23 abc	Chemical Principles (4-0-8)	10	10	10
Ph 5 abc	Intro. to Math. Physics (4-0-8)	12	12	12
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9

FOURTH YEAR

		1st	2nd	3rd
	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	..
Ph 101 abc	Electricity and Magnetism (3-0-6)	9	9	9
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
Ma 10 abc	Differential Equations (3-0-6)	9	6	6
Ay 1	Astronomy (3-1-5)	..	..	9
EE 162	Vacuum Tubes (4-0-8)	..	12	..
Ch 43	Organic Chemistry (2-6-2)	..	..	10
Ma 118 a	Statistics (3-0-6)	9	..	..
Ph 107 a	Atomic Physics (3-0-6)	9	..	..

*See first footnote on page 176.

COURSE IN SCIENCE
APPLIED PHYSICS OPTION

(For First and Second Years, see pages 174 and 179)

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 100.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ch 23 abc	*Chemical Principles* (4-0-6)	10	10	10
Ph 5 abc	Intro. to Math. Physics (4-0-8)	12	12	12
EE 8, 9	Direct Currents (3-3-6)	12	..	..
EE 10, 11	Alternating Currents (3-3-6)	..	12	..
Ec 2	Economics (4-0-6)	..	..	10

FOURTH YEAR

		1st	2nd	3rd
	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
Ay 1	Astronomy (3-1-5)	..	..	9
Ph 8	Electricity and Magnetism (3-0-6)	9	..	..
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
EE 162	Vacuum Tubes (4-0-8)	..	12	..
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Ch 43	*Organic Chemistry* (2-6-2)	..	..	10
Ma 11	Differential Equations (3-0-6)	..	9	..
ME 21	Heat Engineering (3-3-6)	12	..	..

*See first footnote on page 176.

COURSE IN SCIENCE
MATHEMATICS OPTION

(For First and Second Years, see pages 174 and 179)

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 100.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ph 5 abc	Intro. to Math. Physics (4-0-8)	12	12	12
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
	Schedule A (1939-40, 1941-42, etc.):			
Ma 3	Theory of Equations (3-0-7)	10	..	..
Ma 4 ab	Analytic Geometry (3-0-7)	..	10	10
	Schedule B (1940-41, 1942-43, etc.):			
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

		1st	2nd	3rd
	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
Ma 106 ab	Functions of a Real Variable (3-0-6)	9	9	..
	Schedule A (1940-41, 1942-43, etc.):			
Ma 10 abc	Differential Equations (3-0-6)	9	9	9
Ma 102 abc	Higher Geometry (4-0-8)	12	12	12
Ma 16	Introduction to Higher Algebra (3-0-6)	9	..	..
Ma 111	Elementary Theory of Tensors (3-0-6)	..	9	..
Ph 114	Quantum Mechanics (3-0-6)	..	..	9
	Schedule B (1941-42, 1943-44, etc.):			
Ma 3	Theory of Equations (3-0-7)	10	..	..
Ma 4 ab	Analytic Geometry (3-0-7)	..	10	10
Ma 101 abc	Modern Algebra (3-0-6)	9	9	9
Ma 114 abc	Mathematical Analysis (4-0-8)	12	12	12

*See first footnote on page 176.

COURSE IN SCIENCE
CHEMISTRY OPTION

(For First and Second Years, see pages 174 and 179)

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	Physical Chemistry Laboratory (0-6-2; 0-3-1)	..	8	4
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 abc	Organic Chemistry Laboratory (0-6-0; 0-10-0)	6	6	10
Ch 16	Instrumental Analysis (0-6-2)	8	..	..

FOURTH YEAR

		1st	2nd	3rd
	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 21 d	Chemical Principles (1-0-2)	3	..	..
Ch 22	Thermodynamic Chemistry (3-0-6)	..	9	..
Ch 13 ab	Inorganic Chemistry (2-0-4)	6	6	..
Ch 29	Colloid and Surface Chemistry (3-0-5)	..	..	8
	Elective Subjects (see below)	19	17	14

Elective Subjects***

		1st	2nd	3rd
Ch 80-86	Chemical Research	†	†	†
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
Ch 13 c	Inorganic Chemistry (2-0-2)	..	..	4
Ch 48	Qualitative Organic Chemical Analysis	12	..	..
Ch 49	Quantitative Organic Chemical Analysis	..	10	..
Ch 50	Organic Preparations	..	..	9
	Advanced subjects in Physical Chemistry	6-9	6-9	6-9
Ph 5 abc	Introduction to Mathematical Physics	12	12	12
	Advanced undergraduate subjects in Mathematics	6-12	9-12	9-12

*See first footnote on page 176.

**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 should fill out their schedules to a total of not less than 49 units each term from the elective courses. Before registration the student's program must be approved by a representative of the division.

†Units to be arranged.

COURSE IN SCIENCE
APPLIED CHEMISTRY OPTION

(For First and Second Years, see pages 174 and 179)

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

		1st	2nd	3rd
	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 21d	Chemical Principles (1-0-2)	3	..	..
Ch 63c	Chem. Eng. Thermodynamics (1-0-2)	3	..	..
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 176.

**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 174 and 179)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in freshman and sophomore physics and chemistry may, at the discretion of the Division of the Geological Sciences, be refused permission to register for the junior course in the Geological Sciences Option.

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
	Ge 14	Geologic Illustration (0-10-0)	10	..	..
	Ge 21 ab	Field Geology (1-8-1)	..	10	10
A.	Ch 24 ab	Physical Chemistry (4-0-6)	10	10	..
	Ge 3 abc	Mineralogy (3-6-3)	12	12	12
	CE 3	Plane Table Surveying (1-6-1)	..	..	8
B.	Ge 3 abc	Mineralogy (3-6-3)	12	12	12
	Bi 3	General Botany (2-2-2)	6	..	..
		or			
	Bi 13	Mammalian Anatomy (1-2-2)	5	..	..
	Bi 4	Invertebrate Zoology (2-6-2)	..	..	10
	CE 3	Plane Table Surveying (1-6-1)	..	8	..
C.	Ph 5 abc	Introduction to Math. Physics (4-0-8)	12	12	12
	Ch 24 ab	Physical Chemistry (4-0-6)	10	10	..
	CE 3	Plane Table Surveying (1-6-1)	..	..	8

Summer Camp, Ge 123, 12 units, required for Groups A and B.

†Students working for a degree in the Division of the Geological Sciences are required to make a deposit to cover damage to equipment and facilities involved in their work.

COURSE IN SCIENCE
GEOLOGICAL SCIENCES OPTION

FOURTH YEAR

		Units per Term 1st	2nd	3rd
	Humanities Electives* (3-0-6)	9	9	9
Ge 100	Geology Club	1	1	1
Ge 102	Oral Presentation**	1	1	1
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)	..	..	12
L 35 abc	German (4-0-6 or 3-0-3)	10	6***	6***
Ge 109	Structural Geology (4-0-6)	10	..	..
Ge 121 ab	Advanced Field Geology	Units to total 50		
A. Ge 105	Optical Mineralogy (2-6-2)	10	..	..
Ge 106 ab	Petrography (2-6-2)	..	10	10
Ge 111 ab	Invertebrate Paleontology (2-6-2)	10	10	..
B. Ge 111 ab	Invertebrate Paleontology (2-6-2)	10	10	..
Ge 112 ab	Vertebrate Paleontology (2-6-2)	..	10	10
Bi 3	General Botany (2-2-2)	6	..	..
	or			
Bi 13	Mammalian Anatomy (1-2-2)	5	..	..
C. Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 10 abc	Differential Equations (3-0-6)	9	9	9
EE 8	Direct Currents (3-0-4)	..	7	..
EE 9	Direct Current Laboratory (0-3-2)	..	5	..
Ge 175	Elementary Geophysics (2-0-3)	..	..	5

Summer Camp, Ge 123, 12 units, required for Groups A and B. Vertebrate Anatomy, Bi 17, 10 units, given at the Marine Station at Corona del Mar, may be substituted by Group B.

---

*See first footnote on page 176.

**Required of all candidates for a degree. The number of terms required will be determined by the degree of proficiency attained.

***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
BIOLOGY OPTION

(For First and Second Years, see pages 174 and 179)

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 100.

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 41 abc	Organic Chemistry (3-0-5, 3-0-5, 2-0-4)	8	8	6
Ch 46c	Organic Chemistry Laboratory (0-8-0)	..	..	8
Ch 23 abc	Chemical Principles (4-0-6)	10	10	10
A: Courses offered in 1940-41 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 1939-40 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	..	..
Ec 2	Economics (4-0-6)	..	..	10
	And one of the following:			
A: Courses offered in 1940-41, same as in third year		14	12	8
B: Courses offered in 1939-40, 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 176.

***Properly qualified students may substitute Bi 9 (Bacteriology) for Bi 20, if they can obtain permission to carry the resulting overload.

SCHEDULES OF COURSES FOR THE DEGREES OF BACHELOR OF SCIENCE WITH DESIGNATION AND MASTER OF SCIENCE

SUBJECTS COMMON TO ALL COURSES

		Units per Term 1st	2nd	3rd
H 100	Seminar in American History and Government	9	9	9
En 100	or English Literature			
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

(Leading to the degree of Master of Science in Electrical Engineering)

	Subjects common to all courses	11	11	11
EE 120 a	Alternating Current Analysis	12	..	..
EE 120 b	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
EE 165	Electronics Laboratory	..	..	6

CIVIL ENGINEERING

(Leading to the degree of Master of Science in Civil Engineering)

Ec 100 abc	Business Economics	12	12	12
CE 120 a	Statically Indeterminate Structures	12	..	..
CE 121 abc	Structural and Civil Engineering Design	12	9	9
CE 125	Irrigation and Water Supply	..	..	12
CE 126	Masonry Structures	..	9	..
CE 127	Sewerage	..	..	9
Ma 15 abc	Higher Mathematics for Engineers	9	9	9
AM 105 ab	Soil Mechanics	6	6	..
CE 130 abc	Seminar	2	2	2
	Research or Thesis as arranged	3	9	3

	SUPPLEMENTARY SUBJECTS	Units per Term 1st	2nd	3rd
CE 120 bc	Statically Indeterminate Structures	..	..	..
CE 122	Earthquake Effects Upon Structures	..	..	..
CE 131 ab	Sewage Treatment Plant Design	..	..	..
CE 132 ab	Water Power Plant Design	..	..	..
CE 135 ab	Geodesy and Precise Surveying	..	..	..
Ge 110	Engineering Geology	..	..	9
AE 270	Elasticity	12	6	6
AE 273 abc	Synoptic Meteorology	12	12	12
Hy 100	Fluid Mechanics	..	12	..
Hy 103	Hydraulic Problems	..	..	6
Bi 9	Bacteriology	8	..	..

MECHANICAL ENGINEERING

(Leading to the degree of Master of Science in Mechanical Engineering)

Ec 100 abc	†Business Economics	12	12	12
ME 110a	Science of Metals	6	..	..
ME 111a	Metallography Laboratory	6	..	..
ME 120	Heat Engineering	12	..	..
ME 150 abc	Mechanical Engineering Seminar	2	2	2
Ma 15	Higher Mathematics for Engineers	9	9	9
	Electives, as below	..	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	Fluid Mechanics	..	12	..
Hy 101	Hydraulic Machinery	..	..	12
	Research or Thesis, as arranged			

AERONAUTICS

FIFTH YEAR

(Leading to the degree of Bachelor of Science in Aeronautics)

	Humanities (page 188)	9 or 12	9 or 12	9 or 12
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	Engineering Mathematical Physics	15	15	..
or				
*Ma 114 ab	Mathematical Analysis	12	12	..
Ma 14	Vector Analysis	..	..	9
AE 290 abc	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	..	..	6

†Or another Humanities elective (see page 188), 9 units each term.

*Men who lack the prerequisites for these courses may postpone them until the sixth year, replacing them by Ma 15 a, b, c.

SIXTH YEAR

(Leading to the degree of Master of Science in Aeronautics)

		Units per Term 1st	2nd	3rd
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	15	15	15
	Electives	..	9	6

METEOROLOGY

FIFTH YEAR

(Leading to the degree of Bachelor of Science in Meteorology)

	Subjects common to all courses (page 188)	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

(Leading to the degree of Master of Science in Meteorology)

*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

(Leading to the degree of Master of Science in Physics)

	Subjects common to all courses (page 188)	11	11	11

*AE 272 will replace Ph 91 abc on fifth-year students' curricula when a one-year course is pursued.

ELECTIVES

		Units per Term 1st	2nd	3rd
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	..
Ma 114 abc	Mathematical Analysis	12	12	12
Ph 114	Principles of Quantum Mechanics	..	..	9
Ph 115	Applications of Quantum Mechanics	9	..	..
Ph 116	Relativistic Quantum Mechanics	..	9	..
Ma 118 abc	Introduction to Statistics	9	9	9
Ph 120	History of Physics Seminar	4-9	4-9	4-9
	Research	15	15	15

MATHEMATICS

(Leading to the degree of Master of Science in Mathematics)

		1st	2nd	3rd
	Humanities Electives (see page 188)	9	9	9
Ma 114 abc	Math. Anal. (4-0-8) (*Schedule A, page* —) or	12	12	12
Ma 102 abc	Higher Geometry (4-0-8) (*Schedule B, page* —)			
Ma 101 abc	Modern Algebra (3-0-6) or	9	9	9
Ma 16	Introd. to Higher Algebra (3-0-6), Ma 111 Elementary Theory of Tensors (3-0-6), and Ph 114 Quantum Mechanics (3-0-6)			
	Electives and Research	21	21	21

CHEMISTRY

(Leading to the degree of Master of Science in Chemistry)

		1st	2nd	3rd
	Subjects common to all courses (page 188)	11-14	11-14	11-14
Ch 280-286	Research	12-18	12-18	12-18
	Advanced elective subjects to constitute a program of study approved by a member of the Division.			

CHEMICAL ENGINEERING

FIFTH YEAR

(Leading to the degree of Bachelor of Science in Chemical Engineering)

		1st	2nd	3rd
	Subjects common to all courses (page 188)	11-14	11-14	11-14
Ch 166 abc	Chemical Engineering	12	12	12
Ch 167 abc	Chemical Engineering Laboratory	15	15	15
	Advanced elective subjects in Chemistry, Physics, Mathematics, and Mechanical Engineering to constitute a program of study approved by a member of the Division.			

SIXTH YEAR

(Leading to the degree of Master of Science in Chemical Engineering)

		1st	2nd	3rd
Ch 186	Research	20-30	20-30	20-30
	Advanced elective subjects in Chemistry, Physics, Mathematics, and Mechanical Engineering to constitute a program of study approved by a member of the Division.			

GEOLOGICAL SCIENCES

(Leading to the degree of Master of Science in the Geological Sciences)

		Units per Term 1st	2nd	3rd
H 10 En 100 Pl 100	Seminar in History and Gov't., or English Literature, or Philosophy, or	9	9	9
Ec 100 abc	Business Economics	12	12	12
Ge 100	Geology Club	1	1	1
Ge 102	Oral Presentation	1	1	1
	Elected units from group A or B (see below)	39	39	39

A. GEOLOGY AND PALEONTOLOGY

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	10	10	..
Ge 112 ab	Vertebrate Paleontology	..	10	10
Ge 115	Micropaleontology	..	8	..
Ge 121 ab	Advanced Field Geology	8-12	8-12	8-12
Ge 122	Spring Field Trip	..	..	1
Ge 123	Summer Field Geology	..	..	12
Ge 175	Elementary Geophysics	..	..	5
Ge 176	Elementary Seismology	6*	..	..
Ge 200	Mineragraphy	10	..	..
Ge 202	Metalliferous Deposits	..	10	..
Ge 209	Sedimentary Petrology	..	8†	..
Ge 210	Metamorphic Petrology	..	8*	..
Ge 211	Petrology (Seminar)	..	..	5
Ge 212	Non-metalliferous Deposits	..	..	10*
Ge 213	Mineral Deposits (Seminar)	..	5†	..
Ge 214	Mineral Economics (Seminar)	..	5*	..
Ge 215	Mineralogy (Seminar)	5	..	..
Ge 220	History of Geology	5†	..	..
Ge 225	Geology of Western America	3*	..	..
Ge 226	Geomorphology	10	..	..
Ge 227	Shoreline Geomorphology	..	..	6†
Ge 228	Geomorphology of Arid Regions	..	..	6*
Ge 230	Geomorphology (Seminar)	..	..	5
Ge 232 ab	Introduction to Petroleum Geology	10	10	..
Ge 235	Petroleum Geology (Seminar)	..	..	5
Ge 237	Tectonics	..	..	10
Ge 238	Structural Geology (Seminar)	5	..	..
Ge 245 ab	Vertebrate Paleontology (Seminar)	..	5	5
Ge 248	Fossils of the California Tertiary	..	5	..
Ge 249	Stratigraphy of the Coast Ranges	5	5	..
Ge 250 ab	Invertebrate Paleontology (Seminar)	5	..	..

*Given 1939-1940; 1941-1942.
†Given 1940-1941.

B. GEOPHYSICS

		Units per Term 1st	2nd	3rd
AE 275	Structure of the Atmosphere	..	..	3
CE 2	Advanced Surveying	12	..	..
CE 107	Geodesy	6	6	6
CE 122	Analysis of Earthquake Effects upon Structures (units by arrangement)	..	..	..
EE 8/9	Direct Currents	12 or	12	..
EE 10/11	Alternating Currents	..	12 or	12
EE 156	Electrical Communication	6	..	..
EE 162	Vacuum Tubes	..	12	..
EE 165	Electronics Laboratory	..	..	6
Ge 3	Mineralogy	12	12	12
Ge 109	Structural Geology	10	..	..
Ge 121 ab	Advanced Field Geology	8-12	8-12	8-12
Ge 122	Spring Field Trip	..	..	1
Ge 175	Elementary Geophysics	..	..	5
Ge 176	Elementary Seismology	5*	..	..
Ge 225	Geology of Western America	3*	..	..
Ge 226	Geomorphology	10	..	..
Ge 232 ab	Introduction to Petroleum Geology	10	10	..
Ge 238	Structural Geology (Seminar)	5	..	..
Ge 261	Theoretical Seismology	6†	..	..
Ge 262/3	Interpretation of Seismograms	..	5†	5†
Ge 265	Introduction to General Geophysics	..	6†	..
Ge 270	Seismic Instruments	9	..	..
Ge 273	Applied Geophysics I	5*	..	..
Ge 274	Applied Geophysics II	..	5*	..
Ge 275	Applied Geophysics III	..	5†	..
Ge 278	Interpretation of Field Seismograms	..	5*	..
Ge 279	Laboratory and Field Work in Electrical Methods	..	..	7*
Ge 280	Laboratory, Gravitational and Magnetic Methods	..	..	7†
Ge 282	Geophysics Seminar	..	..	3
Ge 283	Geophysical Instruments Seminar	..	3	..
Ge 285 ab	Geophysics Research Conference	2	2	..
Ge 297	Advanced Study (297u or 297w, or 297x) (units by arrangement)	..	..	..
Ge 299	Research (299u, or 299w, or 299x) (units by arrangement)	..	..	..
Ma 8	Advanced Calculus	9	9	9
Ma 10	Differential Equations	9	9	9
Ma 12	Probability and Least Squares	6	..	..
Ma 118	Statistics	9	9	9
Ph 9	Electrical Measurements	4	4	4
Ph 91	Introduction to Mathematical Physics	8	8	8
Ph 101	Electricity and Magnetism	9	9	9
Ph 221	Potential Theory	..	..	15

BIOLOGY

(Leading to the degree of Master of Science in Biology)

Subjects common to all courses (see page 188) .. 11 11 11

Approved elective courses in Biology or other subjects, to be arranged with the professor in charge.

---

*Given 1939-1940.

†Given 1940-1941.

SUBJECTS OF INSTRUCTION

SUBJECTS IN SCIENCE

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: JAMES BONNER, ROBERT EMERSON,[1] ANTHONIE VAN HARREVELD, HUGH M. HUFFMAN, GEORGE E. MACGINITIE, ALBERT TYLER, JOHANNES VAN OVERBEEK

UNDERGRADUATE SUBJECTS

Bi. 1. Elementary Biology. 9 units (3-3-3); second term.
An introductory subject 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 subject 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.
Instructor: MacGinitie.

