History of Chemical and Biological Engineering at Colorado School of Mines, 1944-2019

History of Chemical and Biological Engineering at Colorado School of Mines, 1944-2019

by
E. Dendy Sloan, Ph.D., P.E.
and
Charles R. Vestal, Ph.D., P.E.

Colorado School of Mines
Golden, Colorado

October 2019

History of Chemical and Biological Engineering at Colorado School of Mines
1944-2019

By E. Dendy Sloan and Charles R. Vestal
Book and Cover Design by Elizabeth Youssef

Cover Photos: (Upper left) The 1959 Student AIChE Chapter; (Lower left) Inaugural Professors Ball (L) and Lemaire; (Right) Students working on the Unit Operations Laboratory distillation column during the summer field session.

Printed in the United States of America

First printing: 2019

ISBN: 9781704777146

Table of Contents

Acknowledgements

Many members of the CBE family contributed to this history, beyond their normal assigned duties. Their help is largely responsible for this "by the family, and for the family" work and is gratefully appreciated.

The authors thank Dr. Anuj Chauhan, Chemical and Biological Engineering Department Head, for his encouragement and support in writing this book. Department staff including Kim Luzeckyj, Department Manager, Jennie Gambach, Student Services Coordinator and Savannah Henderson, Office Manager contributed information and support.

Families of Dr. Philip Dickson and Dr. Arthur Kidnay contributed photographs and memorabilia. Dr. Frank Stermole and his wife Dot contributed much information about the early years of the Gary and Dickson department heads. Dr. John Golden and his wife Lynne also contributed information about the early years and the startup of the Abu Dhabi Petroleum Institute. Past department head Dr. Bob Baldwin and Adjunct Professor Bruce Palmer also contributed information and photographs about the Abu Dhabi Petroleum Institute.

Past Department Heads Dr.Bob Balwin, Dr. Jim Ely, Dr. Dave Marr, Dr. Colin Wolden, Dr. Carolyn Koh and Dr. Jennifer Wilcox all contributed information and critiques of their respective chapters.

Current faculty members made significant contributions:

Angel Abbud-Madrid: CBE in Space
Annette Bunge: Women at Mines
Cynthia Norrgan: Tribute to Paul Ogg
Jason Ganley: Unit Operations Laboratory
Josh Ramey: Studio Biology Laboratory
Michael Barankin: Unit Operations Laboratory
Ron Miller: Engineering Education
Tracy Gardner: Unit Operations Laboratory, and [Chemical] Engineering Students

Former faculty member Victor Yesavage wrote the tribute to Sami Selim and much of the biography of Phil Dickson, Judy Schoonmaker wrote part of the Studio Biology Laboratory section and Barbara (Selim) Fagan wrote about the Mardi Gras celebration during the Ely Years.

Special thanks to our hard-working students:

Denali Iboson: Graduates data
Elizabeth Youssef: Book and Cover Design and book production
Jonathan Marchant: Curricula data
Jordan Eldredge: Graduates data
Kelsey Hoon: Graduates data

A special thank you to our capable editors Dr. Bruce Palmer and Dr. Fritz Bart

Foreword

by: Anuj Chauhan

As a new Department Head I am frequently asked to articulate my vision for the future of the Chemical Engineering and Biological Engineering Department (CBE) at the Colorado School of Mines. I usually manage to cobble together a few sentences about improving both the graduate and the undergraduate program, and increasing alumni outreach to present a coherent vision. However, on the nights that I have trouble sleeping due to the extraordinarily large amount of coffee that I consumed during the day, I have wondered about the same question. To formulate a vision for the future, I believe one must understand the past, and it was with that selfish agenda in mind that I discussed with Dendy Sloan the possibility of putting together this book about the history of the Chemical and Biological Engineering Department at the Colorado School of Mines. Co-author Charles (Chuck) Vestal has been integral to this project as well, for his formulation of book concepts and organization of the vital data: the graduates list, the curricula, and the faculty Curricula Vitae.

Our vision for this book was that it should be "by the CBE Family and for the CBE Family." During my first few months as the Department Head, I have greatly enjoyed the warm and cordial atmosphere in our department and the feeling of a family that comes with it. It is sometimes easy to get lost in the rubrics of departmental rankings, graduation rates, program size, and forget the importance of the departmental climate for success of the faculty, staff, and the students. To preserve the amazing climate that we have in our department and to grow it even further is a part of my vision, and I hope this book will help us in achieving that. Our alumni are an integral part of our family, and as our former students read this book, they will hopefully reminisce about their times at Mines and learn more about the history of the department. As our friends and colleagues read this book, hopefully they will enjoy learning about the history of our profession as well as the unique and rather entertaining story of how our department came to be. This book also presents the evolution of the department from the inception to the present, with a separate chapter devoted to the years served by each of the Department Heads.

