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Independent Study and Mentorship 3A

08 September 2017

**Research Assessment #1**

**Date:** 08 September 2017

**Subject:** Chemical Engineering Outlook

**Works Cited:**

"Chemical engineering." World of Chemistry, Gale, 2000. Science in Context, link.galegroup.com/apps/doc/CV2432500150/SCIC?u=j043905010&xid=2e1c7365. Accessed 7 Sept. 2017.

"CAREERS IN BRIEF: Nine per cent pay rise." *The Engineer*, 2 June 2008, p. 52. *Science in Context*, link.galegroup.com/apps/doc/A179644781/SCIC?u=j043905010&xid=bb60a300. Accessed 7 Sept. 2017.

"Chemical engineering." *Britannica School*, Encyclopædia Britannica, 9 Jun. 2006. [school.eb.com/levels/high/article/chemical-engineering/105846](http://school.eb.com/levels/high/article/chemical-engineering/105846). Accessed 8 Sep. 2017.

**Assessment:**

The time to begin this journey in gaining more knowledge in chemical engineering has arrived. Prior to starting the Independent Study Mentorship program, I did know a sufficient amount of information regarding chemical engineering. Since I have already taken the AP Chemistry course at school during my junior year, I was given a huge insight on what chemistry is all about. I learned the key concepts and noticed how much of the labs we did in class were actually used in real life by chemists to create materials for the consumers in the world. This connection made me research more about this topic and discover more about the career itself. As I was challenged while taking this course and how challenging the articles make the topic appear, I was determined to accept this challenge and understand chemical engineering to a deeper level.

 I began my research with two articles, one which was regarding the history of chemical engineering and another one called “Chemical Engineering” which fortunately answered my questions while clarifying the information I already knew. The article carefully explained the role and importance of a typical chemical engineer. I noticed how chemical engineering appears to help out other engineering fields such as industrial engineers and biological engineers and to me, it appeared as if chemical engineering was the main warehouse in the area and the other field are local shops who buy products for their own use and then later sell. In order to do this, the engineers have a strong background in physics and math as well as chemistry. When I first discovered this, it appeared reasonable and made me more determined to learn more because all calculations and data analysis requires extensive quantitative conclusions and math is one of my stronger subjects. As I continued reading, the article brushed up the various specializations in chemical engineering. The one thing I find difficult when I look for a potential career is that I am a very picky person. I would hate doing the same thing every single day until the day I retire. I find that my life would be very straight forward without out any excitement and I would start losing interest. This information encouraged me because I wouldn’t be limited to one subject my entire life but I would have the freedom to hold different occupation under my experience of chemical engineering if I am to pursue this field. While I was exploring, I realized I didn’t know much about the history of chemical engineering. I was later intrigued by the fact that in the earlier years, chemical engineering was not a widely accepted because they did not have unity in their education. This shows how much the career evolved over the past years and excites me to think of how much it will evolve in the future. Different terminology was used in the articles which made me confused. I realized in my journey I will have to learn the technical jargon and add on to my professional vocabulary. The last article I read, “CAREERS IN BRIEF” was an insight on the salary of a typical chemical engineer. It was a very short article that was clear and to the point. I was surprised to learn that the average annual salary has been increasing in the past decade and chemical engineers can start working as graduate students. The salary usually depends on a variety of factors which made me infer that no job is the same. Collectively, the overall outlook looks positive for chemical engineers and appears to be in store for growth.

 Now that I have a better understanding of what chemical engineering is about because of the articles I have read and annotated, I believe that I have a better sense of what to expect on this journey in the future. With keeping this new information on my mind, I feel better prepared and excited for the new challenges that are yet to come.

## Chemical engineering

*World of Chemistry*, 2000 Updated: August 29, 2013

Engineering, in general, is the application of science to the design, planning, construction, operation, and maintenance of systems, buildings, and equipment for both industrial and public uses. Chemical engineering, in particular, is devoted to the development and application of systems and equipment for the manufacture of industrial products such as acids, dyes, drugs, **plastics**, and synthetics for the chemical industry. Chemical engineers are responsible for designing practical applications of basic chemical research in order to transform raw materials into useful products. They must use not only **chemistry**, but also mathematics, physics, and engineering in order to solve problems. Chemical engineering utilizes many aspects of chemistry, including **energy** transfer, **thermodynamics**, **mass**, momentum, and chemical **kinetics**.