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 the chemical processes taking place in the living plant.
Instructors: Went, van Overbeek.

Bi. 6. Embryology. 12 units (2-8-2); second term.
A subject 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.

[1] On leave of absence until 1940.

Bi. 8. Advanced Genetics. 8 units (2-3-3); third term.
A more advanced subject than Bi. 2, dealing especially with mutation, crossing over, and chromosome aberrations.
Instructor: Sturtevant.

Bi. 9. Bacteriology. 8 units (2-4-2); first term.
A course in general bacteriology, emphasizing the biochemical and physiological properties of bacteria.
Instructor: Ellis.

Bi. 12. Histology. 9 units (1-6-2); first term.
A subject 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 subject, 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 subject is intended to give the student practice in the finding and use of original literature. Students may register for this subject with any member of the staff, after consultation.

Bi. 22. Research. Units to be arranged in individual cases.
An opportunity will be given to follow special lines of research under direction. Students may register for this subject with any member of the staff, after consultation.

ADVANCED SUBJECTS

A. Subjects open to graduates, but not to be counted toward a major for the degree of Doctor of Philosophy:

Bi. 92. Biological Assays. 8 units (1-5-2); two terms.
A course, with lectures and laboratory practice, on certain biological tests for physiologically active substances.
Instructors: Went, Haagen-Smit, Bonner, van Overbeek.

Bi. 96 a, b. Animal Physiology. 10 units (3-2-5); first and second terms.
Same as Bi. 16.

Bi. 97 a, b. Biochemistry. 10 units (2-4-4); second and third terms.
Same as Bi. 7.

Bi. 98. Advanced Genetics. 8 units (2-3-3); third term.
This is the same as Bi. 8, but additional outside reading will be required for graduate credit.

Bi. 99. Bacteriology. 8 units (2-4-2); first term.
Same as Bi. 9, with additional reading.

B. Subjects that may be counted toward either a major or a minor for the degree of Doctor of Philosophy:

Bi. 100. Genetics Journal Club.
Meets twice monthly for presentation and discussion of current literature and original work.
In charge: Sturtevant.

Bi. 101. Biology Journal Club.
Meets twice monthly for reports on current literature of general biological interest.
In charge: 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 a, b, c. Advanced Biochemistry. 12 units.
Lectures and laboratory studies of biological oxidations, fermentations, preparation of enzymes and study of their action, chemistry and physiology of vitamins. To be given once every three years.
Instructors: Borsook, Huffman.

Bi. 111. Applications of Thermo-chemistry to biological problems.
To be given if enough students apply for it.
Instructor: Huffman.

Bi. 114 a, b, c. Chemistry of Bio-Organic Substances. 8 units (1-3-4); three terms.
Prerequisite: Ch. 41 a, b, c.
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 naturally occurring substances.
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 subject as the enrollment is necessarily limited.

Instructor: Haagen-Smit.

Bi. 120. Experimental Embryology. 6 units (1-0-5).

Lectures and discussion of the problems of embryonic development, including such topics as growth of the ovary, breeding habits of animals, fertilization, cleavage, organ formation, metamorphosis, regeneration, tissue culture, embryonic metabolism, etc.

The subject may be taken for two consecutive years since the subject matter will be duplicated only in alternate years.

Instructor: Tyler.

Bi. 121 a, b, c. Experimental Embryology Laboratory. Units to be decided by student and instructor; given any term.

The work will include certain classical experiments and instruction in the methods of studying embryonic metabolism, in transplantation, vital staining, etc.

Instructor: Tyler.

Bi. 125. Graduate Genetics. 12 units (2-3-7).

A course of advanced lectures, two per week, running through all three terms.

The course may be taken for three years, since the subject-matter is not duplicated within that period.

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 subject in the analysis of plant materials by macro- and microchemical methods.

Instructor: Bonner.

Bi. 160. Advanced Physiology. 12 units (0-8-4); first and second terms.

A subject 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 subject.

CHEMISTRY AND CHEMICAL ENGINEERING

PROFESSORS: LINUS PAULING, STUART J. BATES, JAMES E. BELL, ROSCOE G. DICKINSON, WILLIAM N. LACEY, RICHARD C. TOLMAN, LÁSZLO ZECHMEISTER
ASSOCIATE PROFESSORS: RICHARD MCLEAN BADGER, HOWARD J. LUCAS, ERNEST H. SWIFT, DON M. YOST
RESEARCH ASSOCIATES: EDWIN R. BUCHMAN, JOSEPH B. KOEPFLI
ASSISTANT PROFESSORS: ARNOLD O. BECKMAN, CARL NIEMANN, BRUCE H. SAGE, JAMES H. STURDIVANT
SENIOR FELLOW IN RESEARCH: ROBERT B. COREY
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, Yost, and Teaching Fellows.

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: *Chemical Analysis*, Swift.
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: *Chemical Analysis*, Swift.
Instructor: Swift.

Ch. 12 c. Analytical Chemistry and Chemistry Review. 10 units (2-6-2); third term.
Prerequisite: Ch. 12 b.
Advanced qualitative analysis and a study of special methods of chemical analysis, including electrometric methods. Analyses of selected alloys, minerals, and other materials will be made. Students may be assigned individual problems 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, c. Inorganic Chemistry. 6 units (2-0-4), first and second terms; 4 units (2-0-4), third term.

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. 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.

Instructors: Swift and Teaching Fellows.

Ch. 21 a, b, c, d. Chemical Principles. 10 units (4-0-6), first, second, and third terms; 3 units (1-0-2), first term.

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.

Instructor: Bates.

Ch. 22. Thermodynamic Chemistry. 9 units (3-0-6); second term.

A continuation of subject Ch. 21, given in much the same way. The topics considered include a further study of electrochemistry and thermodynamic chemistry. Practice is given in the computation of free energies, activities and entropies of typical substances.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

Ch. 23 a, b, c. Chemical Principles. 10 units (4-0-6); first, second, and third terms.

Prerequisites: Ch. 11 or Ch. 12 b; Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

A selection of topics from Ch. 21 a, b, c, d, and from Ch. 22 adapted to the needs of Science Course students in the Physics and Biology Options.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Dickinson.

Ch. 24 a, b. Physical Chemistry. 10 units (4-0-6); first and second terms.

Prerequisites: Ch. 12 a, b; Ma. 2 a, b; Ph. 2 a, b, c, d.

A discussion of selected topics in physical chemistry, adapted to the needs of Science Course students in the Geology Option.

Text: *Physical Chemistry for Colleges,* Millard.

Instructor: Corey.

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.
Instructor: Badger.

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.
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: *Organic Chemistry,* Lucas.
Instructor: Niemann.

Ch. 46 a, b, c. Organic Chemistry Laboratory. 9 units (0-9-0) or 6 units (0-6-0), first and second terms; 10 units (1-9-0), third 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. 48. Qualitative Organic Chemical Analysis. 12 units (2-9-1); first term.
A laboratory study of the class reactions of carbon compounds, and practice in the methods of identifying unknown substances.
Instructor: Lucas.

Ch. 49. Quantitative Organic Chemical Analysis. 10 units (1-9-0); second term.
Practical studies in the quantitative analysis of organic compounds, including the semi-micro estimation of carbon, hydrogen, nitrogen, halogens, sulfur, acetyl, and methoxyl.
Instructor: Niemann.

Ch. 50. Advanced Organic Laboratory. Units to be arranged; any term.
Laboratory practice in the synthesis of typical organic compounds.
Instructors: Lucas, Niemann, Buchman, Koepfli.

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. 62. 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: Lacey.

Ch. 63 a, b, c. Chemical Engineering Thermodynamics. 6 units (2-0-4), second and third terms; 3 units (1-0-2), first term.
Prerequisite: Ch. 21 a.
Class exercises and problems in engineering thermodynamics studied from the point of view of the chemical engineer.
Instructor: Lacey.

Ch. 80-86. Chemical Research.
Opportunities for research are afforded to undergraduate students in all the main branches in chemistry; thus, in analytical or inorganic chemistry (Ch. 80), in physical chemistry (Ch. 82), in organic chemistry (Ch. 84), and in applied chemistry (Ch. 86). 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. 113 a, b. Inorganic Chemistry. 4 units; first and second terms.
Selected groups of inorganic compounds will be considered from modern physicochemical 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. 122 a, b. Thermodynamic Chemistry. 6 units (2-0-4), first term; 9 units (3-0-6), second term.
This subject is open to students who have had a course in physical chemistry.

During the first term the elements of thermodynamics are reviewed. The second term is the same as Ch. 22.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

Ch. 129. Colloid and Surface Chemistry. 8 units; third term.

This course is the same as Ch. 29.

Instructor: Badger.

Ch. 148. Qualitative Organic Chemical Analysis. 12 units (2-9-1); first term.

This course is the same as Ch. 48.

Instructor: Lucas.

Ch. 149. Quantitative Organic Chemical Analysis. 10 units (1-9-0); second term.

This course is the same as Ch. 49.

Instructor: Niemann.

Ch. 150. Advanced Organic Laboratory. Units to be arranged; any term.

This course is the same as Ch. 50.

Instructors: Lucas, Niemann, Buchman, Koepfli.

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 unit operations of chemical industry (such as materials transfer, 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 a, b, c. Chemical Engineering Laboratory. 15 units (0-15-0); first, second, and third terms.

Prerequisites: Ch. 21, Ch. 61, Ch. 63.

A course of laboratory work to give training in the methods and technique fundamental to engineering measurements and research encountered by the chemical engineer.

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. 180-186. Chemical Research.

Opportunities for research in analytic and inorganic chemistry (180), physical chemistry (182), organic chemistry (184), and applied chemistry and chemical engineering (186) are offered to candidates for the degree of Master of Science. The main lines of research in progress are tabulated under Ch. 280-286.

Ch. 221 a, b, c. The Nature of the Chemical Bond (Seminar). 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 seminar be held in 1941-42, and every third year thereafter.

Text: *The Nature of the Chemical Bond,* Pauling.

In charge: Pauling.

Ch. 222 a, b, c. Seminar on Thermodynamics and Statistical Mechanics, with Chemical Applications. 6 units; first, second, and third terms.

A thorough discussion of the fundamental principles and methods of thermodynamics and statistical mechanics, followed by their application to the practical problems of modern chemistry, including the calculation of thermodynamic properties of substances from spectroscopic and structural data.

This seminar will be held in 1939-40, and every third year thereafter.

In charge: Dickinson, Yost, Badger.

Ch. 223 a, b. Kinetics of Homogeneous and Heterogeneous Reactions (Seminar). 6 units; first and second terms.

Lectures and discussions relating to homogeneous and heterogeneous chemical reactions, absorption, and contact catalysis.

This seminar will be held in 1940-41, and every third year thereafter.

In charge: Dickinson, Badger.

Ch. 224 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.

Text: *Principles of Statistical Mechanics,* Tolman.

In charge: Tolman.

Ch. 226 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. 227 a, b, c. The Structure of Crystals. 9 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 in 1940-1941, and every third year thereafter.

Instructors: Sturdivant, Pauling.

Ch. 228 a, b, c. Crystal Structure Laboratory. Units determined by the instructor; any term.

Practical instruction is given in the methods of determining the structure of crystals with X-rays.

Instructor: Sturdivant.

Ch. 229. Diffraction Methods of Determining the Structure of Molecules. 6 units.

A discussion of the diffraction of X-rays and electrons by gases, liquids, glasses, and crystals.

Instructors: Pauling, Sturdivant, Schomaker.

Ch. 230. 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. 232. 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. 234. 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. 251. The Chemistry of Carotenoids. 6 units (2-0-4); second and third terms.
A course of lectures on the chemistry and biochemistry of the carotenoids and related substances.
Instructor: Zechmeister.

Ch. 243. Quantitative Organic Microanalysis. 20 units (0-20-0); any term by arrangement.
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 subject as the enrollment is necessarily limited.
Instructor: Haagen-Smit.

Ch. 244 a, b. The Reactions of Organic Compounds. 6 units; first and second terms.
A consideration of the typical reactions exhibited by the various functional groups in relatively isolated conditions and under conditions where the reaction may be influenced by the unique structure of the molecule or by other coexistent functional groups. Lectures and discussions.
This subject will be presented in 1939-40 and every third year thereafter.
Instructors: Zechmeister, Niemann, Buchman, Lucas.

Ch. 245 a, b. The Synthesis of Organic Compounds. 6 units; first and second terms.
A systematic treatment of the practical synthesis of organic compounds including historical examples of the various types of synthesis.
This subject will be presented in 1940-41 and every third year thereafter.
Instructors: Zechmeister, Niemann, Buchman, Koepfli, Lucas.

Ch. 246 a, b. Theoretical Organic Chemistry. 6 units; first and second terms.
A consideration of the basic theories of organic chemistry including valence, stereochemistry, the structure of organic molecular compounds and organic radicals, tautomerism, intramolecular rearrangements, the structure of aliphatic and aromatic compounds, and the mechanism of organic reactions.
This subject will be presented in 1941-42 and every third year thereafter.
Instructors: Lucas, Niemann, Buchman.

Ch. 252. The Chemistry of Carbohydrates. 4 units (2-0-2); third term.
Lectures and discussions on the chemistry of the mono- and disaccharides.
This subject will be presented in 1939-40 and every third year thereafter.
Instructor: Niemann.

Ch. 253. The Chemistry of Vitamins. 4 units (2-0-2); third term.

Lectures on recent advances in knowledge of the chemical nature of vitamins and related substances.

This subject will be presented in 1940-41 and every third year thereafter.

Instructor: Buchman.

Ch. 255 a, b, c. Chemistry of Bio-Organic Substances. 8 units; three terms.

A series of lectures on selected topics of organic chemistry which have special interest from a biological view-point. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of naturally occurring substances. For undergraduates, prerequisite: Ch. 41 a, b, c; Ch. 46 a, b.

Instructor: Haagen-Smit.

Ch. 256. Chemistry of Bio-Organic Substances.

Advanced work with opportunity for research is offered to properly qualified graduate students.

Instructor: Haagen-Smit.

Ch. 261. 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, primarily in solid-liquid systems.

Instructor: Lacey.

Ch. 262 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. 280-286. Chemical Research.

Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical and inorganic chemistry (280), physical chemistry (282), organic chemistry (284), and applied chemistry and chemical engineering (286).

The main lines of research now in progress are:

- Chemical analysis of the rarer elements.
- Free-energies, equilibria, and electrode-potentials of reactions.
- Low temperature calorimetry.
- Study of crystal structure and molecular structure by diffraction of X-rays and electrons.
- 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.
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.
Flow of fluids through porous media.
Rate of attainment of equilibrium in heterogeneous systems.
The synthesis of hydrocarbons containing three- and four-membered rings.
Studies on the constitution of the phosphotides and the cerebrosides.
The synthesis of fluorine analogs of thyroxine and a study of their role in animal metabolism.
Studies on the mechanism of the in-vivo oxidation of glycosides.
The synthesis of disaccharides and of alkylated monosaccharides.
Configurational studies on the mono- and di-hydroxy amino acids.
The synthesis and properties of the *a*-hydroxy and *a*-alkoxy amines and their role in biological reactions.
The study of plant hormones and related substances of physiological importance.
The chemistry of protozoa.
Chemical genetics.

For a fuller survey of the researches in progress, see publications of the Gates and Crellin Laboratories of Chemistry (pages 130-132).

Ch. 290-296. Chemical Research Conferences.
Each 2 units, except Ch. 293; given all three terms.

Ch. 290. General Research Conference in Chemistry.

Ch. 291. Crystal and Molecular Structure.

Ch. 292. Photochemistry.

Ch. 293. Band Spectra and Molecular Structure. 1 unit.

Ch. 294. Organic Chemistry.

Ch. 296. 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.

GEOLOGICAL SCIENCES

PROFESSORS: JOHN P. BUWALDA, BENO GUTENBERG, CHESTER STOCK
ASSOCIATE PROFESSORS: HUGO BENIOFF, IAN CAMPBELL, GENNADY W. POTAPENKO
ASSISTANT PROFESSORS: HORACE J. FRASER, ROBERT MINSSEN KLEINPELL, JOHN H. MAXSON, CHARLES F. RICHTER
INSTRUCTORS: FRANCIS D. BODE, 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, Bode, and Teaching Fellows.

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, Henshaw.

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: *Mineralogy,* Kraus, Hunt and Ramsdell, 3rd edition.
Instructors: Fraser (Ge. 3 a, b), Campbell (Ge. 3 c), McGill.

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-

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: Willoughby.

Ge. 21 a, b. Introduction to Field Geology. 10 units (1-6-3); second and third terms.

Prerequisites: Ge. 1 a, b, c; 3 a.

An introduction to the fundamental principles and technique used in geologic mapping involving the interpretation of geologic maps, field studies of rock types, the solution of simple field problems in structure and stratigraphy, and geologic computations. To these ends, small areas are mapped in great detail and reports prepared in professional form.

Text: *Field Geology,* Lahee.

Instructor: Bode.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ge. 100. Geology 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. 102. Oral Presentation. 1 unit; first, second, and third terms.

Training in the technique of oral presentation. Practice in the effective organization and delivery of reports before groups.

Successful completion of this course is required of all candidates for the bachelor's, master's, and doctor's degrees in the Division. The number of terms taken will be determined by the proficiency shown in the first term's work.

Instructor: Jones.

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: *Thin Section Mineralogy,* Rogers and Kerr.

Instructors: Fraser, Regan, C. Smith.

Ge. 106 a, b. Petrography. 10 units (2-6-2); second and third terms.

Prerequisites: Ge. 3 a, b, c; 105; Ch. 24 a, b.

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: *Petrology of the Igneous Rocks,* Hatch and Wells.

Instructors: Campbell, Regan.

Ge. 109. Structural Geology. 10 units (4-0-6); first term.

Prerequisite: Ge. 21 a, b.

A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation.

Text: *Structural Geology,* Nevin.

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 reservoirs, 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. 10 units (2-6-2); first and second terms.
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.
Texts: *Tertiary Faunas,* Davies; *Invertebrate Paleontology,* Twenhofel and Shrock.
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. 115. Micropaleontology. 8 units (1-3-4); not given 1939-40.
Prerequisites: Ge. 111 a, b.
Introduction to the morphology and classification of the foraminifera. Their use in stratigraphic correlation with special reference to the Tertiary of California.
Texts: *The Foraminifera, their Classification and Economic Use,* Cushman; *A Manual of the Foraminifera,* Galloway.

Ge. 121 a, b. Advanced Field Geology. 8-12 units any term for graduate students; units to bring total to 50 per term for seniors.
Prerequisites: Ge. 3 a, b, c; 21 a, b.
The student investigates a limited geologic problem in the field. Individual initiative is developed, principles of research are acquired, and practice is gained in technical methods. The student prepares a report setting forth the results of the research and their meaning. This report constitutes the Senior Thesis, which must be submitted by May 25.
Instructor: Bode.

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, Bode.

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 odd-numbered years and in the Great Basin in even-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 subject 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: Bode, Buwalda, Maxson.

Ge. 175. Elementary Geophysics. 5 units (2-0-3); third term.

A survey of pure and applied geophysics designed mainly for geological, engineering, and other students who do not expect to enroll in specialized subjects in this field.

Instructor: Peterson.

Ge. 176. Elementary Seismology. 6 units (3-0-3); first term, 1941-1942.

A survey of the geology and physics of earthquakes.

Instructor: Richter.

GRADUATE SUBJECTS

Courses given in alternate years are so indicated. Courses in which the enrollment is less than five may, at the discretion of the instructor, be postponed.

GEOLOGY

Ge. 200. Mineragraphy. 10 units (2-6-2); first term.

Prerequisite: Ge. 3.

Methods of identification of opaque minerals in crushed samples and polished sections, together with applications to research and practical problems.

Texts: *Microscopic Determination of Ore Minerals,* M. N. Short; U. S. G. S. Bull. 825; *Mineral Deposits,* 4th edition, Lindgren.

Instructors: Fraser, A. Smith.

Ge. 202. Metalliferous Deposits. 10 units (2-6-2); second term.

Prerequisites: Ge. 106, 200.

A study of metalliferous deposits with respect to geographic distribution, structure, alteration, and mode of formation. The laboratory work will consist of a study of ore suites and altered rocks in hand specimens, polished and thin sections.

Text: *Mineral Deposits,* 4th edition, Lindgren.

Instructors: Fraser, A. Smith.