Colorado School of Mines has always taken great pride in providing exceptional hands-on training integrated into a rigorous curriculum. All our former students will certainly remember the six summer weeks that they spent in the field session in the Unit Operations Laboratory, hopefully with some fondness, even if mixed in with some antipathy. Although the laboratory looks very different today, the experience and the rigorous training remains the same. In all my conversations with alumni, two items almost universally come out – field session and faculty. Our dedicated faculty have had an amazing influence on the thousands of students that have graduated from our department since 1947, as evident from the selected alumni letters included in this book.

On behalf of our Chemical and Biological Engineering family, I thank both Dendy and Chuck for putting together this marvelous book, which has all the ingredients of a bestseller. It may not make it to the *New York Times Bestseller List*, but I do feel certain that you will greatly enjoy reading it.

Preface

by: E. Dendy Sloan and Charles R. Vestal

In anticipation of the 150th anniversary of the Colorado School of Mines (2024) we have been asked to write a history of the Chemical and Biological Engineering Department. Formed in 1944 with J.O. Ball as the Department Head, the department split from the then Petroleum Department and was renamed as Petroleum Refining Engineering. Since that time, there have been seven Department Heads, several department name changes, and significant changes in the Chemical and Biological Engineering curriculum. There have been 4900+ graduates of the department, listed in Appendix I.

As we enter the 75th year of the department, we will tell the background story of chemical engineering, the department, the faculty, the staff, the alumni, and the students who make up this 'family' at CSM. We address this with major chapters for each of the Department Heads.

Table 1 is a timeline showing details of development of the State of Colorado, the school, and the department. We are grateful that many department colleagues have contributed to this history, shown on the Acknowledgements page vii. However, we accept all errors as our own, citing the astute observation by Francis Bacon[1], "Truth emerges more readily from error than from confusion."

E. Dendy Sloan, Ph.D., P.E.
University Emeritus Professor
Chemical and Biological Engineering Department

Charles R. Vestal, Ph.D., P.E.
Emeritus Teaching Professor
Chemical and Biological Engineering Department

October 2019

---

[1] *Novum Organum* Vol. VIII of *The Works of Francis Bacon*, ed. J. Spedding, R.L. Ellis, and D.D. Heath, p210, New York, 1969.

Table 1: Chemical and Biological Engineering Timeline

with input from Eckley, W., Rocky Mountains to the World: A History of the Colorado School of Mines, (pp.9-11) Donning Company Publishers, Virginia Beach,Va. (2004)

1859 – Gold discovered in Colorado
1866 – Bishop George Randall arrives in Denver as Episcopal missionary to Colorado Territory
1872 – Randall begins construction of Mining School
1873 – Mining school opens for classes
1874 – Mining school becomes Territorial School of Mines, with E.J. Mallett, Professor-in- Charge (PIC). Official beginning of Colorado School of Mines
1878 – Jarvis (preparatory) and Matthews (divinity) destroyed by fire. Mines moved to downtown Golden. M.Moss appointed PIC.
1880 – 1st classes in new campus building. A.C. Hale appointed PIC, then President
1883 – 1st commencement (W.Wiley and W.Middleton 1st degrees) R.Chauvenet appointed President
1888 – Football at Mines. Miners win State Championships 1889 to 1903
1890 – 2nd addition to original Mines bldg. to include library, auditorium and gym
1894 – 2nd Bldg (Hall of Engineering) completed at Mines
1898 – F. Caldwell is 1st woman to receive Mines degree
1903 – V.C. Alderson appointed President; dismissed 1913
1904 – Stratton Hall (3rd) Building Completed
1906 – Guggenheim Hall (administration) built with $100K from Simon Guggenheim
1908 – "M"blem completed
1913 – W. Phillips appointed President
1917 – H.C. Parmalee appointed President. V.C. Alderson re-appointed President; dismissed 1925
1925 – M.F. Coolbaugh appointed President
1929 – Petroleum Engineering Department begun; 2 profs combine production and refining
1944 – Petrol. Eng. Dept. divided to initiate Petroleum Refining Engineering Dept. (2 PRE Profs.: Ball (Head) and Lemaire)
1946 – B.H. Parker appointed President
1947 – Initial PRE graduates: 11 undergraduates and 2 M.S. Students
1949 – Three PRE profs: J.O. Ball, G.H. Lemaire, and Hugo Geissler
1950 – John W. Vanderwilt appointed President
1953 – Alderson Hall ($1.25 million) completed for Petroleum and Petroleum Refining
1955 – Mines has 6 degrees (all engineering): 1)geology, 2) geophysics, 3) metallurgy, 4) mining, 5)petroleum, and 6) petroleum refining (PRE)
1956 – ABET accredits PRE as Chemical Engineering
1957 – Tuition/semester: $117.50/$275 = resident/non-resident
1960 – Jim Gary named PRE head: PRE has 3 profs (Gary, Lemaire, Morgan) and 1 lab assistant
1962 – PRE curriculum is approved by AIChE
1963 – Orlo Childs appointed President. Gary hires Phil Dickson and Frank Stermole
1965 - Tuition/semester: $150/$400 = resident/non-resident
1965 – Renamed Chemical and Petroleum Refining Engineering (CPR)
1967 – John Golden and Elwyn Shimoda hired
1968 – Art Kidnay hired
1969 – CPR has 6 profs (Gary, Dickson, Golden, Kidnay, Shimoda, Stermole) and 1 research assistant (John Thomas)
1970 – G.T. McBride (Chemical Engineer) appointed 13th President
1972 – Dickson and Gary become Dept Head and VP for Acad Affairs, respectively.
1972 - Richard Robinson hired (72-74)
1973 - Vic Yesavage hired. Tuition/semester: $228/$911 for resident/non-resident
1974 – Ron Miner joins department as Research Technician