Because the field of chemical engineering utilizes many different aspects of chemistry, there are numerous applications in which a member of the profession may specialize. A chemical engineer may specialize in **pharmaceutical chemistry**, **petrochemicals**, food additives, **ceramics**, environmental cleanup, safety engineering, or nuclear chemistry. Other important specializations include biotechnology, chemical production, **electrochemistry**, **paints and coatings**, and **water** technology. Two people who both call themselves chemical engineers may actually involve themselves in very different occupations.

The chemical engineering profession was not always so widely accepted and diverse. In the late 1800s, there were people who called themselves chemical engineers, but there was no unity in their education or specializations. The earliest chemical engineers were mechanical engineers who dabbled in chemistry or worked in a chemical plant. Chemical engineering, as known today, started in 1888, when the Massachusetts Institute of Technology first offered a formal degree in the field. In 1892 the University of Pennsylvania and later, in 1894, Tulane University, in New Orleans, Louisiana, both offered formal chemical engineering programs as well.

The field of chemistry existed long before that of chemical engineering. It became necessary to educate chemists differently as the Industrial Revolution began in the industrializing countries of the world, especially in England and the United States. Many so-called industrial chemicals were becoming necessary in great quantities in order to continue the expansion of industry. One such chemical was **sulfuric acid**. If a company could quickly produce sulfuric acid in large quantities and with low cost, it would enjoy large profits because of the great demand for the chemical. The method that was used to produce this acid in the early 1800s was the Lead-Chamber Method. This method simply required air, water, **sulfur** dioxide, a nitrate, and a large **lead** container. The nitrate was quite expensive and not very efficient to work with. The chemical plants that produced sulfuric acid could barely keep up with the demand. In 1859, a new method was introduced, called the Glover Tower. This utilized a mass transfer tower which recovered nitrate lost to the atmosphere in the Lead-Chamber Method. Engineers were becoming necessary in the chemical industry because of the economic demand for more advanced and more productive chemical plants.

Another important industrial chemical at this time was soda ash (Na2CO3), which was used in the production of **glass**, soap, and textiles. This alkali compound was originally harvested from natural sources, such as trees or kelp. As these natural sources became depleted, a new source was needed. The Le Blanc Process, designed in the early 1800s, converted **salt** into soda ash. One problem with this process was the high levels of **pollution** and the potential health hazards to anyone living near a soda ash plant. Another process, called the Solvay Process, could produce soda ash in a more direct way that created much less pollution. Because it was a more direct process, complex engineering had to be employed in order to use it in a large-scale chemical plant.

The need for a new kind of chemist who had an understanding of engineering processes was quickly becoming apparent. In England, in 1880, a Society of Chemical Engineers was unsuccessfully attempted. Chemical engineering was still not considered a separate profession, and there was no clear-cut definition of what a chemical engineer actually did for a profession. However, it was only a few years later when formal chemical engineering programs were started in colleges and universities. The primary focus of these programs was to prepare chemists to fulfill the demands of the chemical industry. The course work involved an emphasis on mechanical engineering in combination with **industrial chemistry**. Competition between chemical plants to manufacture the most products at the lowest cost increased the demand for the chemical engineer. Early chemical engineers focused on optimizing the chemical plants of the Industrial Revolution, utilizing such processes as continuously operating reactors, purification of products, and **recycling** reactants.

Despite the need for chemical engineers in industry, chemical engineering as a separate profession was not immediately recognized. Many members of industry believed that chemists could solve just as many problems. In 1908, the American Institute of Chemical Engineers (AIChE) was formed in order to validate and unite the profession. Despite early conflicts with the American Chemical Society, AIChE survived. It is still in existence today. The formation of this organization not only gave the field of chemical engineering formal recognition, but also helped convince the chemical industry that chemical engineers should be used in plant design and operation instead of mechanical engineers.

Despite the recognition of chemical engineering as a profession and the introduction of several formal chemical engineering programs, there were still inconsistencies in the education and training of chemical engineers. To solve this problem, the AIChE started an accreditation program for schools offering chemical engineering degrees. In 1925, a list of 14 schools was published that had earned accreditation. Chemical engineering was the first profession that utilized accreditation in order to gain consistency and ensure the appropriate education of its members. Eventually, other branches of engineering followed suit and, in 1932, the Accreditation Board for Engineering and Technology was formed.