Ge. 209. Sedimentary Petrology. 8 units; second term, 1940-1941.

Prerequisite: Ge. 106 a, b.

Discussion, reports and conferences on sediments, particularly from the petrographic view-point. The work in the laboratory affords an introduction to the various quantitative methods for detailed analysis of sediments.

Text: *Manual of Sedimentary Petrography,* Krumbein and Pettijohn.

Instructor: Campbell.

Ge. 210. Metamorphic Petrology. 8 units; second term, 1939-1940; 1941-1942.

Prerequisite: Ge. 106 a, b.

A study of metamorphic processes.

Text: *Metamorphism,* Harker.

Instructors: Campbell, Snow.

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 Deposits. 10 units (2-6-2); third term, 1940-1941.

Prerequisites: Ge. 3, 106 a, b.

A study of the nonmetallic deposits, other than fuels; their occurrence, exploitation, beneficiation. In the laboratory the petrographic microscope is applied not only to problems of identification and paragenesis of the ores, but also to problems involving processed and fabricated materials. Occasional field trips.

Text: *Industrial Minerals and Rocks,* Seeley W. Mudd Series (A. I. M. E.).

Instructor: Campbell.

Ge. 213. Mineral Deposits (Seminar). 5 units; second term, 1940-1941.

Prerequisite: Ge. 202.

Discussion of problems and current literature concerning ore deposits.

In charge: Fraser.

Ge. 214. Mineral Economics (Seminar). 5 units; second term, 1941-1942.

Prerequisite: Ge. 202.

Discussion and investigation of factors involved in ore estimation, economics of mining and evaluation of mineral deposits.

In charge: Fraser.

Ge. 215. Mineralogy (Seminar). 5 units; first term.

Prerequisite: Ge. 200.

Discussion of current literature and special problems related to mineralogy.

In charge: Fraser.

Ge. 220. History of Geology. 5 units; first term, 1940-1941.

A study of the development of the geological sciences. The evolution of fundamental theories as influenced by earlier and contemporary geological investigators, and a presentation in a connected sequence of the development of geological ideas.

Lectures, assigned reading, and reports.

Instructor: Maxson.

Ge. 225. Geology of Western America. 3 units; first term, 1941-1942.

Presents an organized concept of the geologic history of the Rocky Mountains, the Colorado Plateau, Basin and Range, and Coast Range Provinces. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.

Instructors: Buwalda, Campbell, Fraser, Maxson.

Ge. 226. Geomorphology. 10 units (3-0-7); first term.

Prerequisites: Ge. 109, 121 a, b.

Nature of erosional processes in a humid climate and the topographic features developed. Sequence of land forms in the normal physiographic cycle. Brief discussion of the arid, shoreline, and glacial cycles.

Lectures, assigned reading. Field trips to the San Gabriel and San Bernardino Ranges for stream erosion, to selected strips of the California coast, and to the glacial terrane of the high Sierras in the vicinity of the Palisades Glacier.

Instructor: Maxson.

Ge. 227. Shoreline Geomorphology. 6 units (2-0-4); third term, 1940-1941.

Prerequisite: Ge. 226.

Processes of marine erosion and the shoreline cycle.

Field trips along the coast of California.

Text: *Shore Processes and Shoreline Development,* Johnson.

Instructor: Maxson.

Ge. 228. Geomorphology of Arid Regions. 6 units (2-0-4); third term, 1939-1940.

Prerequisite: Ge. 226.

Processes of erosion in an arid climate. Land forms of arid regions and their modes of origin. The arid cycle of erosion in the Basin Range Province.

Lectures, assigned reading. Field trips to the Mojave Desert and Death Valley.

Instructor: Maxson.

Ge. 230. Geomorphology (Seminar). 5 units; third term.

Discussion of research and current literature of geomorphology.

In charge: Maxson.

Ge. 232a. Introduction to Petroleum Geology. 10 units (3-0-7); first term.

Prerequisites: Ge. 109, 121 a, b.

Theories of origin, principles of movement and accumulation of oil and gas; types of reservoir structures.

Instructor: Maxson.

Ge. 232b. Introduction to Petroleum Geology. 10 units (3-0-7); second term.

Prerequisite: Ge. 232 a.

Studies of individual oil fields involving discussion of structural conditions, preliminary estimates of reservoir capacity, practical methods of surface and subsurface mapping, and sub-surface correlation.

Instructor: Bode.

Ge. 235. Petroleum Geology (Seminar). 5 units; third term.

Problems of petroleum geology. Current literature and discussion of new discoveries.

In charge: Bode, Maxson.

Ge. 237. Tectonics. 10 units (3-0-7); third term.
Prerequisites: Ge. 109, or equivalent, and Ge. 121 a, b, or equivalent.
Advanced structural and tectonic geology. Structure of some of the great mountain ranges; theories of origin of mountains, mechanics of crustal deformation; isostasy; continental drift.
Lectures and seminar.
Instructor: Buwalda.

Ge. 238. Structural Geology (Seminar). 5 units; first term.
Critical review of literature dealing with some part of the field of structural geology.
In charge: Buwalda.

PALEONTOLOGY

Ge. 245 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. 248. Fossils of the California Tertiary. 5 units; second term.
Study of some of the more important invertebrate fossils of the California Tertiary with especial emphasis on their use as horizon markers in field geology.
Instructor: Popenoe.

Ge. 249. Stratigraphy of the Coast Ranges (Seminar). 5 units; first and second terms.
Review, discussion, and criticism of literature of the California Coast Ranges, with especial emphasis on correlation and fauna.
In charge: Popenoe.

Ge. 250 a. Invertebrate Paleontology (Seminar). 5 units; first term.
Critical review of classic and current literature in invertebrate paleontology. Study of paleontologic principles and methods.
In charge: Popenoe.

GEOPHYSICS

Ge. 261. Theoretical Seismology. 6 units (2-0-4); first term, 1940-1941.
Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.
Studies and conferences on the principles of physical seismology.
Instructor: Gutenberg.

Ge. 262. Interpretation of Seismograms of Teleseisms. 5 units (0-3-2); second term, 1940-1941.
Prerequisite: Ge. 261.
Instructor: Gutenberg.

Ge. 263. Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes. 5 units (0-3-2); third term, 1940-1941.
Prerequisite: Ge. 261.
Instructor: Richter.

Ge. 265. Introduction to General Geophysics. 6 units (2-0-4); second term, 1940-1941.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.
Structure of the Earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density.
Instructor: Gutenberg.

Ge. 270. Seismic Instruments. 9 units (1-3-5); first term.
Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.
Description and theory of seismographs. Laboratory experiments.
Instructor: Benioff.

Ge. 273. Applied Geophysics I. 5 units (2-0-3); first term, 1941-1942.
Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.
Methods of seismology applied to geological problems and prospecting.
Instructor: Gutenberg.

Ge. 274. Applied Geophysics II. 5 units (2-0-3); second term, 1939-1940.
Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.
Theory of methods of electrical prospecting.
Instructor: Potapenko.

Ge. 275. Applied Geophysics III. 5 units (2-0-3); second term, 1940-1941.
Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.
Theory of gravitational and magnetic methods of prospecting.
Instructor: Potapenko.

Ge. 278. Interpretation of Field Seismograms. 5 units (2-3-3); second term, 1939-1940.
Prerequisite: Ge. 273.
Instructor: Gutenberg.

Ge. 279. Laboratory and Field Work in Electrical Methods of Prospecting. 7 units (2-4-3); third term, 1939-1940.
Prerequisite: Ge. 274.
Instructor: Potapenko.

Ge. 280. Laboratory and Field Work in Gravitational and Magnetic Methods of Prospecting. 7 units (0-4-3); third term, 1940-1941.
Prerequisite: Ge. 275.
Instructor: Potapenko.

Ge. 282. Geophysics (Seminar). 3 units; third term.
Prerequisite: At least two subjects in geophysics.
Discussion of papers in both general and applied geophysics.
In charge: Gutenberg, Buwalda, Potapenko, 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. 285 a, b. Geophysical Research Conference. 2 units; first and second terms.
Prerequisite: Ge. 282, Ge. 283.
Discussion of geophysical problems. For advanced students.
In charge: Gutenberg, Buwalda, Potapenko, Richter.

GENERAL

Ge. 295. Master's Thesis Research. Units to be assigned. List as to field according to the letter system under Ge. 299.

Ge. 297. Advanced Study.
Students may register for 8 units or less of advanced study in fields listed under Ge. 299. Occasional conferences; final examination.

Ge. 299. 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: (e) engineering geology, (f) petroleum geology, (g) ground water geology, (h) metalliferous geology, (i) non-metalliferous geology, (j) geochemistry, (m) mineralogy, (n) areal geology, (o) stratigraphic geology, (p) structural geology, (q) geomorphology, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (w) general geophysics, (x) applied geophysics.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, ARISTOTLE D. MICHAL, HARRY C. VAN BUSKIRK
RESEARCH ASSOCIATE: DINSMORE ALTER, Statistics
ASSOCIATE PROFESSORS: MORGAN WARD, LUTHER E. WEAR
ASSISTANT PROFESSOR: WILLIAM N. BIRCHBY.

UNDERGRADUATE SUBJECTS

NOTE: Students intending to take the Mathematics Option must indicate their choice at the beginning of their sophomore year.

Ma. 1 a, b, c. Freshman Mathematics. 12 units (4-0-8); first, second and third terms.
Includes the fundamentals of plane analytical geometry, and an introduction to the differential and integral calculus.
Texts: *Calculus*, Smith, Salkover, Justice; *Analytic Geometry*, Sisam.

Ma. 2 a, b, c. Sophomore Mathematics. 12 units (4-0-8); first and second terms; 8 units third term.
Includes an introduction to solid analytical geometry, and completes the usual topics of the differential and integral calculus.
Text: *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.
Subjects Ma. 1 a, b, c, and 2 a, b, c, d, form a continuous two-year course in analytical geometry, 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.
Instructor: Wear.

Ma. 4 a, b. Analytic Geometry. 10 units (3-0-7); second and third terms.
Prerequisites: Ma. 1, Ma. 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: *Advanced Geometry*, Campbell.
Instructor: Wear.

Ma. 8 a, b, c. Advanced Calculus. 9 units (3-0-6); 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. Intended for students interested primarily in experimental science.
Text: *Advanced Calculus*, Woods.
Instructors: Birchby, Wyman.

Ma. 9 a, b, c. Advanced Calculus. 9 units (3-0-6); first, second, and third terms.

Prerequisites: Ma. 1, Ma. 2.

The same as Ma. 8, except that it is intended for students of mathematics and theoretical physics.

Instructors: Birchby, Mewborn.

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); second or third term.

Prerequisite: Ma. 2 a, b, c, d.

An abridged course in differential equations for students in Engineering.

Text: *Differential Equations*, 2nd edition, Cohen.

Instructors: Wear, Wyman.

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. 9 units (3-0-6); 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. This course is intended especially for graduate students in Aeronautics, Meteorology, and Mechanical Engineering.

Instructor: 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, Byrne.

Ma. 16. Introduction to Higher Algebra. 9 units; first term.

Prerequisites: Ma. 1, Ma. 2.

The more frequently used parts of linear transformations, quadratic forms, matrices, etc.

Instructor: Bell.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma. 101 a, b, c. Modern Algebra. 9 units; first, second and third terms.
Prerequisites: Ma. 8, reading knowledge of German.
Abstract algebra as developed since about 1910.
Instructor: Bell.

Ma. 102 a, b, c. Introduction to Higher Geometry. 12 units; first, second and third terms.
Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d, 4 a, b.
The course covers selected topics in metrical differential geometry and in algebraic geometry.
Instructor: Wear.

Ma. 106 a, b. Introduction to Theory of Functions of Real Variables. 9 units; first and second 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. 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 a, b, c. 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.
Text: *Functions of a Complex Variable*, Copson.
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 subjects 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.

Instructor: Bateman.

Ma. 202 a, b, c. Modern Theory of Differential Equations. 12 units; first, second and third terms.

Prerequisites: Ma. 10, 107.

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; first term.

Prerequisite: Graduate standing.

Topics selected to suit the class.

In charge: Bell.

Ma. 251 b. Mathematical Logic. 9 units; second term.

Instructor: Bell.

Ma. 251 c. Theory of Algebraic Numbers. 9 units; third term.

Prerequisite: Graduate standing.

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. 253. Seminar in Foundations of Abstract Algebra. 6 units; first, second, and third terms.

Prerequisite: Graduate standing.

Decomposition theorems in rings and hypercomplex systems. Evaluation theorems, and p-adic numbers. Modern structure and lattice theory, Boolean rings and algebras.

In charge: Ward.

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.

PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, CARL D. ANDERSON, 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: JESSE W. M. DUMOND, ALEXANDER GOETZ, GENNADY W. POTAPENKO, WILLIAM R. SMYTHE, FRITZ ZWICKY

ASSISTANT PROFESSORS: H. VICTOR NEHER, WILLIAM A. FOWLER, JOHN D. STRONG

RESEARCH FELLOW: JOSEF J. JOHNSON

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, DuMond, Neher, Strong, and Teaching Fellows.

Ph. 2 a, b, c. Light, Electricity, and Electron Physics. 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, 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.

Instructors: Houston and Davis.

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 and Magnetism,* Harnwell.

Instructor: Fowler.

Ph. 8. Electricity and Magnetism. 9 units (3-0-6); first term.

Prerequisites: Ph. 5 a, b, c.

A special course open only to students who have completed Ph. 5.

Text: *Principles of Electricity and Magnetism,* Harnwell.

Instructor: Fowler.

Ph. 9 a, b. Electrical Measurements. 4 units (0-3-1); first and second 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 subject 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,* Baker.

Instructor: Johnson.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ph. 91 a, b, c. Introduction to Mathematical Physics. 8 units; first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

This subject is the same as Ph. 5 a, b, c but with reduced credit for graduate students.

Instructors: Houston and Fowler.

Ph. 101 a, b, c. Electricity and Magnetism. 9 units (3-0-6); first, second and third terms.

Prerequisites: An average grade of 2 in Ph. 5 a, b, c.

A problem subject 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 laws of motion as formulated by Newton, d'Alembert, Lagrange, Euler, Jacobi, Hamilton, etc. Integration of the differential equations of mechanics by exact methods and by methods of successive approximation. Theory of small oscillations around statically and dynamically stable states; normal modes. Elementary theory of hydrodynamics and elasticity. Applications of the tensor calculus to mechanical problems.

Text: *Dynamics*, Webster.

Instructor: Zwicky.

Ph. 105 a, b, c. Optics. 6 units (3-0-6); first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A problem subject dealing with the fundamental principles of geometrical optics, of diffraction, interference, the electromagnetic theory of light, etc., and their experimental verification.

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, Lauritsen.

Ph. 108. Spectroscopy Laboratory. 3 units; second term.

A laboratory subject 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 or second and third terms.

Prerequisites: Ph. 1 a, b, c, d; Ma. 2 a, b, c, d.

During the first term, the fundamental concepts of the molecular theory of matter are treated from the theoretical, experimental and technical viewpoints (Clausius, Maxwell, Boltzmann, van der Waals, Knudsen equations). During the second term, advanced problems of the constitution of matter as well as practical applications are discussed (such as the thermodynamics of low temperature phenomena, liquefaction of gases, phase relations, specific heats, crystallization, plasticity). The course is supplemented by a weekly seminar, Ph. 239, participation in which is required.

Instructor: Goetz.

Ph. 114. Principles of Quantum Mechanics. 12 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 indetermina-

tion, the Schrödinger 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. 116. Relativistic Quantum Mechanics. 9 units; second term.
Prerequisite: Ph. 114.
A study of Dirac's relativistic equation for an electron in an external field together with selected topics from recent developments of relativistic quantum mechanics.
(Not given in 1939-40.)
Instructor: Houston.

Ph. 120. Seminar on the History of Physics. 4-9 units; first, second and third terms.
Assigned reading and written and oral reports on selected topics in the history of physics. Students will be expected to make the acquaintance of as many as possible of the original memoirs of the great physicists and to study at least one such memoir very thoroughly. Reports will consist of illustrated lectures, biographies, critical studies, translations, bibliographies, etc. Recommended for all students who expect to teach.
Texts: *History of Science,* Dampier; *Rise of Modern Physics,* Crew.
In charge: Watson.

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. 5 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 1939-40.)

Instructor: Epstein.

Ph. 223. Theory of Electromagnetic Waves. 12 units; second term.

Prerequisite: Ph. 222.

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 1939-40.)

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.

(Not given in 1939-40.)

Instructor: Bateman.

Ph. 225. Theory of Electrons. 12 units; third term.

Prerequisites: Ph. 222 and 223.

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 1939-40.)

Instructor: Epstein.

Ph. 226. Heat Radiation and Quantum Theory. 12 units; second term.

Prerequisites: Ph. 103 a, b, c, 211.

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.

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. 229. Quantum Mechanics. 12 units; second and third terms.

Prerequisites: Ph. 103 a, b, c, 107 a, b c.

Schrödinger's equation and matrix calculus. Applications to spectroscopy and atomic structure. Transformation theory. Dirac's electron equation. Fundamentals of the theory of the electromagnetic field and second quartization.

Instructor: Epstein.

Ph. 232. Physics of Ultra-Short Electromagnetic Waves. 6 units (2-0-4); first term.

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. 233. High Frequency Measurements. 6 units (2-0-4); first term.

Methods of physical measurements using high frequencies. Recent developments in methods of generation of ultra-short waves.

(Not given in 1939-40.)

Instructor: Potapenko.

Ph. 234. Topics in Theoretical Physics. 9 units (3-0-6); third term.

The content of this subject will vary from year to year. Typical topics: Theory of atomic collisions; relativistic quantum theory; theory of radiation; statistical mechanics. The course deals 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. 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. Seminar on the Solid State. 4 units; first, second and third terms.

Meets once a week for the report and discussion of problems and selected current publications on the physics of the solid state. The field covered concerns especially low temperature phenomena (every second week), the physics of photographic emulsions and biophysical problems (each every fourth week). Participation is required of students taking Ph. 110.

In charge: Goetz, in collaboration with Dember and Tracy.

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.

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.

SUBJECTS IN ENGINEERING

AERONAUTICS

PROFESSORS: THEODORE VON KÁRMÁN, HARRY BATEMAN
ASSOCIATE PROFESSORS: ARTHUR L. KLEIN, IRVING P. KRICK, CLARK B. MILLIKAN
ASSISTANT PROFESSORS: ALBERT E. LOMBARD, JR., WILLIAM R. SEARS, ERNEST E. SECHLER
INSTRUCTORS: PAUL E. RUCH, H. J. STEWART

UNDERGRADUATE SUBJECTS

AE. 2 a, b. Aircraft Structures. 12 units; second and third terms.

Prerequisite: AM. 1 c.

A subject 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: *Aircraft Structures,* Vols. 1 and 2, Niles and Newell.

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.

Airfoils, wings, and tail groups, stability and control, drag, performance and spinning.

Texts: *Technical Aerodynamics,* Wood; *Engineering Aerodynamics,* Diehl; *Airplane Design,* Warner.

Instructor: Millikan.

AE. 252 a, b, c. Airplane Design. 12 units; first, second and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3, ME. 8.

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.

Instructor: Sechler.

AE. 253 a, b, c. Design of Aircraft Components. 6 units; first, second and third terms.

Prerequisites: AM. 1 a, b, c.

253a, factory equipment and methods; 253b, control systems, flap systems, landing gears, power plants, electrical and instrument installations; 253c, heating and ventilating problems, acoustics, other nonstructural components of the airplane; flight testing.

Instructor: Klein, with the assistance of engineers from neighboring aircraft companies.

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.

Instructor: Klein.

AE. 255. Wind Tunnel Operation and Technique. 6 units; third term.

A one-term course 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.

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: *Aerodynamic Theory,* Vols. I and II, Durand.

Instructor: Kármán, Millikan, or Sears.

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, Millikan, or Sears.

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: AM. 1 a, b, c, 3; Ma. 11 and Ma. 8 a, b, c, or Ma. 15 a, b, c.

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.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.
ASSOCIATE 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: *Analytical Mechanics for Engineers,* Seely and Ensign.
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., or *Carnegie Pocket Companion.*
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: *Analytical Mechanics for Engineers,* Seely and Ensign; *Elements of Strength of Materials,* Timoshenko and MacCullough; *Steel Construction,* A.I.S.C., or *Carnegie Pocket Companion.*
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.
Instructors: Converse and assistant.