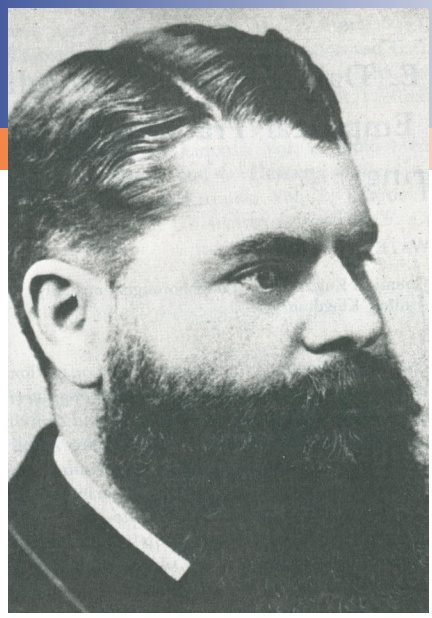
Table 1 (continued)

1975 –Tony Hines hired
1976 – Dendy Sloan and Bob Baldwin hired
1977 –Mike Graboski hired. *Future Graduate Profile* describes educational goals
1978 - Mike Jones hired
1981 – Annette Bunge (1st woman CPR faculty) hired as an Assistant Prof. and Jim Ely Hired as Adjunct Associate Prof
1982 – Sami Selim hired (deceased 2000)
1983 – Phil Dickson dies
1984 – G.S. Ansell appointed President. Kidnay becomes Department Head
1985 – Chemical and Petroleum Refining is renamed Chemical Engineering and Petroleum Refining (CEPR)
1986 – Annette Shine hired as an Assistant Prof. (departed 1988); Ron Miller hired (Assistant Prof.); Paul Bryan hired as an Assistant Prof. (departed 1989)
1988 – Faculty Senate formed. No-confidence vote in administration
1989 – Dendy Sloan named inaugural Weaver Chair in CEPR
1990 – Bob Baldwin becomes Department Head; Art Kidnay becomes Graduate Dean
1991 - Jim Ely (Prof) and Tom McKinnon (Adjunct Prof) hired
1992 – Alderson Hall renovation (classrooms and new research wing) completed
1993 – John Dorgan (Assistant Prof) and Doug Way (Research Prof) hired
1995 – David Marr hired as an Assistant Prof
1995 – Coady Computer Laboratory established
1996 - David Wu hired as an Assistant Prof (joint appointment with Chemistry)
1997 - Colin Wolden (Assistant Prof) and John Persichetti (Lecturer) hired
1998 – Chuck Vestal hired as Adjunct Assistant Prof. T. Bickart appointed President. CSM endowment exceeds $100 million
2000– Tony Dean hired as inaugural W. K. Coors Chair; Andy Herring hired as an Assistant Prof.
2001 – Jim Ely becomes Department Head; John Trefny appointed President;
2002 – Abu Dhabi Petrol. Inst. inaugurated by Mines; Clare McCabe hired as an Assistant Prof.; B. Selim hired as Administrative Asst.; Renamed Chemical Engineering Department
2003 – Mike Staddick hired as Laboratory Manager
2004 – Carolyn Koh hired (Associate Prof.); Tracy Gardner and Cynthia Norrgran hired as Assistant Teaching Profs.
2005 – Sumit Agrawal and Matt Liberatore hired as Assistant Profs.
2007 - Hugh King transferred as Teaching Prof. to CBE from Math and Computer Sciences; Paul Ogg hired as an Assistant Teaching Prof.
2008 – Amadeu Sum and Keith Neeves hired as Assistant Profs.
2009 – Rachel Morrish hired as an Assistant Teaching Prof.
2010 - David Marr named Dept Head; Ning Wu and Mark Maupin hired as Assistant Profs.; Judy Schoonmaker hired as Adjunct Lecturer; Computer lab renovated
2011 – Renamed Chemical and Biological Engineering Department
2012 – Melissa Krebs hired as an Assistant Prof.; Jason Ganley hired as Associate Teaching Prof.; Alderson Hall becomes mostly Chemical Engineering
2013 – Nannette Boyle hired as an Assistant Prof.; Josh Ramey hired as Adjunct Assistant Teaching Prof.
2014 – Kevin Cash hired as an Assistant Prof.; Moises Carreon hired as Associate Prof.
2015 – P. Johnson (Chemical Engineer) becomes Mines 17th President
2016 – Jennifer Wilcox hired as Associate Prof.; Diego Gómez-Gualdrón and Joseph Samaniuk hired as an Assistant Profs.; Michael Barankin hired as an Assistant Teaching Prof.
2018 – A. Chauhan hired as Department Head; Justin Shaffer hired as Teaching Associate Prof.; Jon Peters hired as Machine Trades II

