高等学校教材

English for Chemistry and Chemical Engineering

化学化工专业英语

张裕平　姚树文　龚文君　主编

化学工业出版社

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·北京·

本书为化学化工类的一本综合性英文著作。全书选材面广，适用专业面宽，采用递进式写作，先是概括性的学科描述性短文，宏观介绍化学化工学科的特点以及文献写作、实验记录和查找网上化学资源等一般共性的知识；然后是描述化工过程单元操作及基础化工知识的短文；最后是代表性精读文章，内容涉及普通化学、无机化学、有机化学、分析化学、物理化学、生物化学及材料等内容；最后为各二级学科的化学专业术语，并进行了简单解释，可作为选读部分。

每篇文章后有详细的课文注释，很多文章中附有图片说明，增加了生动性和可读性。本书涉及的词汇量较大，但均注有音标和一些构词规律，对一些语法现象也进行了详细的解释和分析。

本书适合作为高等院校化学、化工及相关专业的本科专业英语的教学用书，也可作为从事化学和化工领域的教学、科研和工程技术人员的参考用书。

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前　言

本教材在吸收国内同类书籍优点的同时，根据现代科技发展补充了一些新知识，如组合化学、纳米技术及绿色化学概貌等。选材面广，适应专业面宽。文章采用递进式写作，先是概括性的学科描述性短文，然后是化工专业重要操作单元介绍及描述性小短文，最后是代表性精读文章。涉及各二级学科的化学专业术语可作为最后的选读部分。每篇文章后有详细的课文注释，很多文章内容之中附有图片说明，增加了文章的生动性和可读性。另外本书涉及的词汇量较大，但均注有音标和一些构词规律，对一些语法现象也进行了详细的解释和分析，书尾列有常用化学化工词汇的英语详细注释。

第一部分共13课，主要是宏观性地介绍化学化工学科的特点，另外还介绍了怎样进行文献写作、实验记录和查找网上化学资源等一般共性的知识。第二部分共50个小短文，主要描述化工过程单元操作及介绍基础化工知识。第三部分是精读部分，共19课，内容涉及普通化学、无机化学、有机化学、分析化学、物理化学、生物化学及材料科学等内容。第四部分主要是化学专业术语，对常用化学各学科专业术语进行简单解释，可作为选读部分。该教材适合作为高等院校化学、化工及相关专业的本科专业英语的教学用书，也适合作为从事化学和化工领域的教学、科研和工程技术人员的自学用书。

本书由河南科技学院张裕平、姚树文、龚文君主编，张毅军、许光日、李英、李永芳、石明旺为副主编，杨胜凯、崔成幸、许明录、汤波、孙凤梅、杨凤霞、王天喜参与了部分工作，另外多位老师为此书的出版提供了宝贵意见和帮助，在此深表谢意！由于我们英语和专业水平的限制，再加上时间仓促，难免有不足之处，盼望读者提出宝贵意见。

编者

2007年5月

Contents

Part A

Descriptive Short Articles

1. Chemistry: A Science for the Twenty-First Century

Chemistry is the study of matter and the changes it undergoes. Chemistry is often called the central science, because a basic knowledge of chemistry is essential for students of biology, physics, geology, ecology, and many other subjects. Indeed, it is central to our way of life; without it, we would be living shorter lives in what we would consider primitive conditions, without automobiles, electricity, computers, CDs, and many other everyday conveniences.

Although chemistry is an ancient science, its modern foundation was laid in the nineteenth century, when intellectual and technological advances enabled scientists to break down substances into ever smaller components and consequently to explain many of their physical and chemical characteristics.[1] The rapid development of increasingly sophisticated technology throughout the twentieth century has given us even greater means to study things that cannot be seen with the naked eye. Using computers and special microscopes, for example, chemists can analyze the structure of atoms and molecules — the fundamental units on which the study of chemistry is based — and design new substances with specific properties, such as drugs and environmentally friendly consumer products.

As we enter the twenty-first century, it is fitting to ask what part the central science will have in this century. Almost certainly, chemistry will continue to play a pivotal role in all areas of science and technology. Before plunging into the study of matter and its transformation, let us consider some of the frontiers that chemists are currently exploring. Whatever your reasons for taking introductory chemistry, a good knowledge of the subject will better enable you to appreciate its impact on society and on you as an individual.[2]