ADVANCED SUBJECTS

AM. 105 a, b. 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.

CHEMICAL ENGINEERING

(See Chemistry and Chemical Engineering, page 191)

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL
ASSOCIATE PROFESSORS: FREDERICK J. CONVERSE, WILLIAM W. MICHAEL
ASSISTANT PROFESSOR: A. PERRY BANTA

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*, Bouchard.

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*, Bouchard.

Instructor: Michael.

CE. 3. Plane Table Surveying. 8 units (1-6-1); third term.

A subject 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 and geological map of the region covered.

Text: *Surveying*, Bouchard.

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. 7. Curves and Earthwork. 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. 6. Transportation Engineering. 6 units (3-0-3); first term.
Prerequisites: CE. 1, 2.
A study of economic railway location and operation; waterways and motor traffic; railway plant and equipment; signaling; the solution of grade problems.
Text: *Elements of Railroad Engineering,* Raymond.
Instructor: Thomas.

CE. 8 c. Route Surveying. 6 units (0-6-0); third term.
Prerequisite: CE. 7.
The class devotes one entire day a week to field surveys of a route location, applying the principles as outlined under course CE. 7.
Text: *Railway Curves and Earthwork,* Allen.
Instructor: Michael.

CE. 9. Elements of Structures. 11 units (3-3-5); second term.
Prerequisite: AM. 1 c.
An abridged subject 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, b. Theory of Structures. 12 units (3-3-6), first term; 9 units (3-0-6), third term.
Prerequisite: AM. 1 c.
Methods used in the calculation of stresses in beams, girders, and columns; study of the effects of moving load systems; graphic statics applied to roofs and bridges. A study of arch, cantilever, and continuous bridges; and deflection of trusses
Text: *Structural Theory,* Sutherland and Bowman.
Instructor: Martel.

CE. 11. Design of Structures. 12 units (3-3-6); second term.
Prerequisite: CE. 10 a.
The computation of stresses in girders, truss members, and building frames; the design of structural parts and their connections.
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: *Reinforced Concrete,* Caughey.
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 AND ADVANCED SUBJECTS

CE. 120 a. Statically Indeterminate Structures. 12 units; first term.
Prerequisites: CE. 11, 12.
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. 120 b, c. Statically Indeterminate Structures. Units to be based upon work done; second and third terms.
A continuation of the study of indeterminate structures as begun in CE. 120 a. with the use of analytical and instrumental methods of solution.
Instructor: Martel.

CE. 121 a. Structural Design. 12 units (0-12-0); first term.
Prerequisites: CE. 10 a, b; CE. 11.
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. 121 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. 121 c. Civil Engineering Design. 9 units (0-9-0); third term.
Prerequisite: CE. 125.
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. 122. 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. 125. Irrigation and Water Supply. 12 units (5-0-7); third term.
Prerequisite: Hy. 1.
A study of modern practice of the collection, storage, purification 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. 126. 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. 127. Sewerage. 9 units (3-0-6); third term.

Prerequisite: Hy. 1.

A study of systems for the collection and treatment of sewage; the design of sewers and storm drains; characteristics of various treatment processes; factors affecting treatment plant design; inspection of local plants.

Text: *Sewerage and Sewage Disposal,* Metcalf and Eddy.

Instructor: Banta.

CE. 130 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 fields of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

CE. 131 a, b. Sewage Treatment Plant Design. Units to be based upon work done; any term.

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: Banta.

CE. 132 a, b. Water Power Plant Design. Units to be based upon work done; any term.

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. 133 a, b. 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. 134 a, b. 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. 135 a, b. Geodesy and Precise Surveying. Units to be based upon work done; any term.

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. 141 a, b, c. Structural Engineering Research. Units to be based upon work done; any term.

Selected problems and investigations to meet the needs of advanced students.

Instructor: Martel.

CE. 142 a, b, c. 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: Banta.

CE. 143 a, b, c. Highway Research. Units to be based on work done; any term.

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.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN
ASSOCIATE PROFESSORS: FREDERICK C. LINDVALL, S. STUART MACKEOWN
ASSISTANT PROFESSOR: FRANCIS W. MAXSTADT
INSTRUCTOR: WILLIAM H. PICKERING

UNDERGRADUATE SUBJECTS

EE. 2 a. Electrical Machinery. 9 units (3-0-6); second term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.
A study of electric and magnetic circuits, electromagnets, direct and alternating current machinery and apparatus. Numerous problems relating to circuits and machinery are solved.
Texts: *Electrical Engineering*, Christie; *Problems in Alternating Current Machinery*, Lyon.
Instructors: Maxstadt, Lentz.

EE. 3 a. Electrical Machinery 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. 2a.
Use of measuring instruments, operation of direct current and alternating current machinery and determination of their characteristics.
Text: Laboratory notes.
Instructors: Maxstadt, Beichley, Worcester, Zarem.

EE. 2 b. Electrical Machinery. 9 units (3-0-6); third term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2a.
Further application of the principles developed in EE. 2a.
Texts: *Electrical Engineering*, Christie; *Problems in Alternating Current Machinery*, Lyon.
Instructors: Maxstadt, Lentz.

EE. 3 b. Electrical Machinery Laboratory. 6 units (0-3-3); third term.
Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2 a; 3 a; registration for EE. 2b.
A further application of the principles involved in EE. 3a.
Text: Laboratory notes.
Instructors: Maxstadt, Engelder, Unholtz.

EE. 6 a, b. Electrical Engineering. 6 units (2-0-4), second term; 9 units (3-0-6), third term.
Prerequisites: EE. 2a, b; 3a, b.
Windings, special characteristics, graphical methods, commutation, machine reactances, and short circuit currents. System stability; short transmission lines.
Texts: *Electrical Engineering*, Christie; *Problems in Alternating Current Machinery*, Lyon.
Instructor: Lindvall.

EE. 7. Electrical Engineering Laboratory. 9 units (0-3-6); third term.
Prerequisites: EE. 2a, b; 3a, b; 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, Engelder, Unholtz.

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 subject 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, Lentz, Youtz.

EE. 9. Direct Current Laboratory. 5 units (0-3-2); first or second term.

An abridged subject 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, Beichley, Engelder, Unholtz, Worcester, Zarem.

EE. 10. Alternating Currents. 7 units (3-0-4); second or third term.

Prerequisites: EE. 8 and 9.

An abridged subject in alternating currents and alternating current machinery similar to EE. 8.

Text: *Principles of Electrical Engineering,* Blalock.

Instructors: Maxstadt, Youtz.

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 subject for other than Electrical Engineering students.

Text: Laboratory notes.

Instructors: Maxstadt, Beichley, Engelder, Unholtz, Worcester, Zarem.

EE. 12. Electric Circuits. 12 units (3-0-9); first term.

Prerequisites: EE. 2a, b; 3a, b.

A course of study involving the calculation of voltage, current, and power in electrical circuits by the symbolic or complex method.

Texts: *Alternating Current Circuits,* Kerchner and Corcoran; *Problems in Alternating Currents,* Lyon.

Instructors: Sorensen, Mackeown.

EE. 70 a, b, c. Engineering Conference. 2 units (1-0-1); first, second and third terms.

Prerequisites: EE. 2a, b; 3a, b.

Presentation and discussion of new developments in the industry. Review of current literature.

Instructors: Sorensen, Lindvall, Mackeown, Maxstadt, Stanton.

FIFTH-YEAR SUBJECTS

EE. 120 a. Alternating Current Analysis and Machinery. 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: *Problems in Electrical Engineering,* Lyon; *Applications of the Method of Symmetrical Components,* Lyon.

Instructor: Sorensen.

EE. 120 b. Advanced Alternating Current Analysis and Machinery. 12 units (4-0-8); second term.

Prerequisites: EE. 120 and preceding subjects.

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. 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. Special emphasis is placed on the report.

Text: Advanced laboratory notes.

Instructors: Maxstadt, Honnell.

EE. 128. Electric Traction. 9 units (3-0-6); third term.

Prerequisites: EE. 2a, b; 6a, b.

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. 2a, b; 6a, b.

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 subjects.

Line performance and protection; elementary transient phenomena; use of hyperbolic functions in line calculations; generalized system constants; the stability problem.

Instructor: Lindvall.

EE. 148. Specifications and Design of Electrical Machinery. 6 units (4-0-2); first term.

Prerequisites: EE. 7 and preceding subjects.

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 subjects.

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: *Theory of Dielectrics*, Schwaiger and Sorensen.

Instructor: Sorensen.

EE. 156. Electrical Communication. 6 units (2-0-4); first term.

Prerequisites: EE. 2a, b; 3a, b.

A study of modern means of communication with special emphasis on recent developments. Includes a study of four terminal networks and filter theory.

Instructor: Mackeown.

EE. 160. Electric Transients. 6 units (2-0-4); second term.

Prerequisites: EE. 120 and preceding subjects.

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. 6a, b, and preceding subjects.

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 subject dealing with fundamentals of Radio Transmission.

Text: *Radio Engineering*, Terman.

Instructor: Mackeown.

EE. 165. Electronics Laboratory. 6 units (0-3-3); third term.
Prerequisite: EE. 162.
Laboratory measurements at audio and radio frequencies, using modern electronic devices.
Instructors: Mackeown, Pickering.

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, Lindvall, Maxstadt.

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*, Schwaiger and Sorensen.
Instructor: Sorensen.

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 subject 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.

ENGINEERING DRAFTING

ASSISTANT PROFESSOR: HOWELL N. TYSON
INSTRUCTOR: 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, Wilson, Borgquist, Crawford.

Descriptive Geometry, D. 3 a, b, c, d and D. 5 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.
Instructor: Wilcox.

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.

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, Crawford, Wells.

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.
Instructor: Tyson.

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.
Instructor: Tyson.

D. 6 a. Engineering Drafting. 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 drafting 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: Hall, Heywood, Sumner.

D. 6 B. Engineering Drafting. 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.
Instructor: Tyson.

D. 7. Advanced Engineering Drafting. 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

UNDERGRADUATE SUBJECTS

Hy. 1 a, b. Hydraulics. 12 units (3-3-6), first or second term; 9 units (3-0-6), second or 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: Knapp, Van Driest, Anderson.

Hy. 2. Hydraulics Laboratory. 6 units (0-3-3); first or second 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, Van Driest, Olsson.

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.

Hy. 5. Hydraulics. 12 units (3-3-6); third term.

Prerequisite: AM 1 a, or to be taken at the same time.

An abridgement of Hy. 1 a, b for electrical engineering students.

Text: *Hydraulics*, Daugherty.

Instructors: Knapp, Van Driest, Anderson.

ADVANCED SUBJECTS

Hy. 100. Fluid Mechanics. 12 units (3-0-9); second term.

Prerequisites: Hy. 1 and 2.

Dimensional analysis; principles of energy, continuity, and momentum; potential flow; use of the flow net; cavitation; equations of viscous motion; laminar flow; turbulence; resistance of immersed bodies; flow in closed conduits; flow in open channels; wave motion.

Text: *Fluid Mechanics for Hydraulic Engineers*, Rouse.

Instructors: Daugherty, Knapp, Van Driest.

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 specific conditions.

Instructors: Daugherty, Knapp.

Hy. 102. Hydraulics of Open Channels. 6 units (0-6-0); third term.
Prerequisite: Hy. 1.

Computation of surface profiles for gradually varied flow in open channels; characteristics of the hydraulic jump; delivery of canals in hydroelectric and irrigation projects.

Text: *Hydraulics of Open Channels*, Bakhmeteff.

Hy. 103. Hydraulics Problems. 6 units (0-6-0); third term.
Prerequisite: Hy. 1.

Selected advanced problems in hydraulics such as penstock design, water hammer and surge chamber calculations, hydraulic jump determinations, etc.

Instructor: 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.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP
ASSOCIATE PROFESSORS: ROBERT T. KNAPP, FREDERICK C. LINDVALL
ASSISTANT PROFESSORS: DONALD S. CLARK, ALBERT E. LOMBARD, JR., ERNEST E. SECHLER, 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: *Elements of Mechanism,* Schwamb, Merrill and James.
Instructors: Clapp, Tyson.

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 (3-0-6), first term; 9 units (3-3-3), second and third terms.
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 (4-0-8); 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 Members,* Vallance.

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); first or second 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: Lindvall, Lombard.

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. 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); third term.

An abridgement of ME. 15, 16, and 17 for students in Civil Engineering.

Instructors: Lindvall, Lombard.

ME. 21. Heat Engineering. 12 units (3-3-6); first term.

An abridgement of ME. 15, 16, and 17 for students in Electrical Engineering.

Instructors: Lindvall, Lombard.

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, Lombard, Waring.

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, Lombard, Waring.

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, Lombard, Van Driest, Waring.

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.
Instructor: 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.

METEOROLOGY

PROFESSOR: BENO GUTENBERG
ASSOCIATE PROFESSOR: IRVING P. KRICK
INSTRUCTORS: PAUL RUCH, H. J. STEWART

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: Stewart.

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.

Instructors: Krick, Ruch.

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.

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: Klein.

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 subjects 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.

SUBJECTS IN THE HUMANITIES

ECONOMICS

PROFESSOR: GRAHAM A. LAING
ASSOCIATE: EDWIN F. GAY
LECTURER: ARCHIBALD B. YOUNG
VISITING LECTURER: ARTHUR H. YOUNG
ASSOCIATE PROFESSORS: PHILIP S. FOGG, HORACE N. GILBERT, RAY E. UNTEREINER
VISITING ASSISTANT PROFESSOR: DWIGHT L. PALMER*
INSTRUCTOR: VICTOR V. VEYSEY

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 subject 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 subject is given in the second and again in the third term.

Instructors: Laing, Fogg, Untereiner, with occasional lectures by Dr. E. F. 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 subject 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.

Prerequisite: Ec. 2.

A general study of the financial organization of society. The subject 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

*On leave of absence from the Massachusetts Institute of Technology.

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 subject 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 at 8 p. m. on Thursday evenings at the home of Professor Laing.
In charge: Laing.

Ec. 48 a, b, c. Industrial Relations. 9 units (3-0-6); first, second and third terms.
An introduction to the study of industrial relations. Stress will be laid on those aspects of the subject most essential to the engineer's understanding of industrial labor.
The areas covered in the course will include the history and background of employer and employee associations and unions, the practices of collective bargaining, the work of the personnel manager, the place of labor in the administration of a firm as well as in the economic and political life of the community, and an analysis and history of the functions of government in the labor field. From time to time lectures will be given by representatives from industrial concerns, labor unions and governmental agencies.
Instructors: Palmer, Arthur H. Young.

Ec. 50. Industrial Management. 9 units (3-0-6); third term.
Open to senior engineers.
This subject aims to give students planning to enter the general field of manufacturing (1) information regarding special management techniques and (2) an idea as to the relationship of the production function to industrial sales, industrial finance, and general executive policies. The scope of the subject is further indicated by the following partial list of topics studied: plant location, types of factory buildings, plant layout, simplification and standardization of products, time and

motion studies, the production budget, production control, cost control, wage systems, and industrial relations.

Several field trips are made to enable students to see industrial management techniques in operation.

Text: *Introduction to Industrial Management,* Folts.

Instructor: Gilbert.

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 subject 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 subject 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 subject.

Texts: *Financial Policy of Corporations,* Dewing; *Principles of Industrial Organization,* Kimball; *Fundamentals of Industrial Marketing,* Elder.

Instructor: Gilbert.

Ec. 106. Business Economics Seminar. 3 units; 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.

Ec. 110 a, b. Seminar in Industrial Relations. 12 units (4-0-8); second and third terms. Open to graduate students.

The course will include the study of labor relations, personnel management and labor economics. The seminar method, permitting general participation through individual investigation, and special reports will be largely followed. Training in research methods and the use of the pamphlet material of the new Industrial Relations Library will also be included. Special attention will be given to those problems of labor relations approached best by simultaneous utilization of several of the following related disciplines: business management, psychology, personnel administration, sociology, and economics.

During the first term of Ec. 110, one meeting each week will be devoted to the special study of labor relations. Attendance in Ec. 110 will be limited to twelve students to be chosen from among the students of Business Economics on the basis of demonstrated interest and ability in the special field of industrial relations.

ENGLISH

PROFESSOR: CLINTON K. JUDY
VISITING PROFESSOR: CHARLES G. OSGOOD
ASSOCIATES: DIXON WECTER, LOUIS B. WRIGHT
ASSOCIATE PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, GEORGE R. MACMINN
ASSISTANT PROFESSORS: L. WINCHESTER JONES, ROGER STANTON

English composition is prescribed for all students in the Freshman year, and a 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 subjects 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 subject 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: *A Modern Reader*, Lippmann and Nevins; *Writing and Thinking*, Foerster and Steadman; *American Plays*, ed. by Watson and Pressey; *College Readings in the Modern Short Story*, MacMinn and Eagleson; *Webster's Collegiate Dictionary*.

Instructors: Eagleson, Huse, Jones, MacMinn, Stanton.

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 major authors: in the first term, Shakespeare; in the second, Swift, Wordsworth, and the Romantic Movement; in the third, Arnold, Browning, and Masefield.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn, Stanton.

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.

Text: *This Generation,* Anderson and Walton.

Instructors: Eagleson, Judy.

En. 9. Contemporary American Literature. 9 units (3-0-6); first or second term.

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: *Oxford Anthology of American Literature,* Vol. II, Benet and Pearson, editors.

Instructor: MacMinn.

En. 10. Modern Drama. 9 units (3-0-6); second and third terms.

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.

Text: *Representative Modern Dramas,* Whitman.

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.

Texts: *The Bible* (Authorized Version); *Biblical Literature and Its Backgrounds,* Macarthur.

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 subjects in English and History, or independently of any subject, but under the direction of members of the department.

En. 14. Special Composition. 2 units (1-0-1); any term.

This subject 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.

Instructor: MacMinn.

En. 16. Spelling. No credit.

This subject 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: Osgood, Wright, ——————

En. 101. Reading and Research. Units to be arranged with the instructor.

HISTORY AND GOVERNMENT

PROFESSOR: WILLIAM B. MUNRO
VISITING LECTURER: VLASTIMIL KYBAL
ASSOCIATES: GODFREY DAVIES, EDWIN F. GAY, EDWARD A. WHITNEY
ASSOCIATE PROFESSOR: RAY E. UNTEREINER
ASSISTANT PROFESSOR: J. E. WALLACE STERLING*
INSTRUCTORS: HARDIN CRAIG, JR., KERMIT ROOSEVELT, 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 1939, presented as the background and development of movements underlying present conditions.

Instructors: Munro, Roosevelt.

H. 4. The British Empire. 9 units (3-0-6); third term. Not given 1939-40.

A study of the expansion of England and of the development of empire which has led to the existing British Commonwealth. Attention will be paid to such topics as: The beginnings of English overseas commerce; England in the Age of Discovery; the growth of the Royal Navy; England's struggle against Spain, the Netherlands and France for commerce and colonies; colonial policy and the organization of the Old Empire (to 1763); the American Revolution, the effect on the Empire of the revolution in industry, transport and communication; the development of the self-governing dominions; the problem of Home Rule for India; the World War and its effect on the Empire; the Empire as a Commonwealth of Nations.

Instructor: Sterling.

H. 5 a, b. Current History. 2 units (1-0-1); first and second terms.

This subject is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion.

Instructor: Craig (with lectures by other members of the Division of Humanities).

*On leave of absence, 1939-40.

H. 6. Oliver Cromwell and His Times. 9 units (3-0-6); second term.

Open as a Humanities elective to seniors.

A study of certain phases of English history, political and religious, during the period in which the colonization of America was getting under way.

Instructor: Roosevelt.

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: The Industrial Revolution.

In charge: Gay.

Second term: English History in the Nineteenth Century.

In charge: Davies.

Third term: Subject to be announced.

In charge: Whitney.

H. 101. Reading and Research. Units to be arranged with the instructor.

LANGUAGES

Professor: John R. Macarthur

The subjects in modern languages are arranged primarily to meet the needs of science 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 subject 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 subject 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 this subject without consulting the Professor of Languages.

Texts: *Minimum Essentials of French,* Shelton; selected readings, including *Aventures par la Lecture,* Bovée.

Instructor: Macarthur.

L. 11. Elementary Italian. 9 units (3-0-6); one term, as required.

A subject 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. Will be offered in the winter term, 1939-40, if a sufficient number of graduate students in Mathematics register for it.