Introduction: The Beginning of Chemical Engineering

This is a summary of U.S.A. Undergraduate Chemical Engineering Education through 1960 (when our second Department Head, J.H. Gary arrived). Because the Mines Chemical and Biological Engineering Department had its beginnings relatively late, in 1944, we begin this book with a brief summary of the development of Chemical Engineering in the United States, where the inaugural department was started in 1905. By showing the changes in undergraduate education through five decades, we hope to set the stage for the reader, and indicate that by our department's late startup, we obviated some of the initial growing pains of the Chemical Engineering Education profession.

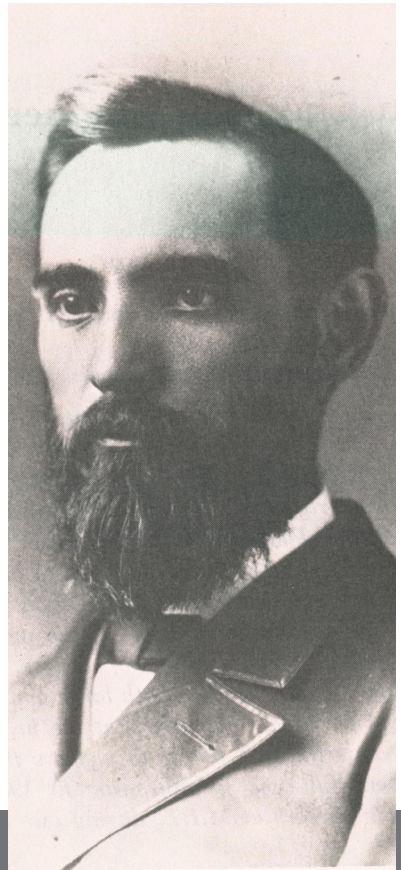
Chemcial Engineering Orgins



Manchester's George E. Davis

Chemical Engineering had its origins in the 18th and 19th centuries in France and Germany as applied chemistry, although some might say the discipline began with alcohol distillation in Mesopotamia about 5,000 years ago. Many early U.S.A. Chemical Engineering professors obtained training and degrees in Europe, in such universities as Göttingen and Heidelberg, with Industrial Chemistry professors. Two of the famous Göttingen Applied Chemists were F. Strohmeyer (1775-1835) and R. Bunsen (1811-1899).

The English Professor George E. Davis coined the term 'Chemical Engineering' in 1880. He defined the discipline of Chemical Engineering in a series of lectures at the Manchester Technical School in 1888, and published *A Handbook of Chemical Engineering* in 1901 (3). Professor Lewis Norton (1855-1893) at the Massachusetts Institute of Technology (MIT) is given credit for starting Chemical Engineering courses by writing a Chemical Engineering chapter in his text *Outline of Industrial Chemical Engineering*. The first four-year undergraduate Chemical Engineering curriculum was established at MIT by Chemistry Professor Norton in 1888, although that curriculum was in the Chemistry Department until the Chemical Engineering Department was established in 1920 (10).



MIT Professor Lewis Norton

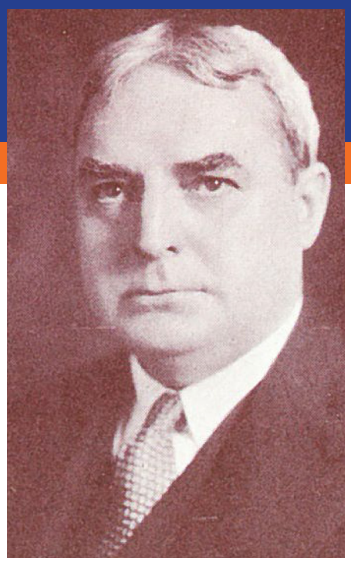
The First Chemical Engineering Department

Wisconsin's Olaf Hougen

The first Chemical Engineering Department was inaugurated at the University of Wisconsin in 1905. In legendary Chemical Engineering Professor Olaf Hougen's Wisconsin undergraduate years (1911-1915) there were no courses in unit operations (a term coined by Arthur D. Little in 1915), none in material and energy balances, none in Chemical Engineering thermodynamics, kinetics, transport phenomena, or process design. No math went beyond calculus, and the slide rule was both an exciting novelty, and the upper limit of computing facilities. In 1907 Chemical Engineering was 99% art and 1% science. There was no integration between Chemistry, and mostly Mechanical Engineering. "Our instruction… consisted in trying to solve individual, independent, trouble-shooting problems through literature search and experiments of our own devising." (5)