The focus of the chemical engineering profession changed with the onset of World War I. Instead of being concerned with industrialization, the chemical engineer was enlisted to create materials that could be used in the war. Chemical industries in the United States were now working toward a common goal instead of competing against each other. As a result, **ammonia** plants, for example, were built that produced not only **fertilizers**, but the necessary **explosives** to help win the war.

During World War II, new applications of chemical engineering were introduced. In the beginning of the war, Japan captured rubber-producing lands, including 90 percent of the United States's natural rubber sources. Rubber was very important during the war and was used by the military for such needed items as tires, gaskets, hoses, and boots. Chemical engineers had to design factories to produce synthetic rubber and actually increased synthetic rubber production by over one hundred times. Efficient high-octane **gasoline** was also important for war efforts and, in 1940, the Standard Oil Company developed a catalytic reforming process that produced not only high octane fuel from less expensive petroleum, but also toluene for the explosive trinitrotoluene (TNT). In 1942 the chemical engineers at Du Pont began the design and eventually the operation of a **plutonium** production plant to use for atomic bombs. This plant was called Hanford Engineering Works and was a major contribution of chemical engineering to the war efforts.

After the war, the chemical engineering profession began to focus on the petroleum industry, which is still a major branch of chemical engineering today. With the continuous introduction of new technologies, the field of chemical engineering is constantly evolving. Chemical engineers today need to respond to industrial as well as technological demands. Chemical engineering education is also changing, with a much stronger mathematical and technical background now than was found in the original chemical engineering programs. New fields of specialization are constantly being introduced, especially in the areas of biotechnology, electronics, food processing, pharmaceuticals, and environmental cleanup.

**Source Citation**

"Chemical engineering." *World of Chemistry*, Gale, 2000. *Science in Context*, link.galegroup.com/apps/doc/CV2432500150/SCIC?u=j043905010&xid=2e1c7365. Accessed 7 Sept. 2017.

**Gale Document Number:** GALE|CV2432500150

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## CAREERS IN BRIEF: Nine per cent pay rise

*The Engineer*, June 2, 2008

Chemical engineers have seen a nine per cent increase in their pay since 2006, according to a survey released by the Institution of Chemical Engineers. The average annual salary for chemical engineers in the UK and Ireland has risen to #47,000. The survey puts the average chemical engineering graduate salary at #26,000, an increase of #2,000 since 2006.

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**Source Citation**

"CAREERS IN BRIEF: Nine per cent pay rise." *The Engineer*, 2 June 2008, p. 52. *Science in Context*, link.galegroup.com/apps/doc/A179644781/SCIC?u=j043905010&xid=bb60a300. Accessed 7 Sept. 2017.

**Gale Document Number:** GALE|A179644781

# Introduction

Chemical engineering, the development of processes and the design and operation of plants in which materials undergo changes in their physical or [chemical](http://school.eb.com/levels/high/article/chemical-industry/108378#82212.toc) state. Applied throughout the process industries, it is founded on the principles of chemistry, physics, and mathematics.

The laws of physical chemistry and physics govern the practicability and efficiency of chemical engineering operations. Energy changes, deriving from thermodynamic considerations, are particularly important. Mathematics is a basic tool in optimization and modeling. Optimization means arranging materials, facilities, and energy to yield as productive and economical an operation as possible. Modeling is the construction of theoretical mathematical prototypes of complex process systems, commonly with the aid of computers.

# History

Chemical engineering is as old as the process industries. Its heritage dates from the fermentation and evaporation processes operated by early civilizations. Modern chemical engineering emerged with the development of large-scale, chemical-manufacturing operations in the second half of the 19th century. Throughout its development as an independent discipline, chemical engineering has been directed toward solving problems of designing and operating large plants for continuous production.

Manufacture of chemicals in the mid-19th century consisted of modest craft operations. Increase in demand, public concern at the emission of noxious effluents, and competition between rival processes provided the incentives for greater efficiency. This led to the emergence of combines with resources for larger operations and caused the transition from a craft to a science-based industry. The result was a demand for chemists with knowledge of manufacturing processes, known as industrial chemists or chemical technologists. The term chemical engineer was in general use by about 1900. Despite its emergence in traditional chemicals manufacturing, it was through its role in the development of the petroleum industry that chemical engineering became firmly established as a unique discipline. The demand for plants capable of operating physical separation processes continuously at high levels of efficiency was a challenge that could not be met by the traditional chemist or mechanical engineer.