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 this subject without consulting the Professor of Languages.

Texts: *First German Course for Science Students,* Fiedler and Sandbach; *Einführung in die Chemie,* Curts (for Chemistry sections); *A German Science Reader,* Raschen and Fairfield (for other sections); *Technical and Scientific German,* Greenfield.

Instructors: Macarthur and Teaching Fellows.

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: *Berühmte Forscher und ihre Beiträge,* Sokol and Nye.

Instructors: Macarthur and Teaching Fellows.

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 subject 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 subject 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.

PHILOSOPHY, ETHICS AND SOCIOLOGY

PROFESSORS: THEODORE G. SOARES, GRAHAM A. LAING
VISITING LECTURER: ROBERT ROSS

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, *An Introductory Course in Philosophy*, Nicholson.
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: *Social Ethics*, Ericksen; *Readings in Ethics*, Clark and Smith.
Instructor: Soares.

Pl. 5. Sociology. 9 units (3-0-6); first and second terms.
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.

Psychology. Psychological Foundations of Personality. Second term; no credit.
A series of nine lectures on psychology which contribute to an understanding of personality adjustments and failures. Primarily for seniors, but open to any interested students. Lectures at 7:30 p.m. Thursdays, beginning Jan. 4, 1940, in 206 Dabney.
Lecturer: Robert Ross.

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.

PHYSICAL EDUCATION

Physical Director: William L. Stanton
Assistant Director and Manager of Athletics: Harold Z. Musselman
Consulting Physician: Dr. E. D. Kremers
Assistant to the Consulting Physician: Dr. M. Y. 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 freshman 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 year, all students are given physical strength and skill tests in the first and third terms. These tests are used as a basis for determining the proper exercise for students and for measuring the benefits obtained therefrom. Corrective or special exercises are prescribed for those who cannot compete in intramural or intercollegiate sports.

DEGREES CONFERRED, JUNE 9, 1939

Doctor of Philosophy

Fredrick Taylor Addicott, A.B., Stanford University
Hubert Andrew Arnold, A.B., University of Nebraska
Carrol Menefee Beeson, A.B., University of California at Los Angeles
Roland Anthony Budenholzer, B.S., New Mexico State College; M.S., California Institute
Nephi Albert Christensen, B.S., Brigham Young University; B.S.C.E., University of Wisconsin; M.S., California Institute
Djen-Yuen Chu, B.S., National Central University; M.S., California Institute
Horace Willard Davenport, B.S., California Institute; B.A., and B.Sc., Oxford University
Robert Palmer Dilworth, B.S., California Institute
Robert Marx Dreyer, B.S., Northwestern University; M.S., California Institute
Paul Charles Fine, B.A., University of Oklahoma; M.S., California Institute
Mark Gardner Foster, A.B., Miami University
Bruce Lathan Hicks, B.S., and M.S., California Institute
Richard Hutchinson Hopper, B.A., and M.A., University of California at Los Angeles
Norman Harold Horowitz, B.S., University of Pittsburgh
Walter Lavern Howland, B.S., and M.S. in ME, and M.S. in AE, California Institute
Frederick Delbridge Knoblock, B.Sc., and M.S., University of Michigan
Thomas Lauritsen, B.S., California Institute
Albert Eaton Lombard, Jr., B.S., and M.S., California Institute
Robert Harlan MacKnight, A.B., Columbia University
Gilbert Donald McCann, Jr., B.S., and M.S., California Institute
William Burdette McLean, B.S., and M.S., California Institute
Frank Oppenheimer, B.A., Johns Hopkins University
Simon Pasternack, B.Sc., University of Alberta
Robert Sorg Schairer, B.S., Swarthmore College; M.S., California Institute
William Sheldon Stewart, B.A., and M.A., University of California at Los Angeles
Arthur James Stosick, B.S., University of Wisconsin
Charles Hard Townes, B.A., and B.S., Furman University; M.A., Duke University
Angus Campbell Tregidga, B.A., and B.A.Sc., University of British Columbia
Hsue-Shen Tsien, B.S., Chiao-tung University; M.S., Massachusetts Institute of Technology
John Norton Wilson, B.A., and M.A., University of British Columbia
Reuben Esselstyn Wood, B.S., California Institute; M.S., University of Chicago
Lloyd Robert Zumwalt, B.S., University of California

Master of Science in Science

PHYSICS

Edgar Leo Armi, Diploma, Munich Institute of Technology
Chris Gregory, B.S., California Institute
Chao-Wang Hsueh, B.S., National University of Peking
Robert Horner Olds, B.S., California Institute
Joseph Anthony Vargus, Jr., A.B., Amherst College; B.A., Cambridge University

CHEMISTRY

Gustav Alexander Albrecht, B.S., California Institute
Kenneth Justin Goering, B.S., Montana State College
Franklin Ross Hepner, B.A., University of Wyoming

CHEMICAL ENGINEERING

William Thomas Cardwell, Jr., B.S., California Institute
Ellsworth Eugene Gullekson, B.S., University of North Dakota
George Putnam Hinds, Jr., B.E., ChE., Tulane University
Harrison Morton Lavender, Jr., B.S., California Institute
Max F. Smith, B.S., University of California
Hodge Scott Taylor Jr., B.S., University of Illinois
George Wald, Jr., B.S., California Institute

GEOLOGICAL SCIENCES

William Ross Cabeen, A.B., University of California at Los Angeles
James Henry DeLong, Jr., A.B., Lafayette College
Jack Francis Dougherty, B.S., California Institute
Arthur Bernard Drescher, B.S., South Dakota School of Mines
Alexis Martin Eichelberger, Jr., A.B., University of California at Los Angeles
Noel Williamson Hendry, B.S., University of British Columbia
Robert Beck Hoy, B.S., Lafayette College
Robert Joseph Urick, B.S., Brooklyn College
Harry David Bruce Wilson, B.S., University of Manitoba

MATHEMATICS

Robert Jules Levit, B.S., California Institute
Bertram Yood, B.S., Yale University

BIOLOGY

Ole Lilleland, B.S., University of California

Master of Science in Engineering

ELECTRICAL ENGINEERING

Byron Luther Havens, B.S., University of Washington
Winthrop Gilman Jones, B.S., University of Arizona
John Jacob Lentz, B.S., California Institute
Charles Smyth Milliken, B.S., California Institute
Thomas William Mouat, Jr., B.A.Sc., University of British Columbia
David Marx Sherwood, B.S., California Institute
James Farren Stevens, B.S., California Institute
Karl Unholtz, B.S., California Institute
Joseph Weinstein, B.S., University of California

MECHANICAL ENGINEERING

Byron Fremont Beanfield, B.S., University of Southern California
Sydney Ford Duncan, B.S., California Institute
Calvin Andrew Gongwer, B.S., Columbia University
Donald Ellis Hudson, B.S., California Institute
Carr Chia-Chang Liang, B.Sc., Catholic University of Peiping
Harry Majors, Jr., B.S., University of California
William Francis Nash, Jr., B.S., California Institute
Peter Van Horne Serrell, B.S., California Institute
Herbert Barnett Shapiro, B.S., and M.S. in My, California Institute
Harold Wilson Sharp, B.S., California Institute
William Owen Wetmore, B.S., California Institute

CIVIL ENGINEERING

William Henry Bonell, B.S., South Dakota State College
Harry Hall Carrick, B.S., California Institute
George Martin Dorwart, B.S., California Institute
Richard Wilson Folkins, B.S., California Institute
Charles Mackintosh, B.S., and M.S. in CE, Colorado College
Jose Pulido Ortiz, C.E., Military College of the National University of Mexico
Herbert Ramsey Sheppard, B.S., California Institute
Arthur William Sidler, B.S., California Institute
Warren Elvin Wilson, C.E., Lehigh University; M.C.E., Cornell University

AERONAUTICS

Irving Louis Ashkenas, B.S., and M.S. in ME, California Institute
George Francis Beardsley, Lieut. U.S.N., B.S., United States Naval Academy
Leonidas Dixon Coates, Jr., Lieut. U.S.N., B.S., United States Naval Academy
Hsu-Tsi Fan, Eng. in M.E., Harbin Polytechnic Institute; M.S. in ME, California Institute

Andrew McBurney Jackson, Jr., Lieut. U.S.N., B.S., United States Naval Academy
Sunao Kanemitsu, B.S., University of California; M.S. in ME, California Institute
Noble Nojima, B.S., and M.S. in ME, California Institute
Elliott Walter Parish, Jr., Lieut. U.S.N., B.S., United States Naval Academy
Clark Neil Piper, First Lieut. U.S.A., B.S., United States Military Academy
George Yoshio Tsubota, B.S., and M.S. in ME, California Institute
Tsun-Kuei Wang, B.S., National University of Peking; M.S. in ME, California Institute

METEOROLOGY

Martin Charles Burns, Lieut. U.S.N., B.S., United States Naval Academy
Leo Peter Dahl, First Lieut. U.S.A., B.S., United States Military Academy
Robert Loyal Easton, Captain U.S.A., B.S., United States Military Academy
Ivan Lonsdale Farman, First Lieut. U.S.A., B.S., California Institute
Robert Freeman Fulton, First Lieut. U.S.A., B.S., United States Military Academy
John DePeyster Townsend Hills, First Lieut. U.S.A., B.S., United States Military Academy
Wilson Hawkes Neal, First Lieut. U.S.A., B.S., United States Military Academy
Paul Elmer Ruch, B.S., Massachusetts Institute of Technology
Frank Briscoe Stephens, Lieut. U.S.N., B.S., United States Naval Academy
John Fletcher Tatom, Lieut. U.S.N., B.S., United States Naval Academy
Donald Norton Yates, First Lieut. U.S.A., B.S., United States Military Academy

---

Bachelor of Science (Five Year Course)

AERONAUTICS

Steven Eric Belsley, B.S., Purdue University
Andrew Fejer, M.E., Technische Hochschule at Prague, Czechoslovakia
Harold Fischer, B.A., University of California at Los Angeles
Joseph Louis Fredrick, B.S., Louisiana State University
Dalimil Kybal, B.S., California Institute
Henry Takeshi Nagamatsu, B.S., California Institute
Walter Brown Powell, B.A., Stanford University
Jose Luis Velazquez, B.S., California Institute
Robert Henry Widmer, B.S., Rensselaer Polytechnic Institute

METEOROLOGY

Edgar Allen Aime, B.S., Tulane University
Kenneth Smith Norquest, B.S., College of Idaho
Robert Alexander Sanders, B.S., Cumberland University
Paul Beals Streckewald, B.S., University of Wisconsin

Bachelor of Science (Four Year Course)

SCIENCE

George Asakawa
John Allen Battle
William Eugene Berg
Richard Hawley Bishop
Robert Carter
Claude Howard Craft
Virgil Kenmore Crawford
Barry Dibble, Jr.
Herman Sigmund Englander
John C. Evvard
Delos Edward Flint
William Rex Frampton, Jr.
Ray Van Deusen Gerhart
Joseph John Gombotz
John Robert Griffiths
Robert Christian Hagen
‡Francis Chandler Ingalls
Louis Lawrence Kolb
Robert McClung Kyte
Leo Silvio Lavatelli
Melvin N. Levet
*Kenneth Gordon Macleish
Walter Heinrich Munk
Edward Haig Parker
John McCowan Peat, Jr.
*Edmund Joy Pinney
Keats A. Pullen, Jr.
Frank Radovich
Leo James Rainwater
Volney K. Rasmussen, Jr.
Louis John Regan, Jr.
Francis Allen Robertson
*Bert Victor Roudebush
*Sylvan Rubin
Ralph John Ruggiero
David Holcomb Scott
Thurston Skei
Philip Ernest Smith
James Eugene Stones
†Robert William White
Udene Earl Younger
Homer Smith Youngs

ENGINEERING

Clarence Russell Anderson
†Noah Herbert Anderson, Jr.
Basil Petrovich Antonenko
Charles Henry Bauer, Jr.
Leo Roy Beard
†Duane Wesley Beck
John William Black
Lawrence Glenn Borgeson
Richard R. Bradshaw
Kenneth Rankin Bragg
James William Braithwaite
Claude Hancock Brown, Jr.
Perry Harrington Brown
William Lowe Brown
John Jake Browne
Francis Lacey Carlisle
*Charles Frederick Carstarphen
Ralph Kenneth Collins
Ronald B. Connelly
George Olds Crozier
Harry Owens Davis, Jr.
*Philip Sarkis Devirian, Jr.
Walter A. Diehm
Paul O. Engelder
Richard A. Fischer
Stuart MacMillan Fraser
James Scott Gassaway
*Jack Hugh Goodell

*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.
‡Deceased, February 28, 1938. Degree awarded posthumously in recognition of outstanding scholastic attainment.

Harry Allen Goodin, Jr.
*Albert Pennington Green
William Manning Green
Edgar Allen Griswold
Marcus A. Hall
Harold Vivian Hance
Andrew Lucien Hannon
Robert Walter Haussler
Ernest Michael Hiehle
Frederick Carl Hoff
George Marion Hotz
David Elmore Hoyt
Robert Barry Kimball
John Konecnik
†Donald Gibb Lawrie
†William G. Lawson
†Curtis Munn Lee
†Harlowe Julius Longfelder
Tyler Matthew
*†Roderick Marshall McClung
Frank Ewing McCreery
James Robb McKinlay
W. Deming Merrick
George Kiyoshi Morikawa
William Mear Norton, Jr.
Spencer Whittemore Oakley
†John Edward Osborn
Carl Hutton Paul
Charles Edward Pettingall
Richard Kelley Pond
James Clifton Ritchey
†William Arthur Root
William Franklin Ropp
Carl Joseph Schneider
Quido Miles Shultise
George William Sinclair
Josiah Edward Smith
†Paul Louis Smith
Robert Louis Smith
Willard Mitchell Snyder
†Herbert Davis Strong, Jr.
Edwin Franklin Sullivan
Robert Fulton Tangren
Robert Winslow Winchell
Lester Goffin Zukerman

*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, 1939-40

JUNIOR SCHOLARS:

Wayne Gordon Abraham
Glenn W. Billman
Robert R. Bowles
Robert N. Hall
Miyoshi Ikawa
William L. Ingersoll
Robert B. Leighton
John M. Richardson
Claud S. Rupert
Stanley G. Stroud
Roger William Wallace
John R. White
David S. Wood

WALTER HUMPHRY JUNIOR SCHOLAR:

Robert Buss

SOPHOMORE SCHOLARS:

Robert Earl Densmore, Jr.
Arnold L. Grossberg
Willard J. Hendrickson
David Lawrence Hill
William T. Holser
David R. Howton
Alexander S. Jerrems
William G. Kennedy
Carl H. Savit
Arthur J. R. Schneider
Irvin P. Seegman
Clifford Ambrose Truesdell, III

DRAKE SOPHOMORE SCHOLARS:

Jack H. Irving
Homer Jacobson
Robert E. MacKenzie
John W. Miles
Russell F. Rhyne

BLACKER FRESHMAN SCHOLARS:

Roderick K. Clayton
David L. Douglas
Richard Latter
Thomas S. Lee
Samuel P. Morgan, Jr.
Gerald D. Mylander
Donald H. Potts
William J. Russell, Jr.
Robert M. Sherwin

HARRIET HARVEY FRESHMAN SCHOLAR:

Robert C. Frost

AMERICAN CHEMICAL SOCIETY FRESHMAN SCHOLARS:

David J. Klein
Richard Latter

LAVERNE NOYES SCHOLARS:

James Donovan Acord
Philip Daniel Brooks
Sheldon Cyr Crane
Robert Earl Densmore, Jr.
William E. Dobbins
John Archibald Drake
Thomas Davidson Elliott
David Lawrence Hill
Berl Dave Levenson
William Donald Rolph, Jr.
David Shepard Shisler
Clifford Ambrose Truesdell, III.
Roger William Wallace

GRADUATE STUDENTS

Abbreviations: Eng., Engineering; Sci., Science; A.Ch., Applied Chemistry; AE, Aeronautics; 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
Abraham, Lewis Harry B.S., North Carolina State College, 1938	AE	Portsmouth, Virginia
Akman, Mustafa Seyfettin B.S., Robert College, 1939	ME	Istanbul, Turkey
Alexis, Carl Odman A.B., University of Nebraska, 1937; M.S., University of Arizona, 1940	Ge	Lincoln, Nebraska
Anderson, O'Dean B.S., Utah State Agricultural College, 1939	CE	Glenwood, Utah
Armi, Edgar Leo (†) Diploma, Munich Institute of Technology, 1931; M.S., California Institute, 1939	Ph	Pasadena
Atsumi, John Shoichi (†) B.S., University of Southern California, 1932; M.S.E., University of Michigan, 1935	AE	Stockton
Avann, Sherwin Parker B.S., University of Washington, 1938	Ma	Clinton, Washington
Axelrod, Joseph Meyer (†) B.S., California Institute, 1937; M.S., 1938	Ch	Los Angeles
Bailey, Howland Haskell (†) A.B., Haverford College, 1932	Ph	Hyde Park, Massachusetts
Baird, Raymond Charles B.A., University of California at Los Angeles, 1938	Ph	Santa Monica
Batu, Muhtar B.S., Robert College, 1939	ME	Istanbul, Turkey
Baumgarten, Werner Diploma, University of Munich, 1937	Ch	Pasadena
Beck, Duane Wesley B.S., California Institute, 1939	ME	Los Angeles
Becker, Robert Adolph (†) B.S., College of Puget Sound, 1935; M.S., California Institute, 1937	Ph	Tacoma, Washington
Beichley, Francis Wendell B.S., Kansas State College, 1937	EE	Clay County, Kansas
Bell, Richard William B.A., Oberlin College, 1939	AE	Elyria, Ohio
Belsley, Steven Eric B.S., Purdue University, 1938; B.S. in AE, California Institute, 1939	AE	Peoria, Illinois
Benson, Andrew Alm B.S., University of California, 1939	Ch	Modesto
Berg, William E. B.S., California Institute, 1939	Bi	Round Mountain, Nevada
Bergren, William Raymond (†) B.S., California Institute, 1932	Bi	Pasadena
Biglow, James Otis B.S., United States Naval Academy, 1938	AE	New London, Ohio
Blewett, Stephen Errol A.B., Stanford University, 1939	My	Stockton
Blohm, Clyde L. B.S., California Institute, 1930; M.S., 1931	Ch	Los Angeles

Name	Major Subject	Home Address
Bohm, David Joseph B.S., Pennsylvania State University, 1939	Ph	Wilkes-Barre, Pennsylvania
Bonner, David Mahlon (†) B.A., University of Utah, 1936	Bi	Salt Lake City, Utah
Borgeson, Lawrence G. B.S., California Institute, 1939	EE	Pasadena
Borgquist, Neil Erasmus B.S., University of Arizona, 1939	CE	Tucson, Arizona
Botkin, Daniel Funderburg B.S., New Mexico College of Agriculture and Mechanic Arts, 1939	Ch	New Mexico
Bradner, Hugh (†) A.B., Miami University, 1936	Ph	Hamilton, Ohio
Braithwaite, James William B.S., California Institute, 1939	AE	Arcadia
Brasch, Frederick Martin A.B., Nebraska Wesleyan University, 1939	My	Farnam, Nebraska
Brettell, George Alvin, Jr. B.S., Lehigh University, 1937	EE	Newark, New Jersey
Brown, Claude H., Jr. B.S., California Institute, 1939	ME	Los Angeles
Brown, Frank William, III B.S., Massachusetts Institute, 1938	Ph	Rome, New York
Burcik, Emil Joseph (†) B.S., Carnegie Institute, 1937	Ch	Pittsburgh, Pennsylvania
Byrne, Ralph Edward, Jr. (†) B.S., California Institute, 1933; M.S., 1934	CE	Pasadena
Cabell, John Bell B.S., Virginia Military Institute, 1937	CE	Savannah, Georgia
Canright, Richard Bruce A.B., Miami University, 1939	Ph	Akron, Ohio
Carlisle, Francis L. B.S., California Institute, 1939	ME	Pasadena
Carstarphen, Charles Frederick B.S., California Institute, 1939	ME	Denver, Colorado
Carter, Robert Trissel B.S., California Institute, 1939	ChE	Glendale
Caswell, Robert Little B.S., University of California, 1939	Ch	San Francisco
Christensen, John Whittaker B.S., University of Utah, 1937	Ph	Cedar City, Utah
Cooley, Robert Alonzo B.S., University of California, 1938	Ch	Berkeley
Crockett, Harold Brown B.S., University of Texas, 1939; M.S., 1939	AE	Austin, Texas
Cushing, John Eldridge, Jr. A.B., University of California, 1938	Bi	San Francisco
Dailey, James Wallace A.B., Stanford University, 1935; M.S., California Institute, 1937	ME	Pasadena
Daniels, Jack B.S., Centenary College, 1939	AE	Shreveport, Louisiana
Davis, Leverett, Jr. (†) B.S., Oregon State College, 1936; M.S., California Institute, 1938	Ph	Cornucopia, Oregon