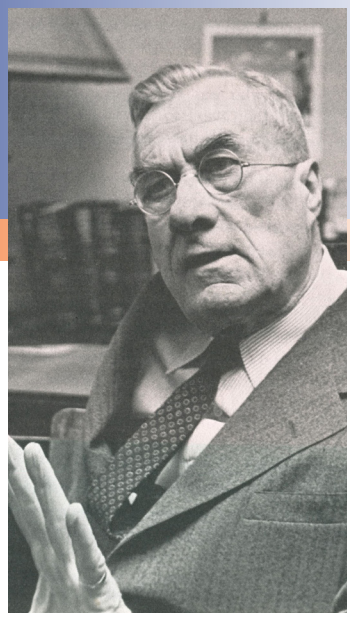
In 1967 Hougen estimated the solution to many industrial problems was still 50% art. "Successful solutions of industrial problems depend upon engineering judgement and experience with the unknown and undocumented areas of science as well as upon principles that have already been well established, This divergence of responsibilities is the principal distinction between the scientist and the engineer." (5)

In 1908 the American Institute for Chemical Engineers (AIChE) was established with 40 members out of a possible 500. By 1914 AIChE had expanded to 214 members. The 1967 AIChE membership was 28,000 - a 700-fold increase (5). In 2019 there are over 60,000 AIChE members.



Professor Whittaker was the 1914 AIChE President

Some early Chemical Engineering heroes were W.K. "Doc" Lewis, (MIT), G.G.Brown (Michigan), Olaf Hougen (Wisconsin), Neal Amundson (Minnesota) and Allan Colburn (Delaware). Other universities which initiated a four-year curriculum in Chemical Engineering were Pennsylvania (1894), Tulane (1894), Michigan (1898), and Tufts (1898), but these curricula were always part of Chemistry departments.



MIT's "Doc" Lewis was a Ph.D. Advisor to Mines' President G.T. McBride

One of the most powerful early influences was Professor Whittaker, who became the 1914 President of AIChE. He obtained his Ph.D. in Chemistry from Columbia University (1902), and studied with Professor Sachs at Heidelberg. He believed in the rapid separation of Chemical Engineering from the previous incorporation in Industrial Chemistry. However, the full separation of Chemical Engineering was not accomplished until the 1950's, with the arrival of professors like Amundson and Aris at Minnesota, and Bird, Stewart, and Lightfoot at Wisconsin.

As an example Professor Whittaker's academic tree went as follows (each arrow [--->] indicates a student of the previous professor): Whittaker (Columbia) ---> Leslie (Michigan) ---> G.G. Brown (Michigan) ---> Warren McCabe (MIT). Until 1955 MIT and Michigan were considered the finest Chemical Engineering graduate programs in the U.S.A. (10).

"The log-jam retarding the development of Chemical Engineering education was broken in 1923 with the publication of the classical text *Principles of Chemical Engineering*, by Walker, Lewis and McAdams. As stated by Professor Lewis, the profession of Chemical Engineering "lifted the iron curtain which previously separated chemistry and engineering." (7)

Professor McCabe generated the diagram emblematic of Chemical Engineering with his advisor Thiele