Health and Medicine

Three major advances in the past century have enabled us to prevent and treat diseases. They are public health measures establishing sanitation systems to protect vast numbers of people from infectious disease; surgery with anesthesia, enabling physicians to cure potentially fatal conditions, such as an inflamed appendix; and the introduction of vaccines and antibiotics that make it possible to prevent diseases spread by microbes. Gene therapy promises to be the fourth revolution in medicine. (A gene is the basic unit of inheritance.) Several thousand known conditions, including cystic fibrosis and hemophilia, are carried by inborn damage to a single gene. Many other ailments, such as cancer, heart disease, AIDS, and arthritis, result to an extent from impairment of one or more genes involved in the body's defenses. In gene therapy, a selected healthy gene is delivered to a patient's cell to cure or ease such disorders. To carry out such a procedure, a doctor must have a sound knowledge of the chemical properties of the molecular components involved. The decoding of the human genome, which comprises all of the genetic material in the human body and plays an essential part in gene therapy, relies largely on chemical techniques. [3]

Chemists in the pharmaceutical industry are researching potent drugs with few or no side effects to treat cancer, AIDS, and many other diseases as well as drugs to increase the number of successful organ transplants. [4] On a broader scale, improved understanding of the mechanism of aging will lead to a longer and healthier life span for the world's population.

Energy and the Environment

Energy is a by-product of many chemical processes, and as the demand for energy continues to increase, both in technologically advanced countries like the United States and in developing ones like China, chemists are actively trying to find new energy sources. Currently the major sources of energy are fossil fuels (coal, petroleum, and natural gas). The estimated reserves of these fuels will last us another 50～100 years, at the present rate of consumption, so it is urgent that we find alternatives.

Solar energy promises to be a viable source of energy for the future. Every year Earth's surface receives about 10 times as much energy from sunlight as is contained in all of the known reserves of coal, oil, natural gas, and uranium combined. [5] But much of this energy is "wasted" because it is reflected back into space. For the past 30 years, intense research efforts have shown that solar energy can be harnessed effectively in two ways. One is the conversion of sunlight directly to electricity using devices called photovoltaic cells. The other is to use sunlight to obtain hydrogen from water. The hydrogen can then be fed into a fuel cell to generate electricity. Although our understanding of the scientific process of converting solar energy to electricity has advanced, the technology has not yet improved to the point where we can produce electricity on a large scale at an economically acceptable cost. [6] By 2050, however, it has been predicted that solar energy will supply over 50 percent of our power needs.

Another potential source of energy is nuclear fission, but because of environmental concerns about the radioactive wastes from fission processes, the future of the nuclear industry in the United States is uncertain. Chemists can help to devise better ways to dispose off nuclear waste. Nuclear fusion, the process that occurs in the sun and other stars, generates huge amounts of energy without producing much dangerous radioactive waste. In another 50 years, nuclear fusion will likely be a significant source of energy.

Energy production and energy utilization are closely tied to the quality of our environment. A major disadvantage of burning fossil fuels is that they give off carbon dioxide, which is a greenhouse gas (that is, it promotes the heating of Earth's atmosphere), along with sulfur dioxide and nitrogen oxides, which result in acid rain and smog. (Harnessing solar energy has no such detrimental effects on the environment.) By using fuel-efficient automobiles and more effective catalytic converters, we should be able to drastically reduce harmful auto emissions and improve the air quality in areas with heavy traffic. In addition, electric cars, powered by durable, longlasting batteries, should become more prevalent, and their use will help to minimize air pollution.

Materials and Technology

Chemical research and development in the twentieth century have provided us with new materials that have profoundly improved the quality of our lives and helped to advance technology in countless ways. A few examples are polymers (including rubber and nylon), ceramics (such as cookware), liquid crystals (like those in electronic displays), adhesives and coatings (for example, latex paint).

What is in store for the near future? One likely possibility is room-temperature superconductors. Electricity is carried by copper cables, which are not perfect conductors. Consequently, about 20 percent of electrical energy is lost in the form of heat between the power station and our homes. This is a tremendous waste. Superconductors are materials that have no electrical resistance and can therefore conduct electricity with no energy loss. Although the phenomenon of superconductivity at very low temperatures (more than 400 degrees Fahrenheit below the freezing point of water) has been known for over 80 years, a major breakthrough in the mid-1980s demonstrated that it is possible to make materials that act as superconductors at or near room temperature. Chemists have helped to design and synthesize new materials that show promise in this quest. The next 30 years will see high-temperature superconductors being applied on a large scale in magnetic resonance imaging (MRI), levitated trains, and nuclear fusion.