Name	Major Subject	Home Address
Devirian, Philip Sarkis, Jr. B.S., California Institute, 1939	ME	Altadena
Dibble, Barry, Jr. B.S., California Institute, 1939	Ph	Redlands
Dilworth, John Andrew, III B.S., Louisiana State University, 1939	AE	Shreveport, Louisiana
Doane, Edwin Addison B.S., University of Wisconsin, 1930; M.D., University of Oregon, 1933	Bi	Salem, Oregon
Doescher, Russell Nimtz (†) B.S., California Institute, 1933; M.S., 1934	Ch	Santa Monica
Donnell, Earl Roe, Jr. B.S., University of Texas, 1939	AE	Dallas, Texas
Doolittle, Russell Carter A.B., Princeton University, 1935	Ge	Garden City, New York
Dorwart, George M. B.S., California Institute, 1937; M.S., 1939	Ge	Pasadena
Dourson, Robert H. B.S., California Institute, 1935	ChE	Redondo Beach
Eberhardt, John Charles A.B., Occidental College, 1929	My	San Diego
Edson, James Brown A.B., University of Kansas, 1935; M.A., 1938	Ph	Flagstaff, Arizona
Ellis, Charles Herbert B.A., Whittier College, 1934; M.S., 1937	Bi	Pasadena
Engelder, Paul Oscar B.S., California Institute, 1939	EE	Douglas, Arizona
Evvard, John C. B.S., California Institute, 1939	Ph	Phoenix, Arizona
Fan, Hsu Tsi Eng. in M.E., Harbin Polytechnic Institute, 1935; M.S., California Institute, 1937; M.S. in AE, 1939	AE	Tientsin, China
Farquhar, John Percival B.S., Harvard College, 1935	Ch	Pasadena
Fejer, Andrew M.E., Technische Hochschule at Prague, 1936; B.S. in AE, California Institute, 1939	AE	Bratislava, Czechoslovakia
Felbeck, George Theodore B.S., University of Illinois, 1919; M.S., 1921	Ch	Altadena
Fink, Harold Kenneth A.B., Princeton University, 1938	Bi	New York City
Fischer, Charles Fink B.S., United States Naval Academy, 1934	AE	Erie, Pennsylvania
Fischer, Harold B.A., University of California at Los Angeles, 1938; B.S. in AE, California Institute, 1939	AE	Los Angeles
Fischer, James Rodney B.A., Ohio State University, 1938	Ch	Warsaw, Ohio
Fredrick, Joseph Louis B.S., Louisiana State University, 1938; B.S. in AE, California Institute, 1939	AE	New Orleans, Louisiana
Gage, Walter Henry B.A., University of British Columbia, 1925; M.A., 1926	Ma	Vancouver, British Columbia, Canada
Gant, Edward Victor B.E., Vanderbilt University, 1939	CE	Nashville, Tennessee

Name	Major Subject	Home Address
Gentner, William Ellis, Jr. B.S., United States Naval Academy, 1938	AE	San Pedro
Gerhart, Ray Van Deusen B.S., California Institute, 1939	ChE	Pasadena
Gibson, Arville Clifford B.A., Indiana Central College, 1931	My	Murfreesboro, Tennessee
Gould, Clark Webster, Jr. B.S., College of Puget Sound, 1938	Ch	Tacoma, Washington
Gould, Martin James (†) B.A., Rice Institute, 1935; M.A., 1936	Ge	Houston, Texas
Gould, Wendell Oliver B.S. and M.S., Washington State College, 1930	Ph	Pasadena
Green, William Jeffrey B.A., University of Manitoba, 1938	My	Fort William, Ontario, Canada
Gregory, Chris B.S., California Institute, 1938; M.S., 1939	Ph	Hollywood
Gringorten, Isaac (†) B.A., University of Toronto, 1935; M.A., 1936	My	Toronto, Ontario, Canada
Grobecker, Alan John B.S., California Institute, 1937	Ge	San Diego
Guerin, Jack Tichenor A.B., Stanford University, 1940	ME	San Francisco
Hall, Forrest H. B.S., Colorado State College, 1939	CE	Fort Collins, Colorado
Hannon, Andrew L. B.S., California Institute, 1939	AE	Los Angeles
Harris, Franklin Stewart, Jr. M.A., Brigham Young University, 1936	Ph	Pasadena
Hartlein, Robert L. B.S., California Institute, 1936	ME	Pasadena
Hatton, George Anthony B.S., United States Naval Academy, 1931	AE	Washington, D. C.
Havens, Byron Luther B.S., University of Washington, 1938; M.S., California Institute, 1939	EE	Spokane, Washington
Hays, John Thomas B.S., Montana State College, 1935; B.A., Oxford University, 1937; B.Sc., 1938	Ch	Bozeman, Montana
Hazlett, Thomas Herbert A.B., Allegheny College, 1939	Ph	Butler, Pennsylvania
Heaps, Stanley Newton B.A., Rice Institute, 1939	My	Houston, Texas
Henshaw, Paul Carrington (†) A.B., Harvard College, 1936; M.S., California Institute, 1938	Ge	Rye, New York
Hepner, Franklin Ross B.A., University of Wyoming, 1937; M.S., California Institute, 1939	Ch	Laramie, Wyoming
Hetzel, Eustace Plumb B of AE, Rensselaer Polytechnic Institute, 1939	AE	Harrisonville, Missouri
Heywood, Harold Elston B.S., Oklahoma Agricultural and Mechanical College, 1939	ME	Tulsa, Oklahoma
Hite, Jonas Ewing, Jr. B.S., Georgia School of Technology, 1938	ChE	Jackson, Mississippi
Holloway, John Marshall B.S., University of Manitoba, 1937	Ge	Winnipeg, Manitoba, Canada

Name	Major Subject	Home Address
Honnell, Pierre Marcel B.Sc., Agricultural and Mechanical College of Texas, 1930; EE, 1938; M.Sc., Massachusetts Institute, 1939	EE	Houston, Texas
Horne, Riley Coleman, Jr. B.S., Virginia Military Institute, 1936	EE	Marianna, Florida
Hosmer, Clark L. B.S., United States Military Academy, 1936	My	Pasadena
Hough, Eldred Wilson B.S., University of Illinois, 1939	Ph	Tucson, Arizona
Housner, George William B.S. in CE and B.S. in Ma, University of Michigan, 1933; M.S., California Institute, 1934	CE	Flintridge
Howell, Benjamin Franklin A.B., Princeton University, 1939	Ge	Princeton, New Jersey
Howell, William Jasper, Jr. B.A., Swarthmore College, 1938	Ch	Toledo, Ohio
Hoy, Robert Beck B.S., Lafayette College, 1937; M.S., California Institute, 1939	Ge	Easton, Pennsylvania
Hsu, Chang-Pen (†) B.S., Chiao-Tung University, 1935; M.E.E., Cornell University, 1938	EE	Changsha, China
Hsueh, Chao-Wang B.S., National University of Peking, 1931; M.S., California Institute, 1939	Ph	Shantung, China
Hudson, Donald E. B.S., California Institute, 1938; M.S., 1939	ME	Pasadena
Hughey, Albert Hall B.S., Purdue University, 1934; M.S., California Institute, 1938	AE	Allentown, Pennsylvania
Hulett, Richard B. B.S., University of Michigan, 1937	AE	Farmington, Michigan
Ivanoff, Nickolas G. B.S., California Institute, 1938	AE	Los Angeles
Jackson, John Warren B.S., University of Cincinnati, 1934; M.E., 1937	ME	New Albany, Indiana
Johnson, Kenneth D. B.S., Emmanuel Missionary College, 1932	Ch	Los Angeles
Jones, Laurence Carpenter B.S., University of Virginia, 1915	Bi	Beverly Hills
Jordan, Charles B. (†) B.S., California Institute, 1936; M.S., 1937	Ph	Los Angeles
Kanemitsu, Sunao B.S., University of California, 1937; M.S., California Institute, 1939	AE	Artesia
Katz, Leon B.Sc., Queen's University, 1934; M.Sc., 1937	Ph	Kingston, Ontario, Canada
Kaufman, Martin Donald A.B., University of Southern California, 1939; M.S., 1939	Ph	Los Angeles
Kennedy, David Hamilton B.S., United States Military Academy, 1932	My	Pasadena
King, James Leslie B.S., United States Naval Academy, 1912	ME	Washington, D. C.
Kipp, Samuel Millard, Jr. B.A., Wooster College, 1939	Ma	San Marino
Kleckner, Harold Francis B.S., University of Illinois, 1939	AE	Rockford, Illinois

Name	Major Subject	Home Address
Krause, William B.A., Arizona State Teachers College, 1939	Ph	Hamburg, New York
Kybal, Dalimil B.S., California Institute, 1938; B.S. in AE, 1939	AE	Mexico City, Mexico
Kyropoulos, Peter Rudolf B.S., University of Gottingen, 1936	AE	Pasadena
Lam, Ping Yan B.S., Yenching University, 1928	CE	Shamshuipo, Hong Kong, China
Langmuir, Robert Vose (†) A.B., Harvard College, 1935	Ph	Englewood, New Jersey
Lapin, Ellis B.S., Drexel Institute of Technology, 1939	AE	Philadelphia, Pennsylvania
LaSalle, Joseph Pierre B.S., Louisiana State University, 1937	Ph	Pasadena
Leech, William D. B.A., Union College, 1919; M.A., University of Southern California, 1926	Bi	Cooranbong, New South Wales, Australia
Lentz, John Jacob B.S., California Institute, 1938; M.S., 1939	EE	Los Angeles
Lester, Raymond T. B.S., United States Military Academy, 1931	My	Washington, D. C.
Levet, Melvin Newton B.S., California Institute, 1939	Ge	Monterey Park
Lewis, Edward Butts, Jr. B.A., University of Minnesota, 1939	Bi	Wilkes-Barre, Pennsylvania
Lewis, Lloyd Alan E.M., University of Minnesota, 1938	Ge	Henning, Minnesota
Lewis, Richard Newton A.B., University of California, 1937; B.A., Oxford University, 1938	Ch	Berkeley
Lewis, William Dabney A.B., Denison University, 1938	Ge	Granville, Ohio
Liang, Carr Chia-Chang B.Sc., Catholic University of Peiping, 1937; M.S., California Institute, 1939	ME	Peiping, China
Lieber, Paul Johns Hopkins University	Ge	Baltimore, Maryland
Longfelder, Harlowe Julius B.S., California Institute, 1939	AE	Los Angeles
LuValle, James Ellis (†) B.A., University of California at Los Angeles, 1936; M.A., 1937	Ch	Los Angeles
Lyon, Channing Bruce S.B., University of Nebraska, 1938; S.M., University of Chicago, 1939	Bi	Cheyenne, Wyoming
MacDonald, Torrence Hugh B.A., Montana State University, 1938	My	Missoula, Montana
Malina, Frank Joseph (†) B.S., Texas Agricultural and Mechanical College, 1934; M.S., California Institute, 1935; M.S. in AE, 1936	AE	Brenham, Texas
Mampell, Klaus Joachim B.A., University of Southern California, 1939	Bi	Los Angeles
Mao, Yu-yueh Alva B.S., Yenching University, 1937	Ph	Peiping, China
Martin, Don Stanley, Jr. B.S., Purdue University, 1939	Ch	Indianapolis, Indiana

Name	Major Subject	Home Address
Mayer, Rollins H. B.S., United States Naval Academy, 1932	EE	Los Angeles
McGill, William James B.Sc., Queen's University, 1937; M.Sc., 1939	Ge	Calgary, Alberta, Canada
McRary, Willard Lee (†) B.S., California Institute, 1936; M.S., 1938	Bi	Los Angeles
Mead, James Franklyn A.B., Princeton University, 1938	Ch	Evanston, Illinois
Menis, Luigi Lauria in Ingegneria, Royal Polytechnic Institute of Turin, 1935	AE	Bergamo, Italy
Metz, Charles Baker A.B., Johns Hopkins University, 1939	Bi	Baltimore, Maryland
Mewborn, Aladuke Boyd (†) B.S., University of Arizona, 1927; M.S., 1933	Ma	Tucson, Arizona
Miller, Dwight Dana (†) A.B., Whittier College, 1937	Bi	Whittier
Mitchell, Fern Wood, Jr. A.B., University of Alabama, 1938	Ch	Pensacola, Florida
Moore, Carl Anderson, Jr. B.S., University of Colorado, 1938	My	Hanover, New Mexico
Moore, Robert Sydney B.A., University of Western Ontario, 1938	Ch	London, Ontario, Canada
Morikawa, George K. B.S., California Institute, 1939	ME	San Diego
Morse, Francis B.E., Yale University, 1939	AE	Southport, Connecticut
Moyers, Frank N. B.S., California Institute, 1930; M.S., 1931	AE	Hemet
Munk, Walter Heinrich B.S., California Institute, 1939	Ge	Pasadena
Myers, Charles Stinson B.S., Alabama Polytechnic Institute, 1939	EE	Opp, Alabama
Nagamatsu, Henry Takeshi B.S., California Institute, 1938; B.S. in AE, 1939	AE	Santa Ana
Naiditch, Sam B.A., University of California at Los Angeles, 1939	Ch	Los Angeles
Nash, William Francis, Jr. B.S., California Institute, 1938; M.S., 1939	ME	San Diego
Nelson, Norton Harold B.A., St. Olaf College, 1937	EE	Iowa Falls, Iowa
Nichols, P. L., Jr. B.A., Texas Christian University, 1938	Ch	Fort Worth, Texas
Novitski, Edward B.S., Purdue University, 1938	Bi	New York City
Noyes, Richard Macy A.B., Harvard College, 1939	Ch	Urbana, Illinois
Olds, Robert Horner B.S., California Institute, 1938; M.S., 1939	Ph	Los Angeles
Olsson, Justus A. B.S., University of California, 1935	CE	Oakland
Omer, Guy Clifton, Jr. B.S., University of Kansas, 1936; M.S., 1937	Ph	Lawrence, Kansas

Name	Major Subject	Home Address
Ortiz, Jose Pulido Second Lieutenant, Naval Academy, 1924; Construction Engineer, Military College of the National University of Mexico	CE	Mexico, D. F., Mexico
Otvos, John William B.S., Harvard College, 1939	Ch	Hollywood
Panofsky, Wolfgang Kurt Hermann A.B., Princeton University, 1938	Ph	Princeton, New Jersey
Peterson, Norman Lewis B.A., Yale University, 1932	My	San Antonio, Texas
Pinney, Edmund Joy B.S., California Institute, 1939	Ma	Seattle, Washington
Powell, Walter Brown B.A., Stanford University, 1937; B.S. in AE, California Institute, 1939	AE	Burlingame
Pressman, David (†) B.S., California Institute, 1937; M.S., 1938	Ch	Los Angeles
Rannie, William Duncan (†) B.A., University of Toronto, 1936; M.A., 1937	AE	Chesley, Ontario, Canada
Rasmussen, Robert Severin (†) S.B., University of Chicago, 1938	Ch	Chicago, Illinois
Regan, Louis John, Jr. B.S., California Institute, 1939	Ge	Hollywood
Rempel, William Herbert B.A., Montana State University, 1939	My	Dutton, Montana
Roberts, Ellis Earl B.S., Michigan College of Mining and Technology, 1937	Ge	Houghton, Michigan
Robinson, Charles Franklin A.B., Missouri State Teachers College, 1935; B.S., Drury College, 1936	Ph	Springfield, Missouri
Rogers, Max Tofield (†) B.Sc., University of Alberta, 1937; M.Sc., 1938	Ch	Tofield, Alberta, Canada
Roosevelt, Kermit, Jr. B.A., Harvard College, 1937	Humanities	Pasadena
Rosenthall, Edward B.Sc., McGill University, 1937; M.Sc., 1938	Ma	Montreal, Quebec, Canada
Roudebush, Bert Victor B.S., California Institute, 1939	ChE	Glendale
Rubin, Sylvan B.S., California Institute, 1939	Ph	Los Angeles
Rudkin, George Thomas B.S., California Institute, 1938; A.M., Stanford University, 1939	Bi	San Marino
Rumph, Lewis Benning, Jr. B.S., Georgia School of Technology, 1933; M.S., 1936	AE	Pasadena
Rundle, Robert Eugene B.S., University of Nebraska, 1937; M.S., 1938	Ch	Lincoln, Nebraska
Rupnik, John Joseph Geological Engineer, Colorado School of Mines, 1933	Ge	Denver, Colorado
Russell, Horace, Jr. B.S., Duke University, 1938	Ch	Washington, D. C.
Saunders, Paul Rome B.S., University of California, 1939	Bi	Carmel
Schlatter, Maurice Jay B.S., California Institute, 1938	Ch	Pasadena

Name	Major Subject	Home Address
Seekins, Charles William A.B., Occidental College, 1938	Ma	Van Nuys
Shaffer, Philip Anderson, Jr. (†) B.S., Harvard College, 1937	Ch	St. Louis, Missouri
Sheppard, Charles Wilcox (†) B.S., California Institute, 1937; M.S., 1938	Ph	Coldwater, Ontario, Canada
Shideler, James Henry B.S., University of Southern California, 1926	EE	Hemet
Sloane, Richard Lewis B.C.E., Ohio State University, 1938	AE	Columbus, Ohio
Smith, Alexander B.A., University of British Columbia, 1932; M.A., 1933	Ge	Victoria, British Columbia, Canada
Smith, Clay Taylor B.S., California Institute, 1938	Ge	Glendale
Smith, Jack Carlton (†) B.E., Ohio State University, 1935; M.Sc., 1936	Ph	Akron, Ohio
Smith, Josiah Edward B.S., California Institute, 1939	AE	Corona
Smith, Robert Beaton B.A., Ohio State University, 1936; M.S., California Institute, 1938	AE	Columbus, Ohio
Smith, Theodore Beaton A.B., Ohio State University, 1938	Ph	Columbus, Ohio
Snow, William Eugene (†) B.A.Sc., University of British Columbia, 1935; M.A.Sc., 1936	Ge	North Vancouver, British Columbia, Canada
Spitzer, Ralph William A.B., Cornell University, 1938	Ch	Erie, Pennsylvania
Spizizen, John B.A., University of Toronto, 1939	Bi	Toronto, Canada
Springer, Edwin Kent B.S., University of Southern California, 1936	ME	Los Angeles
Spurr, Robert Anton A.B., Rollins College, 1936; B.S., 1937; M.S., Harvard University, 1938	Ch	East Alstead, New Hampshire
Staple, William James B.Sc., University of Saskatchewan, 1933; M.Sc., 1936	Ph	Saskatchewan, Canada
Stearns, Charles Edward A.B., Tufts College, 1939	Ge	Billerica, Massachusetts
Steele, George Floyd B.A., University of Colorado, 1939	AE	Boulder, Colorado
Steinebrey, Frank Julius, Jr. B.S., University of Southern California, 1938; M.S., 1939	Ch	Glendale
Stever, Horton Guyford B.A., Colgate University, 1938	Ph	Corning, New York
Stewart, Homer Joseph B. AE, University of Minnesota, 1936	AE	Pasadena
Stewart, William Thomas B.S., University of Arizona, 1937; M.S., 1938	Ch	Phoenix, Arizona
Stivers, Louis Scott, II B.A., George Pepperdine College, 1939	AE	Bell
Stoltz, Fred W. B.S., Washington State College, 1937	ME	Buckley, Washington