60 Years of Chemical Engineering Education Changes

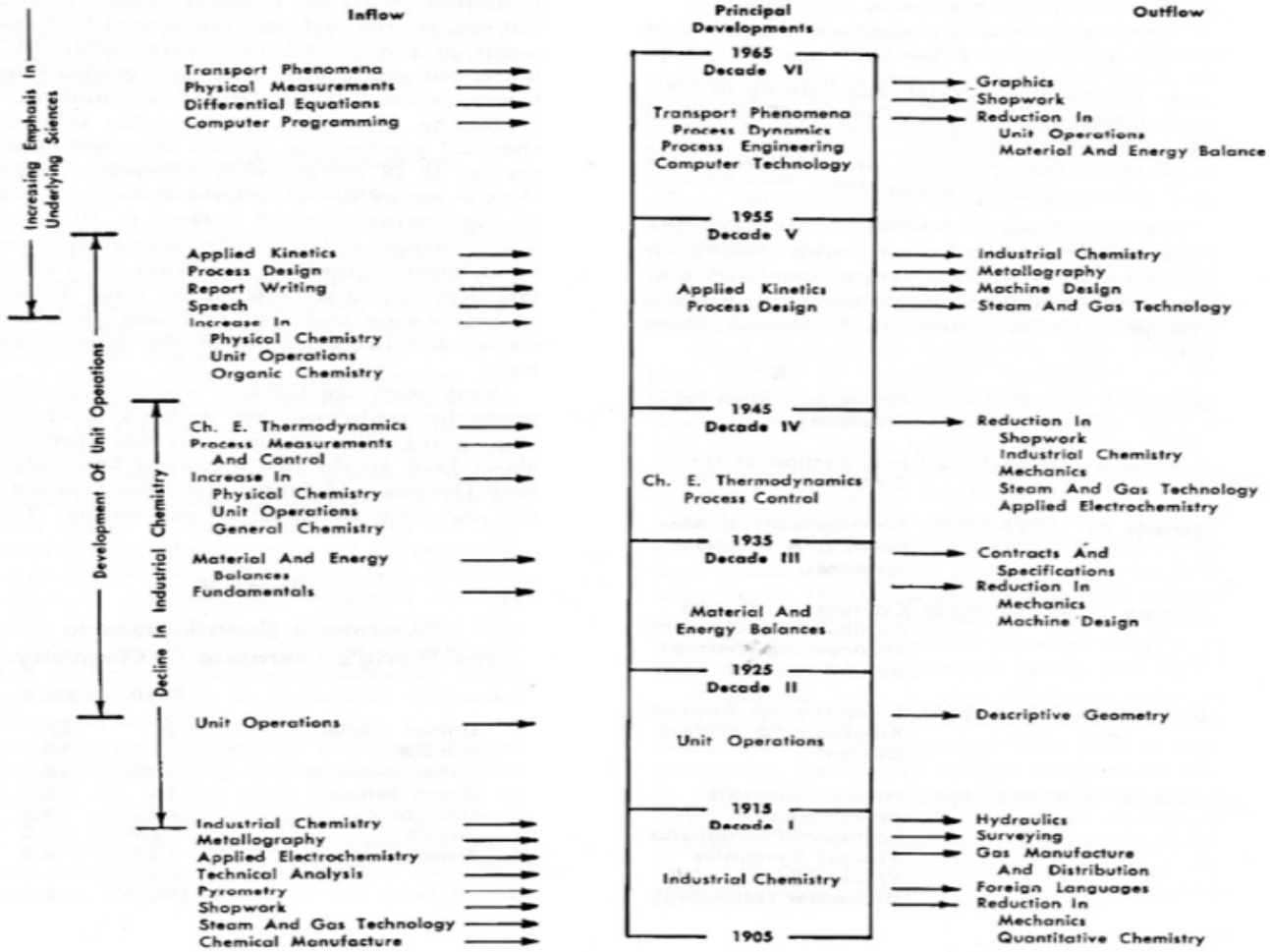
Table 1 (on the following page from Hougen (5)) provides a picture-at-a-glance of how the profession changed from 1905 to 1967 in three overlapping aspects:

1. Three major trends in the curriculum:
   - The decline in Industrial Chemistry from 1915 to 1945,
   - The development of Unit Operations from 1920 to 1955, and
   - Increasing emphasis on underlying sciences from 1950 to 1967.
2. The principal developments of each decade were:
   - 1905-1915 - Industrial Chemistry
   - 1915–1925 - Unit Operations
   - 1925-1935 - Material and Energy Balances
   - 1935-1945 - Chemical Engineering Thermodynamics and Process Control
   - 1945-1955 - Applied Kinetics and Process Design
   - 1955-1965 - Transport Phenomena, Process Engineering, and Computer Technology
3. The subject matter initiated and discarded. Refer to the columns of Table I on the following page (left: initiated; right: discarded) -these are too numerous to list in the text.

During these 60 years Chemical Engineering courses increased from 4% to 28% of the curriculum, and became "pretty much as we know it today in 2015" (3) while other engineering service courses in the Chemical Engineering curriculum decreased from 28% to 10%.

Table 1
Changes In A Typical Undergraduate Curriculum Of Chemical Engineering During 60 Years

Initial Curriculum In 1906 Consisted Of Separate Courses In Chemistry And Conventional Engineering



Language and Faculty Summer Schools

Table II

Percentage Contributions to the World's Literature in Chemistry.

	1910	1960
United States	20	27
U.S.S.R.	2.5	19
Other Nations	8.5	18
Great Britain	14	16
Germany	40	8.5
Japan	2.0	7.0
France	13.0	4.5
	100.0	100.0

Prior to World War I, leading professors in Chemistry were trained in Germany, which led the world in the development of chemical industries. In 1910 40% of the world's chemical literature was printed in German and only 34% was in English. However by 1960 those percentages had changed to 8.5% and 43% for German and English, respectively. Chemical Engineering as taught in the U.S.A. was of distinctly American origin even though its early scientific background stemmed from Germany.

In 1907 German was a required language for undergraduate students in Chemical Engineering – a requirement dropped about1920. Hougen shows Table II indicating the changes in a half century of Chemical world literature, from 1910 to 1960. With modern computer translation software (e.g., *Microsoft Translator*™), proficiency in a language other than English may be obviated (EDS).