A landmark in the development of chemical engineering was the publication in 1901 of the first textbook on the subject, by George E. Davis, a British chemical consultant. This concentrated on the design of plant items for specific operations. The notion of a processing plant encompassing a number of operations, such as mixing, evaporation, and filtration, and of these operations being essentially similar, whatever the product, led to the concept of unit operations. This was first enunciated by the American chemical engineer Arthur D. Little in 1915 and formed the basis for a classification of chemical engineering that dominated the subject for the next 40 years. The number of unit operations—the building blocks of a chemical plant—is not large. The complexity arises from the variety of conditions under which the unit operations are conducted.

In the same way that a complex plant can be divided into basic unit operations, so chemical reactions involved in the process industries can be classified into certain groups, or unit processes (*e.g.,* polymerizations, esterifications, and nitrations), having common characteristics. This classification into unit processes brought rationalization to the study of process engineering.

The unit approach suffered from the disadvantage inherent in such classifications: a restricted outlook based on existing practice. Since World War II, closer examination of the fundamental phenomena involved in the various unit operations has shown these to depend on the basic laws of mass transfer, heat transfer, and fluid flow. This has given unity to the diverse unit operations and has led to the development of chemical engineering science in its own right; as a result, many applications have been found in fields outside the traditional chemical industry.

Study of the fundamental phenomena upon which chemical engineering is based has necessitated their description in mathematical form and has led to more sophisticated mathematical techniques. The advent of digital [computers](http://school.eb.com/levels/high/article/computer/117728#235888.toc) has allowed laborious design calculations to be performed rapidly, opening the way to accurate optimization of industrial processes. Variations due to different parameters, such as energy source used, plant layout, and environmental factors, can be predicted accurately and quickly so that the best combination can be chosen.

# Chemical engineering functions

Chemical engineers are employed in the design and development of both processes and plant items. In each case, data and predictions often have to be obtained or confirmed with pilot experiments. Plant operation and control is increasingly the sphere of the chemical engineer rather than the chemist. Chemical engineering provides an ideal background for the economic evaluation of new projects and, in the plant construction sector, for marketing.

# Branches of chemical engineering

The fundamental principles of chemical engineering underlie the operation of processes extending well beyond the boundaries of the chemical industry, and chemical engineers are employed in a range of operations outside traditional areas. Plastics, polymers, and synthetic fibres involve chemical-reaction engineering problems in their manufacture, with fluid flow and heat transfer considerations dominating their fabrication. The dyeing of a fibre is a mass-transfer problem. Pulp and paper manufacture involve considerations of fluid flow and heat transfer. While the scale and materials are different, these again are found in modern continuous production of foodstuffs. The pharmaceuticals industry presents chemical engineering problems, the solutions of which have been essential to the availability of modern drugs. The nuclear industry makes similar demands on the chemical engineer, particularly for fuel manufacture and reprocessing. Chemical engineers are involved in many sectors of the metals processing industry, which extends from steel manufacture to separation of rare metals.

Further applications of chemical engineering are found in the fuel industries. In the second half of the 20th century, considerable numbers of chemical engineers have been involved in space exploration, from the design of fuel cells to the manufacture of propellants. Looking to the future, it is probable that chemical engineering will provide the solution to at least two of the world’s major problems: supply of adequate fresh water in all regions through desalination of seawater and environmental control through prevention of pollution.

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# Additional Reading

A treatment of the history of the field is contained in William F. Furter (ed.), *History of Chemical Engineering* (1980), and *A Century of Chemical Engineering* (1982). Classic works include George E. Davis, *A Handbook of Chemical Engineering*, 2nd ed., 2 vol. (1904); and William H. Walker et al., *Principles of Chemical Engineering*, 3rd ed., rev. and rewritten (1937). More recent information may be found in Don W. Green and James O. Maloney (eds.), *Perry’s Chemical Engineers’ Handbook*, 6th ed. (1984), a comprehensive handbook; D. Joseph Hagerty, Earl R. Gerhard, and Charles A. Plank, *Opportunities in Chemical Engineering* (1979, reissued 1985); J.M. Coulson, *Chemical Engineering: An Introduction to Design* (1983); and J.M. Coulson et al., *Chemical Engineering*, 6 vol. in various editions (1977–96), a general textbook.

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