Name	Major Subject	Home Address
Stone, Newton C. B.E., *Southern Illinois Teachers College, 1934; M.S., University of Illinois, 1935*	My	Fairfield, Illinois
Storms, Harrison Allen, Jr. B.S., Northwestern University, 1938; M.S., 1939	AE	Wilmette, Illinois
Streckewald, Paul Beals B.S., University of Wisconsin, 1936; B.S. in My, California Institute, 1939	My	La Canada
Streib, John Fredrick, Jr. (†) B.S., California Institute, 1936	Ph	Pasadena
Summerfield, Martin (†) B.S., Brooklyn College, 1936; M.S., California Institute, 1937	Ph	Brooklyn, New York
Sumner, Herbert Clark B.A., Stanford University, 1939	ME	La Jolla
Sundarachar, C. K. B.A., Central College, Bangalore, 1916; M.A., 1918	Ph	Bangalore, India
Sweberg, Harold H. B.S., Louisiana State University, 1939	AE	Brooklyn, New York
Swift, Jonathan Dean A.B., University of California, 1939	Ma	Berkeley
Swingle, Stanley Morse B.S., Montana State College, 1939	Ch	Bozeman, Montana
Tangren, Robert Fulton B.S., California Institute, 1939	AE	Pasadena
Tao, Shih Chen B.A., The College of Yale-in-China, 1926; M.S., Yenching University, 1932	EE	Shanghai, China
Thomas, Jacob Earl A.B., Johns Hopkins University, 1939	Ph	Drexel Hill, Pennsylvania
Tomlinson, Everett Parsons (†) B.S., Yale University, 1936	Ph	Montclair, New Jersey
Torrey, Preston B.S., University of New Hampshire, 1939	My	Edinburg, New York
Unholtz, Karl B.S., California Institute, 1936; M.S., 1939	EE	Los Angeles
Ustel, Sabih Aziz B.S., Robert College, 1939	CE	Istanbul, Turkey
Van Driest, Edward Reginald (†) B.S., Case School of Applied Science, 1936; M.S., State University of Iowa, 1937	CE	Cleveland Heights, Ohio
Vernon, James Benson B.S., University of Iowa, 1938; M.S., 1939	AE	Marion, Iowa
Wagner, Charles Daniel A.B., Grinnell College, 1939	Ch	LaGrange, Illinois
Wahrhaftig, Austin Levy A.B., University of California, 1938	Ch	Sacramento
Wallace, Robert Earl B.S., Northwestern University, 1938	Ge	Demarest, New Jersey
Wang, Hsih-Heng B.S., Harbin Polytechnic Institute, 1935; M.S., California Institute, 1938	CE	Tientsin, China
Wang, Tsung-Su B.S., National Central University, 1933	EE	Sian, Shensi, China
Waring, Dana Bushnell M.E., Cornell University, 1939	ME	Ithaca, New York

Name	Major Subject	Home Address
Waser, Jurg Heinrich Ernst Federal Certificate of Maturity, University of Zurich, 1935	Ch	Zurich, Switzerland
Waterman, Alan Tower, Jr. A.B., Princeton University, 1939	My	North Haven, Connecticut
Webb, John Leyden (†) B.S., California Institute, 1936	Bi	Altadena
Wells, Robert Lynn B.S., University of Rochester, 1939	ME	Evanston, Illinois
Wessale, John Oswald B.S., State University of Iowa, 1939	AE	Cedar Rapids, Iowa
Wetmore, William Owen B.S., California Institute, 1937; M.S., 1939	ME	Bakersfield
Wheeler, Donald Bingham, Jr. B.S., Lehigh University, 1938	Ph	Buffalo, New York
Wheeler, George Frederick B.A., Ohio State University, 1938	Ph	Columbus, Ohio
Wiggins, John Shearon A.B., Earlham College, 1936; M.S., California Institute, 1938	Ph	Richmond, Indiana
Wild, John Meincke B.S., Purdue University, 1937	AE	Chicago, Illinois
Wilson, Harry David Bruce (†) B.Sc., University of Manitoba, 1936	Ge	Winnipeg, Manitoba, Canada
Winchell, Robert Winslow B.S., California Institute, 1939	EE	Beverly Hills
Winget, James Lyle B.S., Oklahoma Agricultural and Mechanical College, 1939; M.S., 1939	Ph	Cushing, Oklahoma
Woolson, John Robert Ph.B., Gonzaga University, 1936; B.S., California Institute, 1938	Ma	Spokane, Washington
Worcester, Willis George B.S., University of Colorado, 1939	EE	Boulder, Colorado
Wouk, Victor B.A., Columbia College, 1939	EE	New York City
Wright, Ernest Bevier B.S., Yale University, 1938	Ph	New Brunswick, New Jersey
Wright, Frederick Hamilton (†) B.A., Haverford College, 1934	Ph	Washington, D. C.
Wyman, Max (†) B.Sc., University of Alberta, 1937	Ma	Edmonton, Alberta, Canada
Yost, Russell Raymond, Jr. B.S., Haverford College, 1939	Ph	Johnstown, Pennsylvania
Yuan, Luke Chia-liu (†) B.S., Yenching University, 1932; M.S., 1934	Ph	Tientsin, China
Yuan, Shao Wen B.S., University of Michigan, 1936	AE	Peiping, China
Zarem, Abe Mordecai B.S., Armour Institute of Technology, 1939	EE	Chicago, Illinois

UNDERGRADUATE STUDENTS

Students whose names are starred attained honor standing during the preceding year.

SENIORS

Name	Option	Home Address
Acker, Roy Mitchell	ME	Riverdale
Adams, Robert Powell	ME	Arcadia
Alcock, Robert Ward	ME	Iowa City, Iowa
Alonso, Frank Anthony	EE	Los Angeles
Anderson, Keith E.	Ge	South Pasadena
Arvin, George Howard	APh	Long Beach
Baller, Howard S.	EE	Newark, New Jersey
Ballreich, Newell	ACh	Los Angeles
Barber, George Clair	AE	Pasadena
Baumgarten, Erwin	Ch	Pasadena
Bennett, Dwight Henry	AE	Tulsa, Oklahoma
Berlot, Robert Raymond	Ph	Los Angeles
Biddison, Cydnor Mark	CE	San Gabriel
Billheimer, John S.	Ch	Altadena
Blackinton, Roswell J.	ACh	Bell
Brewer, Alexander F.	EE	Hollywood
Brewer, Leo	Ch	Los Angeles
Brose, Frederic Morgner	ME	North Hollywood
Brown, George Reynolds	ACh	Colorado City, Texas
Brown, William Emil	ACh	Huntington Park
Brumfield, Robert Clarence	ME	Los Angeles
Brunner, Frederick Calvert	ACh	Alhambra
Burton, Clifford Chickering	ACh	Coffeyville, Kansas
Campbell, Donald Cameron	ME	Pasadena
Carey, John Crawford	EE	Hollywood
Carson, Donald Bell	EE	Pasadena
Cleveland, William Roy, Jr.	Ge	Whittier
Clinton, Raymond Otto	Ch	Glendale
Compton, Arthur Mandeville	AE	Davenport, Iowa
Cox, Robert Osborne	ME	Altadena
Crane, Sheldon Cyr	Bi	Los Angeles
Crawford, James Vaile	ME	Burbank
Crawford, John Henry	EE	Los Angeles
Daams, Gerrit	APh	Alhambra
Davies, Claude Edward	APh	Santa Ana
Davis, Leo	Ph	Los Angeles
Day, John Paul	Ph	Arcadia
Dessel, Frank William	Bi	San Francisco
Dickerson, Edward Oakes	ME	Redlands
Epstein, Ludwig	Ph	Beverly Hills
Espy, W. Dawkins	EE	New Orleans, Louisiana
Fleming, Robert Ernest	APh	Glendale
Foster, Gerald Pentland	ME	Los Angeles
France, Albert Finley, III	ME	Washington, D. C.
Freehafer, Paul Robinson	ACh	Payette, Idaho

Name	Option	Home Address
German, Irvine Fisk, Jr.	ACh	Garden Grove
Gewe, Robert Alexander	CE	Los Alamos
Glassco, James B.	ME	San Gabriel
Glassco, Robert B.	ME	San Gabriel
Goodmanson, Lloyd Twedt	AE	Eagle Rock
Grigg, Robert Webb	EE	Pasadena
Guillou, Alfred Victor	EE	Van Nuys
Haffner, Bernhard	Ge	Kimberly, Nevada
Harper, John C.	ACh	Denver, Colorado
Hines, Marion Earnest	APh	Long Beach
Hofeller, Gilbert Walter	ME	Pasadena
Hofmann, Walter	CE	Bell
Hohwiesner, Henry George, Jr.	ME	Sacramento
House, William Carl	AE	Eau Claire, Wisconsin
Hudspeth, Tom	EE	Santa Ana
Jacobs, Millard W.	CE	Los Angeles
Janssen, Robert Ramsay	EE	Whittier
Jongeneel, James William	CE	Honolulu, Hawaii
Kemp, Leroy James	ME	Bell
Keyser, John Harold, Jr.	EE	Hayward
Kluge, William Thomas	ACh	Portland, Oregon
Kohl, Jerome	ACh	Los Angeles
Krieger, Stuart Alvin	AE	Los Angeles
Kupfer, Donald Harry	Ge	Los Angeles
Kuttler, Luther P.	CE	Los Angeles
Langerud, Ralph Owes	AE	Oslo, Norway
Larson, Walter Ramey	EE	Los Angeles
Laue, Eric Gilbert	EE	Los Angeles
LeGrand, Charles Croxall	EE	South Pasadena
Lemm, Willys	ME	Pasadena
Levin, Gerald Balfour	APh	Los Angeles
Loeffler, Don Edward	Ch	Inglewood
Lolmaugh, Orson Bernard	EE	Hemet
Longwell, Paul Alan	ACh	Santa Maria
Love, Bernard	Ch	Los Angeles
MacKay, Wallace M.	ME	Los Angeles
Manildi, Joseph Frank	EE	Soquel
Marriott, William Robert Victor	Ch	Los Angeles
Mayer, Jules F.	ME	Los Angeles
Meyer, Robert B.	ME	Alhambra
Mickley, Harold Somers	ACh	Long Beach
Mills, Chester David	Ph	San Diego
Mills, Mark Muir	Ph	Estes Park, Colorado
Nagle, Darragh E.	Ph	Hartsdale, New York
Nakada, Yoshinao	Ph	Azusa
Neiswander, Robert South	EE	Phoenix, Arizona
Newby, Clinton Toms	AE	Long Beach
Nickerson, Douglas Blain	ME	Redlands
Oder, Frederic Emil	Ge	Alhambra
Oldson, Norman P.	ME	Pasadena
Olney, Frank	EE	Moneta
Palmer, Charles Sumner	ME	Pasadena

Name	Option	Home Address
Palmer, John Gordon	ME	Brawley
Paul, Ralph Graham	Ch	Laguna Beach
Payne, Charles Melvin	ME	Altadena
Phillips, Robert Austin	EE	Downey
Powell, Richard Wells	EE	Twin Falls, Idaho
Quarles, Miller Winthrop	Ge	Los Angeles
Ray, Robert Stanley	ACh	Riverside
Reynolds, Howard William, Jr.	Ge	Beverly Hills
Richards, Raymond Gardner	ME	Exeter
Rogers, Lawrence Arnold	Ge	Los Angeles
Rose, Charles Herrick	ME	Carlsbad
Rush, Hugh M.	AE	Tulsa, Oklahoma
Samuel, Hubert David, Jr.	ME	Los Angeles
Sandiford, Perry Lathrop, Jr.	EE	Huntington Park
Sargent, Herbert	Ch	Pasadena
Scarborough, William Bertram	ACh	Denver, Colorado
Schrader, Carl G.	ME	Mill Valley
Shisler, David Shepard	ME	Santa Monica
Silvertooth, E. Wilbur	Ph	Long Beach
Smith, Randlow	ACh	Los Angeles
Smith, William D.	AE	Porterville
Spalding, Delman Seward	CE	Guilford, Connecticut
Spielberger, Robert Elmer	ME	Palo Alto
Spooner, William Austin	ACh	Long Beach
Staatz, Dumont Sutherland	Bi	Olive View
Staatz, Mortimer Hay	Ge	Olive View
Steel, Collis K.	EE	Butte City
Steinmetz, David Henry, III	ME	Los Angeles
Stevens, Jean Barrieu	EE	Long Beach
Stone, William Welch	Ph	Los Angeles
Stoner, Willis Allen	ME	Pasadena
Stowell, Ellery Cory, Jr.	Bi	Santa Barbara
Stroud, Robert Addis	CE	Los Angeles
Sullivan, Richard Louis	EE	Glendale
Svimonoff, Constantine	CE	Los Angeles
Tajima, Yuji	Bi	Pasadena
Thompson, Ross D. F.	Ph	Los Angeles
Tielrooy, Jack	ACh	North Hollywood
Tobin, Bernard M.	Ph	Brooklyn, New York
Todd, George Judson	ME	Altadena
Tomiyasu, Kiyo	EE	Las Vegas, Nevada
Van Dyke, Gilbert Rush	Ge	Fallbrook
Varnes, David Joseph	Ge	Los Angeles
Vetter, Warren Herman	CE	Los Angeles
Walker, Richard Langan	ME	Alhambra
Walter, Don Lombard	AE	Glendale
Wasem, Richard	Ge	Long Beach
Watkins, James M.	ACh	Pasadena
Wayman, Robert W.	ME	Los Angeles
Weaver, Theodore Sol	ACh	Hollywood
Weir, Gordon Bruce	Ge	Los Angeles
White, Howard Jack	ME	Los Angeles

Name	Option	Home Address
Whittlesey, David Walter	ME	Portland, Oregon
Whittlesey, James Wright	ME	Portland, Oregon
Williams, Charles	EE	San Juan Capistrano
Williamson, John Bridgers	EE	Fontana
Wilts, Charles Harold	EE	Los Angeles
Worcester, Herbert Moore, Jr.	AE	Pasadena
Young, David Arthur	ME	Utica, Missouri
Young, Robert Busbey	ME	Los Angeles

JUNIORS

Name	Option	Home Address
Abbey, Edward Kirk	APh	San Diego
*Abraham, Wayne Gordon	Ph	Long Beach
Almassy, George Weber	EE	Glendale
Anderson, Robert Edwin	Ge	Los Angeles
Ashbrook, Fred Mulock	EE	San Gabriel
Barber, John Howland	Bi	Mexico City, Mexico
Beers, Kenneth Hurst	EE	Los Angeles
Beller, Gordon	CE	Los Angeles
Benson, Arthur S.	AE	Hollywood
Berman, Dave Bryon	ACh	Phoenix, Arizona
Bersbach, Alfred John	EE	Culver City
*Billman, Glenn Wagner	ACh	Long Beach
Billmeyer, Fred Wallace, Jr.	Ch	Pasadena
Boardman, Warren	ME	Los Angeles
*Bowles, Robert Ryland	ACh	Denver, Colorado
Bowlus, Robert Glenhart	ACh	San Marino
Bramhall, George Hardy	ME	Webster Groves, Missouri
Brandt, Roger	EE	San Marino
Brooks, Philip Daniel	AE	Pasadena
Buchzik, Charles Mallory	Ch	North Hollywood
Buss, Robert	ACh	Centerville, Iowa
Callaway, William Franklin	ME	Long Beach
Capron, Sanford Donley	ME	Santa Monica
Carlson, Carl Arthur	CE	Fontana
Carr, John Henry	ME	Rosemead
Casserly, Frank Gordon	EE	Pasadena
Chapin, William F.	ACh	Long Beach
Chastain, J. Alexander	EE	Berkeley
Clarke, Frederick Weaver, III	ME	Omaha, Nebraska
Cooper, Robert George	Ch	Pasadena
Corcoran, William H.	ACh	Los Angeles
Dailey, Charles Lee	AE	Los Angeles
Davis, Walter Z.	ME	Spokane, Washington
Dawson, Donald Edwin	EE	Pasadena
Deniston, William	EE	South Pasadena
Dickey, Frank Host	Ch	Los Angeles
Dill, Douglas Gordon	AE	Sierra Madre
Dobbins, Willis E.	EE	Lakewood, New York
Edwards, Gene L.	ME	Crockett
Elliott, Quentin	ACh	Aurora, Nebraska
Elms, James Cornelius	ME	Phoenix, Arizona

Name	Option	Home Address
Eusey, Merritt V.	EE	Pasadena
Ewald, Grant Walker	ME	Redwood Estates
Fahs, James Roger	ACh	Fullerton
Faris, Frank Edgar	AE	Grand Junction, Colorado
Farrington, Paul Stephen	ACh	North Chicago, Illinois
Faust, Paul Harry	ACh	Pasadena
Fisher, Robert Edwin	AE	West Los Angeles
Frank-Jones, Glyn	EE	Los Angeles
Fredrick, Arden Hugo	EE	San Diego
Gale, George Phipps	EE	Pasadena
Galeski, Robert Benjamin	Ge	Los Angeles
Gally, Sidney Kilburne	EE	Pasadena
Geitz, Robert Charles	Ch	McKeesport, Pennsylvania
Gillings, John William	EE	Los Angeles
Gold, Sydney Kendall	ME	Los Angeles
Green, Jerome	ACh	San Francisco
Greenhalgh, Francis	ME	Los Angeles
Hall, Robert Franklin	ME	San Diego
*Hall, Robert Noel	Ph	Berkeley
Hardin, Paul Verle	Ch	Colton
Harlan, James T.	ACh	South Pasadena
Harr, George Bowman	ACh	Long Beach
Harris, Robert H.	Ch	Dayton, Ohio
Harter, Wendell W.	AE	Pasadena
Hassard, Thomas Jason	APh	Chula Vista
Head, Richard Moore	AE	Pasadena
Hebenstreit, William Benton	APh	Pasadena
Hill, Kim	Ge	Glendale
Horne, Othniel	ME	El Centro
Howard, Kenyon Bales	ACh	Altadena
Howenstein, John Barrett	EE	Westmorland
*Ikawa, Miyoshi	Ch	Venice
Ikeda, Carol Kazuo	Ch	Pasadena
*Ingersoll, William Lee	ME	West Linn, Oregon
Jones, Gilbert Allan	EE	Scottsdale, Arizona
Jones, Jeremy Aldan	ACh	San Marino
Jones, John Willard	ACh	Los Angeles
Kingsmill, Robert E.	EE	Long Beach
LaBombard, Emerson Hogue	ME	Santa Monica
Lakos, Eugene Alexander	CE	Santa Barbara
Lawrence, Bruce	Ph	Pasadena
Leighton, Robert B.	EE	Alhambra
Levenson, Berl D.	EE	Los Angeles
Levitt, Leo Charles	Ph	Sierra Madre
Lewis, Joseph Walters	ME	South Pasadena
Long, Calvin Washburn	ME	West Los Angeles
Lyle, Francis Vivian	Ph	Los Angeles
Main, John Hamilton	ACh	Evanston, Illinois
Makepeace, Gershom Reynolds	Bi	Pasadena
Maker, Robert	EE	Santa Barbara
Maninger, Ralph Carroll	Ph	Pasadena
Marquardt, Roy Edward	AE	Burlington, Iowa
McIntosh, James	ME	Sidney, British Columbia, Canada