Chemical Engineering Summer Schools were started by the Society for the Promotion of Engineering Education (later the American Society of Engineering Education [ASEE]), (4). ASEE Chemical Engineering Summer schools were usually restricted to younger faculty who applied, and the summer schools were taught by experts in both established and emerging areas.

Summer schools helped to ensure a reasonably uniform national curriculum in Chemical Engineering, along with courses in emerging areas. The first five Chemical Engineering summer schools were:

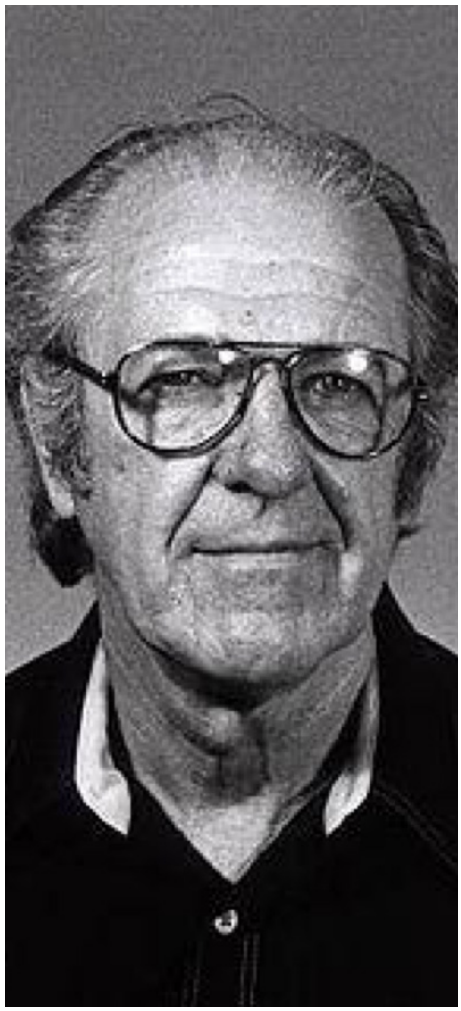
1st 1931 at Michigan
2nd 1939 at Penn State
3rd 1948 at Wisconsin
4th 1955 at Penn State
5th 1962 at Colorado

In 1959 the number of Chemical Engineering graduates in all U.S.A. universities were: B.S. (3,131), MS(591) and Ph.D.(143). (8)

Four Major Changes to Modern Chemical Engineer Education

Concluding this brief history and setting the stage for the growth of the Mines Chemical Engineering Department, Wankat and Peppas (10) note that the period from 1955 to 1965 was a period of turbulence and unrest in teaching Chemical Engineering. The turbulence came from four initiatives, together with the influx of returning soldiers from World War II and the Korean War.

1. The year 1955 marked the start of an important change in engineering education throughout the United States. In May 1952 ASEE President S.C.Hollister appointed a Committee on Evaluation of Engineering Education, with the goal to evaluate engineering education and suggest new approaches to teaching engineering. When the report of this committee was published on June 15, 1955, a long chapter in the history of engineering education began to fade away. The report was only 36 pages long; it was polite to the older tradition but firm in its recommendations to the new generation. The major impact of the 1955 ASEE report, commonly called *The Grinter Report*, mandated less Art and more Science in Engineering. An abstract is provided in the chapter Appendix.
2. At Minnesota beginning in 1951 Neal Amundson (a mathematics Ph.D.) and Rutherford (Gus) Aris (also from mathematics at Cambridge (UK)) worked to integrate applied math (especially partial differential equations and linear algebra) in the curriculum. The development of computers was sufficiently powerful to solve partial differential equations and matrices numerically, when previously analytical solutions had been intractable. Among other faculty originating from this Minnesota school of mathematical analysis who taught elsewhere were Andy Acrivos (Stanford and CCNY) and Leon Lapidus (Princeton).



Neal Amundson moved Chemical Engineering toward mathematical rigor

Bob Bird brought Transport Phenomena into Chemical Engineering with his colleagues Stewart and Lightfoot

3. At Wisconsin, transport phenomena changed the profession under the leadership of Bird, Stewart, and Lightfoot, with first a hand-written transport phenomena notes (1957) and then a typed hardcopy (1960). This brought a major change to the profession, using the mathematics in Item 2 above. Many Chemical Engineering faculty took sabbaticals at Wisconsin to learn Transport Phenomena. For example, many faculty from Iowa State University became disciples of Wisconsin Transport Phenomena, to encourage the spread of this more fundamental perspective.
4. There was fourth major change: an interdisciplinary component added with professors from a number of different universities, many with a biological slant: Elmer Gaden (Columbia – Biomedical), Art Humphrey (Pennsylvania – Biochemical Engineering), Art Metzner (Delaware) and Bob Bird (Wisconsin) – both Art M. and Bob in Polymer Science, and Michel Boudart (Stanford) and Bill Wilhem (Princeton) – both in Catalysis. In 1953 Wisconsin began a four-year curriculum leading to a B.S. in Biochemical Engineering (6, pg 172).

It should be noted that the above four changes caused significant turbulence in the profession of Chemical Engineering during the 1950's and 1960's. This turbulence was due in part to many older professors wishing to maintain the long-established teaching method of unit operations.

For Mines, the above four changes including the influential 1955 ASEE *The Grinter Report* came at a good time, because Mines' Chemical Engineering Departmental startup years incorporated the revolution. In 1960, there were only three Mines PRE professors (Ball, Lemaire, and Geissler) - too few and too busy to be set in their teaching methods during startup. Petroleum Refining Engineering (PRE) was just getting started from 1944-1960 when Gary came aboard as department head.

The Structure of This Book

With the stage set for our department, the remainder of this history is parsed by Department Head tenure and general development as follows:

J.O. Ball (1944-1960)	Startup
J.H. Gary (1960-1972)	Coming to Steady State
P.F. Dickson (1972-1983)	Transition to Education and Research
A.J. Kidnay (1984-1990)	Ensuring Rigor and Quality
R.M. Baldwin (1990-2000)	Modern Computerization
J.F. Ely (2000-2010)	Adding Biological Life Sciences
D.W.M. Marr (2010-2016)	Integrating Biology and Chemical Engineering
A. Chauhan (2018-Present)	Current Department

Cultural changes of the U.S.A. have affected the department in a major way. In later chapters four major changes will be shown to affect the education process:

1. The return of soldiers from World War II and the Korean War overfilled the class rooms.
2. The 1973 Arab Oil Embargo caused a major shift to energy, filling the research labs. Prior to 1972, the department research concerned mostly oil shale and coal.
3. The 1982 Oil Crisis caused oil prices to rapidly rise and caused a subsequent drop in enrollment and faculty, not recovered for 15 years.
4. A fourth major change was the departmental teaching of biology to almost one quarter of the Mines Freshmen, showing a cultural change to biology.

Chapter Appendix
Grinter Report Summary

"The objective in engineering curricula will not be achieved by repair of patchwork curricula. It requires complete reconstruction of curricula. Some attention to engineering art and practice is necessary, but its high purpose is to illuminate the engineering science, analysis or design, rather than to teach the art as engineering methodology. It is the responsibility of the engineer to recognize those new developments in science and technology that have significant potentialities in engineering. Moreover, the rate at which new scientific knowledge will be translated into engineering practice depends, in a large measure, upon the engineer's capacity to understand the new science as it develops. Fortunately, some things do not change. Reactions, stresses, and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics, and heat flow will be as important to the next generation of engineers as to the present one. Solids, fluids, and gases will continue to be handled, and their dynamics and Chemical Engineering behavior will have to be understood. The special properties of materials as dependent upon their internal structure will be even more important to engineers a generation hence than they are today. *These studies encompass the solid, unshifting foundation of engineering science upon which the engineering curriculum can be built with assurance and conviction*.

Gradually the committee built the framework of a scientifically oriented curriculum. According to their recommendation the curriculum should consist of humanistic and social studies (one-fifth), mathematics and the basic sciences (one-fourth), engineering sciences (one-fourth), engineering analysis and design (one-fourth), and elective courses (one-tenth)."

The recommendations of *The Grinter Report* created much discussion throughout the country. The older generation of instructors opposed them vehemently. The younger generation accepted them. For the first time the word *engineering science* was appearing in an official document on engineering education.

References:

1. American Society for Engineering Education, *Report of Committee on Evolution of Engineering Education* (1955) (known as *The Grinter Report*)
2. Furter, W.F., ed., *A Century of Chemical Engineering*, Plenum Press, NY (1982)
3. Felder, R.W., "The OSU ConocoPhillips Lectures on Chemical Engineering Education: A Half-Century of Recollections, Opinions, and Wisdom" Oklahoma State University (10/13/15)
4. Hanesian, D., Buonopane, R., and Perna, A., *History of the Summer Schools for the Chemical Engineering Teacher (Faculty)* ASEE Chemical Engineering Division, (1988).
5. Hougen, O. A., Phillips Petroleum Inaugural Lecture "Progress and Future in Chemical Engineering Education" Oklahoma State University (5/11/67)
6. Hougen, O.A., and R.B. Bird *100 Years of Chemical Engineering at the University of Wisconsin* (2005),
7. Lewis, W.K., "Evolution of the Unit Operation," *Chemical Engineering Progress Symposium Series*, vol 55, no 26 (1959)
8. Linquist C.B., U.S. Dept. of Health, Education and Welfare, Circular 710 (1963)
9. Peppas, N.W., "The First Century of Chemical Engineering", Chemical Heritage (2008)
10. Wankat, P.W., and Peppas, N.W., *100 Years of Chemical l Engineering at Purdue University 1911-2011*, Purdue University Press (2011)