Name	Option	Home Address
Meyer, George Frederick	Ge	Los Angeles
Mitchell, Stanley John	APh	San Gabriel
Moore, Charles LeRoy	Ge	Pasadena
Myers, Robert Francis	ME	Redondo Beach
Noland, Robert LeRoy	ME	San Diego
Nyborg, Meredith McRae	ME	San Anselmo
Oakes, Gibson	ME	Seattle, Washington
Partch, Newell	ME	Pasadena
Partlow, John Graydon	EE	Los Angeles
Paulson, John Joseph	EE	Pasadena
Peters, Ralph	EE	Los Angeles
Pickles, Arthur M.	ME	Victoria, British Columbia, Canada
Porter, Livingstone	Ge	Clarkdale, Arizona
Reimers, George I.	ME	New York, New York
*Richardson, John Mead	Ch	Sacramento
Roen, Charles Brandt	ACh	Alhambra
Rominger, Joseph Franklin	Ge	Long Beach
Routt, Robert Patterson	ACh	Los Angeles
*Rupert, Claud Stanley	Ph	Exeter
Rutherford, Charles Ettinger	ACh	Beverly Hills
Sakai, George Chitsugi	AE	Pasadena
Schaff, Al	AE	Pasadena
Schubert, William	ME	Huntington Park
Silberstein, Richard Frederick	CE	Sacramento
Skalecky, Frank Hamilton, Jr.	Ge	Coronado
Small, John Gilbert	Ph	San Rafael
Snodgrass, Reuben	AE	Tulsa, Oklahoma
Sohler, Stanley Edward	ME	Portland, Oregon
Spikes, John Daniel	Bi	Redondo Beach
Stadum, Clarence Bernhard	EE	Sioux Falls, South Dakota
Stewart, Wilton Alexander	ME	San Diego
*Stroud, Stanley Grover	EE	Fillmore
Sturdevant, C. Victor, III	AE	Pasadena
Sutton, Richard Alvord	ME	Hollywood
Svendsen, Norman F.	AE	Chicago, Illinois
Thayer, C. Louis	Ch	Ogden, Utah
Thiele, Frederick William	EE	Hollywood
Thomas, Delbert David	ACh	Pasadena
Trauerman, Joe Klee	ACh	Fort Dodge, Iowa
Trindle, Joseph Warren	Ph	Kuling, Kiangsi, China
Turner, Dale Edward	Ge	Kingsburg
Tyler, Edmund Forrest	Ma	Hollywood
Vartikian, Onick	AE	Fresno
Vaughan, Dick	CE	Burbank
Vey, Ebenezer	CE	Grates Cove, Newfoundland
Wagner, William J.	EE	Los Angeles
Wahrhaftig, Clyde Adolph	Ge	Fresno
*Wallace, Roger	Ph	Hermosa Beach
Weiss, Joseph	EE	Tujunga
*White, John Robertson	CE	Los Angeles
White, Thomas Leeming	AE	Los Angeles
Widdoes, Lawrence Curtis	ACh	Sebastopol

Name	Option	Home Address
Williamson, Herbert Edward	ME	Newport Beach
Wilson, Lindley Sothern	Ma	Long Beach
*Wood, David S.	ME	Sierra Madre
Young, Cecil Gilbert	EE	Palmyra, Missouri
Zebb, Keirn	AE	Denver, Colorado

SOPHOMORE CLASS

Name	Course	Home Address
Acord, James Donovan	Sci	Glendale
Albrecht, Albert Pearson	Eng	Riverside
Alford, Jack Leland	Eng	Long Beach
Allan, John Reppy	Eng	Pasadena
Allen, Paul Hodges	Eng	Fresno
Atkinson, Thomas George	Eng	Altadena
Ayers, Alden Whittemore	Sci	Alhambra
Bangs, William John	Sci	Beverly Hills
‡Becker, Paul Henry	Sci	Los Angeles
Bell, Alan Eddy	Sci	Seattle, Washington
Berdahl, Carroll Martin	Sci	Sioux Falls, South Dakota
Bergh, Paul Sigvar	Eng	Honolulu, Hawaii
Bevan, James Wetherell	Sci	Ogden, Utah
Bishop, Robert Carskaddan	Eng	Muscatine, Iowa
Blight, Arthur Frederick, Jr.	Sci	South Pasadena
Blumenthal, William David	Sci	Los Angeles
Bowen, Dwain Burns	Sci	Los Angeles
Bowen, John Thomas	Eng	Los Angeles
Brockman, John A., Jr.	Sci	Reno, Nevada
Brown, Charles M., Jr.	Eng	Hollywood
Bruce, Victor Gardiner	Eng	Los Angeles
Cannon, George Richards	Sci	Salt Lake City, Utah
Carr, Earle Albert	Eng	Lone Pine
Carter, Claude LeVerne	Eng	Santa Monica
Clark, Robert John	Eng	Glendale
Cobb, Alfred Burl, Jr.	Sci	Cut Bank, Montana
Cohn, George Irving	Eng	Lake Forest, Illinois
Cox, Richard Horton	Eng	Eleele, Kauai, Hawaii
Critchlow, Arthur Jess	Sci	Alhambra
Cunningham, Robert Ernest	Sci	Beverly Hills
Curtis, Thomas Grey	Eng	Los Angeles
Davis, Stewart	Eng	Kingston, Pennsylvania
*Densmore, Robert Earl, Jr.	Sci	Inglewood
DeVault, Robert Tenney	Eng	Arcadia
Dixon, John Kerner	Eng	Chicago, Illinois
Drake, John Archibald	Eng	Pasadena
Driscoll, Robert Bruce	Sci	Hood River, Oregon
Dubbs, Clyde Andrew	Eng	Los Angeles
Edmund, William James	Sci	Santa Cruz
Elliott, Thomas Davidson	Eng	Eagle Rock
Ellis, Joe Walter	Eng	Pasadena
Elmer, David Arthur	Sci	South Pasadena
Ersöz, Ali Muzaffer	Sci	Istanbul, Turkey
Felberg, Fred Hartman	Eng	Monrovia

‡Deceased, November 23, 1939.

Name	Course	Home Address
Fiul, Abraham	Sci	Hoboken, New Jersey
Fleck, Frank Andrew	Sci	Jackson, Mississippi
Foster, William Wright	Eng	Santa Monica
Fox, Thomas Warren	Sci	Palo Alto
Franzini, Joe Bernard, Jr.	Eng	Pasadena
Gayer, Martin Roger	Eng	Santa Monica
Geib, Elden Ray	Sci	Redlands
Gillette, Warren	Sci	Los Angeles
Glenn, Alfred Hill	Sci	Pomptain Plains, New Jersey
Glover, Patrick Norman	Sci	Los Angeles
Green, Howard Lewis	Sci	London, England
Greenwood, Robert	Eng	Pacific Palisades
Grossberg, Allan Louis	Sci	Helena, Montana
*Grossberg, Arnold Lewis	Sci	Los Angeles
Harris, John Sterling	Sci	Oklahoma City, Oklahoma
Hatcher, David Sheridan	Eng	South Pasadena
Haupt, Laurence Oliver, Jr.	Eng	Hanford
Head, Alfred Benjamin	Eng	Waddell, Arizona
Hedrick, Langdon Clyde	Eng	Seattle, Washington
*Hendrickson, Willard James	Sci	Battle Creek, Michigan
Herrmann, Theodore	Eng	Pasadena
Hicks, William Berkeley	Eng	Berkeley
*Hill, David Lawrence	Sci	Corinth, Mississippi
*Holser, William Thomas	Eng	Moorpark
Holzman, George	Sci	Los Angeles
Hovey, Serge	Sci	Beverly Hills
*Howton, David Ronald	Sci	Glendale
Hunt, Carter	Sci	West Los Angeles
*Irving, Jack Howard	Sci	Los Angeles
*Jacobson, Homer	Sci	Los Angeles
*Jerrems, Alexander Stapler	Eng	Kansas City, Missouri
Johnson, Philip Ord	Eng	Los Angeles
Jones, John Alastair	Eng	San Francisco
Kafitz, Peter Henry	Sci	Glendale
Kashiwabara, Naomi	Eng	Los Angeles
Kendall, George Alden	Eng	San Gabriel
*Kennedy, William Grady	Eng	Hobbs, New Mexico
LaForge, Gene Rolfe	Sci	Pasadena
Larson, Erwin Raymond	Eng	South Pasadena
Lawrence, Harvey John, Jr.	Sci	Los Angeles
LeFever, Ralph Raymond	Sci	Hollywood
Lesser, Murray Leon	Eng	Glendale
Lind, George William, Jr.	Eng	Portland, Oregon
Lutz, Philip Brooks	Eng	Aberdeen, Washington
*MacKenzie, Robert Earl	Sci	Los Angeles
MacRostie, Wayne	Eng	Santa Barbara
Mader, Paul Miller	Sci	Los Angeles
Maguire, George Herbert	Eng	Hollywood
Marshall, Boyd Thomas	Eng	Rock Springs, Wyoming
Mayer, Adrian Sherman	Sci	Pasadena
McClain, John Franklin, Jr.	Eng	Coronado
McCornack, Richard William	Eng	Elgin, Illinois
McGirk, Lon Soland, Jr.	Sci	El Monte

Name	Course	Home Address
McKibben, Paul Stilwell	Eng	Los Angeles
McLain, Earl Anderson	Sci	Sacramento
Menard, Henry William	Sci	Los Angeles
Merrick, Robert Tresilian	Sci	Huntington Park
*Miles, John Wilder	Eng	Oakland
Miller, Herman	Eng	Long Beach
Mitchel, Walter Page	Eng	Kansas City, Missouri
Moore, Robert Layton	Eng	Los Angeles
Noble, Edward Dodds	Sci	Yuma, Arizona
Osborne, Herbert George	Eng	Arcadia
Paul, Albert D.	Eng	Cedar Falls, Iowa
Pearson, Charles William	Eng	San Marino
Piatt, Alvin Ray	Eng	Long Beach
Pichel, Pichel Wilson	Eng	La Canada
Price, Harrison Alan	Eng	San Bernardino
Proctor, Warren George	Eng	Long Beach
*Rhyne, Russell Foote	Sci	Valley Center
Ridland, Alexander Charles	Sci	Flintridge
Roese, Henry Valentine	Eng	Los Angeles
Rubel, John H. W.	Eng	Los Angeles
Sabersky, Rolf Heinrich	Eng	Los Angeles
*Savit, Carl Hertz	Sci	Burbank
Saye, Roland Stanley	Eng	Venice
*Schneider, Arthur J. R.	Eng	Alameda
Schureman, Kenneth Danforth	Eng	Santa Monica
*Seegman, Irvin Phillip	Sci	Hollywood
Seibel, Charles McCutchen	Eng	Wichita, Kansas
Shapiro, Haskell	Eng	Los Angeles
Smith, Lawrence Wesley	Eng	Altadena
Smith, Marcius Curtis	Sci	Los Angeles
Staley, Robert Ross	Sci	Tulsa, Oklahoma
Steele, Harry Max	Sci	Glendale
Stone, Jack Dell	Sci	Los Angeles
Taylor, Thayle Flandars	Eng	Laguna Beach
True, Leighton, Jr.	Sci	Van Nuys
*Truesdell, Clifford Ambrose	Sci	South Pasadena
Turner, William Russell	Eng	Salt Lake City, Utah
Urbach, Kenneth	Eng	Seward, Alaska
Van Ness, Everett Willard	Sci	Los Angeles
Veronda, Carol McCauley	Eng	San Marino
Webster, Paul Winston	Eng	Santa Monica
Weiler, Harry Burkhart	Sci	North Hollywood
Weller, LeRoy Ashton, Jr.	Eng	Upland
Willits, Ralph Milton	Eng	Wrightwood
Wilmoth, Robert Carlyle	Sci	Burbank
Wilson, Webster DeLong	Sci	Oakland
Wood, Frank William	Eng	Huntington Park
Woods, Gordon Keaton	Eng	Bellingham, Washington
Wyckoff, Donald Mackenzie	Eng	Canoga Park

FRESHMAN CLASS

Name	Home Address
Adams, John Walker	Wayzata, Minnesota
Allen, James Stewart	Ogden, Utah

Name	Home Address
Allingham, John Wing	Los Angeles
Alpert, Leonard Stamm	Buffalo, New York
Anderson, Jack Cassells	Los Angeles
Anspach, Kenneth Eldred	Glendale
Arnold, David Rice	Los Angeles
Atkins, Earle Richardson, Jr.	Whittier
Bacon, John William, Jr.	Hermosa Beach
Barlow, Griffith Chaffin	Los Angeles
Barrow, Cran Hardin	Odessa, Texas
Bashor, Robert Horace	Los Angeles
Bauer, John Russell	Millbrae
Beckstead, Maurice Webster	Carpinteria
Beebe, Walter Bowne	Portland, Oregon
Begovich, Nicholas Anthony	San Francisco
Bell, Harold	Cleveland, Ohio
Bennett, Robert Laurance	Long Beach
Bewley, John Walter	Lodi
Bishop, Amasa Stone	Novelty, Ohio
Blayney, James Arthur	Fowler
Bracken, Glenn Russell	Long Beach
Bradley, Harold Herbert	Alhambra
Bragg, Robert Melvin	Fowler
Briglio, Anthony, Jr.	Los Angeles
Brown, Glenn Harold, Jr.	Alhambra
Brown, Wayne Harold	Los Angeles
Buchanan, George Albert	Saskatoon, Saskatchewan, Canada
Buchanan, John William	Los Angeles
Buettell, Theodore Dwight	Mitchell, South Dakota
Bunker, Earle Robert	Alhambra
Calkins, John Bartlett	Spokane, Washington
Cassell, John Kelty	Pasadena
Chalmers, James Ferguson	La Jolla
Chase, Patrick Stanley	Pasadena
Christianson, Warren Lindsey	Riverside
Clayton, Roderick Keener	Pasadena
Dauwalter, Chadwick Schuyler	Pasadena
Dazey, Mitchell Harding	Santa Monica
Dewdney, Harold Stuart	Penticton, British Columbia, Canada
Douglas, David Lewis	Brooklyn, New York
Dunn, Stanley Austin	Laguna Beach
Engle, Paul Randal	Des Moines, Iowa
Enikeieff, Oleg Constantine	Kobe, Japan
Fair, William Rodden	San Francisco
Farmer, Howard Norman, Jr.	Fallbrook
Flavell, Edgar William	Glendale
Fleischer, Edward Paul	Oxnard
Francis, Robert Milton	Santa Ana
French, John Martin	Phoenix, Arizona
Frey, George Comfort	Hermosa Beach
Frost, Robert Carlson	Milwaukee, Wisconsin
Gardner, Arthur Henry	Bell
Garner, Harold Karl	Delano

Name	Home Address
Giacomazzi, William Francis	San Jose
Goetze, Klaus Robert	Los Angeles
Graner, Jesse Blaine	Hollywood
Granicher, Donald Irving	San Francisco
Griffith, George Durward	Anaheim
Grimm, Lewis Leroy	Yorba Linda
Grote, Albert Otto	Wilmington
Gruen, Harold	Los Angeles
Gustavson, Robert Gordon	Altadena
Halpenny, William Herbert	Riverside
Hanchett, Hollis Kermit	Inglewood
Hann, John Philip	West Los Angeles
Harshaw, William Andrew	Cleveland, Ohio
Hartnell, Doan Melville	Hammond, British Columbia, Canada
Haymond, Dexter Carl	Tacoma, Washington
Hedstrom, Donald Edward	Long Beach
Hodder, Wayne Kassell	Glendale
Hubay, Paul William	New Britain, Connecticut
Hull, James Byrne	La Jolla
Johns, Robert Ralph	Los Angeles
Johnsen, Edwin George	Reedley
Johnson, Kenneth Wolcott	Palo Alto
Jones, Lawson Wendell	Hollywood
Kincaid, Freeman Mills	Santa Monica
King, Arthur Godwin	Buckeye, Arizona
Klein, David Joseph	Los Angeles
Koehler, Carl David	Ainsworth, Iowa
Kott, Warren Orvil	Los Angeles
Larson, Robert LaFollette	Pasadena
Lassen, Herbert Arthur	Van Nuys
Latter, Richard	Beverly Hills
Lawrence, Theodore Gibson	Los Angeles
Lee, Thomas Seymour	Menlo Park
LeVine, Robert Paul	Belle Harbor, New York
Lingle, Harrison Church	Evanston, Illinois
Loftness, Robert Leland	Tacoma, Washington
Luce, Ralph Waldo	San Diego
Macartney, Everett Jesse	Los Angeles
Marsh, Richard Edward	Redlands
Marshall, Ralph Waldo, Jr.	Mentor, Ohio
Martin, Franklin Townsend	Winslow, Arizona
Mason, David Malcolm	Los Angeles
McCoubrey, Arthur Orlando	Los Angeles
McDougall, Charles Henry, Jr.	Evanston, Illinois
McGee, Charles Gilbert	Hudson, Ohio
McWethy, Richard Edwin	Aurora, Illinois
Mead, Orin Johnson	Boulder City, Nevada
Merritt, Melvin Leroy	Portland, Oregon
Mitchum, William Robson	Beverly Hills
Morgan, Samuel Pope, Jr.	Casa Grande, Arizona
Morris, Deane Northrup	Los Angeles
Mylander, Gerald Dwane	Huntington Park

Name	Home Address
Nahas, Robert Theodore	Pasadena
Nevill, Benjamin	Los Angeles
Peltier, Eugene Paul	Santa Barbara
Peterson, John Edvin	Los Angeles
Pettit, William Alfred	South Pasadena
Ploeser, James McTague	Beverly Hills
Potts, Donald Harry	Seattle, Washington
Powers, Wesley Grayson	Pasadena
Powlesland, Kenneth Lee	San Fernando
Quan, Andrew Sydney	Oakland
Rambo, Lewis William	Los Angeles
Ree, William Russell, Jr.	Saticoy
Rhoades, Rex Vance	Seattle, Washington
Rice, Richard Frank	Mill Valley
Richards, Virgil Hanson, Jr.	San Gabriel
Richardson, David Bonner, Jr.	Los Angeles
Robinson, Stephen Bernard, Jr.	San Marino
Rolph, William Donald	National City
Russell, William Julius, Jr.	Minneapolis, Minnesota
Safanov, George Michael	Pasadena
Sandell, Wesley Robert	Van Nuys
Schamberg, Richard	Los Angeles
Schofield, Richard McMillan	Sacramento
Sheldon, David Butterfield	Los Angeles
Sherwin, Robert Mitchell	Batavia, New York
Shonerd, David Edwin	Inglewood
Sigworth, Harrison William	Long Beach
Simmons, Robert Wilson	Pasadena
Simon, Hubert Ernst	Nice, France
Snyder, William	Van Nuys
Spencer, Jack Raymond	Los Angeles
Steinle, Shelton Edward	Glendale
Strickland, Charles Percival	Santa Paula
Summerhays, Keith Stirling	Los Angeles
Tedrick, Ray Adams	Lore City, Ohio
Tenney, Frederick Haworth	Ridgewood, New Jersey
Terrell, Oscar David	Pasadena
Thiene, Paul George, Jr.	Pasadena
Thompson, William Charles, Jr.	Alhambra
Tileston, Peter Ayer	New Haven, Connecticut
Townsend, Jerry Slade	Columbus, Georgia
Vordermark, Jonathan Sawyer	Altadena
Waterfall, Gerald Malan	Ogden, Utah
Watson, Thomas Woodrow	La Crescenta
Weir, Kenneth Owen	Portland, Oregon
Wheeler, Edward Anderson	Pasadena
Wheelock, Wayne Sanborn	Los Angeles
Whitehill, Jack	Idaho Falls, Idaho
Wilcox, Philip Edwin	Eagle Rock
Wittig, Paul Karl	Rochester, New York
Wright, Palmer Winslow	Santa Monica
Young, James Arthur, Jr.	Seattle, Washington
Young, Joseph Frederic	Los Angeles

SUMMARY

GRADUATE SCHOOL

RESEARCH FELLOWS

American Petroleum Institute Fellow	1	
Asphalt Institute Fellow	1	
Civil Aeronautics Authority Research Fund Fellow	1	
Cooperative Agent, U. S. Weather Bureau	1	
Hale Fellow	1	
Hawaiian Pineapple Producers Cooperative Association Fellow	1	
Hixon Fund Fellow	1	
International Research Fellow of the Rockefeller Foundation	1	
National Research Fellows	2	
Noyes Fellows	2	
Research Fellows of the Institute	22	
Sino-British Boxer Indemnity Fund Scholar	1	
Soil Conservatory Service, Department of Agriculture, Fellow	1	
		36
Research Assistants of the Institute		34
		70

GRADUATE STUDENTS

Aeronautics	49	
Biology	20	
Chemistry	42	
Chemical Engineering	5	
Civil Engineering	13	
Geology	23	
Electrical Engineering	20	
Humanities	1	
Mechanical Engineering	22	
Meteorology	18	
Mathematics	10	
Physics	49	
		272

UNDERGRADUATE SCHOOL

Seniors	157	
Juniors	151	
Sophomores	146	
Freshmen	159	
		613
Total Number of Students		885

COURSES AND OPTIONS OF UNDERGRADUATE STUDENTS

	Seniors	Juniors
SCIENCE COURSE		
Biology	5	3
Chemistry	9	11
Applied Chemistry	20	24
Geology	13	10
Mathematics	0	2
Physics	12	10
Applied Physics	6	4
Total	65	64

ENGINEERING COURSE		
Aeronautics	12	17
Civil	10	7
Electrical	29	31
Mechanical	41	32
Total	92	87

INDEX

California Institute of Technology
PASADENA, CALIFORNIA