If we had to name one technological advance that has shaped our lives more than any other, it would be the computer. The "engine" that drives the ongoing computer revolution is the microprocessor—the tiny silicon chip that has inspired countless inventions, such as laptop computers and fax machines. The performance of a microprocessor is judged by the speed with which it carries out mathematical operations, such as addition. The pace of progress is such that since their introduction, microprocessors have doubled in speed every 18 months. The quality of any microprocessor depends on the purity of the silicon chip and on the ability to add the desired amount of other substances, and chemists play an important role in the research and development of silicon chips. For the future, scientists have begun to explore the prospect of "molecular computing", that is, replacing silicon with molecules. The advantages are that certain molecules can be made to respond to light, rather than to electrons, so that we would have optical computers rather than electronic computers.[7] With proper genetic engineering, scientists can synthesize such molecules using microorganisms instead of large factories. Optical computers also would have much greater storage capacity than electronic computers.

Food and Agriculture

How can the world's rapidly increasing population be fed? In poor countries, agricultural activities occupy about 80 percent of the workforce, and half of an average family budget is spent on foodstuffs. This is a tremendous drain on a nation's resources. The factors that affect agricultural production are the richness of the soil, insects and diseases that damage crops, and weeds that compete for nutrients. Besides irrigation, farmers rely on fertilizers and pesticides to increase crop yield. Since the 1950s, treatment for crops suffering from pest infestations has sometimes been the indiscriminate application of potent chemicals. Such measures have often had serious detrimental effects on the environment. Even the excessive use of fertilizers is harmful to the land, water, and air.

To meet the food demands of the twenty-first century, new and novel approaches in farming must be devised. It has already been demonstrated that, through biotechnology, it is possible to grow larger and better crops. These techniques can be applied to many different farm products, not only for improved yields, but also for better frequency, that is, more crops every year.[8] For example, it is known that a certain bacterium produces a protein molecule that is toxic to leaf-eating caterpillars. Incorporating the gene that codes for the toxin into crops enables plants to protect themselves so that pesticides are not necessary.[9] Researchers have also found a way to prevent pesky insects from reproducing. Insects communicate with one another by emitting and reacting to special molecules called pheromones. By identifying and synthesizing pheromones used in mating, it is possible to interfere with the normal reproductive cycle of common pests; for example, by inducing insects to mate too soon or tricking female insects into mating with sterile males. Moreover, chemists can devise ways to increase the production of fertilizers that are less harmful to the environment and substances that would selectively kill weeds.

The Study of Chemistry

Compared with other subjects, chemistry is commonly believed to be more difficult, at least at the introductory level. There is some justification for this perception; for one thing, chemistry has a very specialized vocabulary. However, even if this is your first course in chemistry, you already have more familiarity with the subject than you may realize. In everyday conversations we hear words that have a chemical connection, although they may not be used in the scientifically correct sense. Examples are "electronic", "equilibrium", "catalyst," "chain reaction," and "critical mass." Moreover, if you cook, then you are a practicing chemist! From experience gained in the kitchen, you know that oil and water do not mix and that boiling water left on the stove will evaporate. You apply chemical and physical principles when you use baking soda to leaven bread, choose a pressure cooker to shorten the time it takes to prepare soup, add meat tenderizer to a pot roast, squeeze lemon juice over sliced pears to prevent them from turning brown or over fish to minimize its odor, and add vinegar to the water in which you are going to poach eggs. Every day we observe such changes without thinking about their chemical nature. The purpose of this course is to make you think like a chemist, to look at the macroscopic world—the things we can see, touch, and measure directly—and visualize the particles and events of the microscopic world that we cannot experience without modern technology and our imaginations.

At first some students find it confusing that their chemistry instructor and textbook seem to be continually shifting back and forth between the macroscopic and microscopic worlds. Just keep in mind that the data for chemical investigations most often come from observations of large-scale phenomena, but the explanations frequently lie in the unseen and partially imagined microscopic world of atoms and molecules. In another words, chemists often see one thing (in the macroscopic world) and think another (in the microscopic world). Looking at the rusted car, for example, a chemist might think about the basic properties of individual atoms of iron and how these units interact with other atoms and molecules to produce the observed change.

The Scientific Method

All sciences, including the social sciences, employ variations of what is called the scientific method, a systematic approach to research. For example, a psychologist who wants to know how noise affects people's ability to learn chemistry and a chemist interested in measuring the heat given off when hydrogen gas burns in air would follow roughly the same procedure in carrying out their investigations. The first step is to carefully define the problem. The next step includes performing experiments, making careful observations, and recording information, or data, about the system—the part of the universe that is under investigation. (In the examples just discussed, the systems are the group of people the psychologist will study and a mixture of hydrogen and air.)

The data obtained in a research study may be both qualitative, consisting of general observations about the system, and quantitative, comprising numbers obtained by various measurements of the system. Chemists generally use standardized symbols and equations in recording their measurements and observations. This form of representation not only simplifies the process of keeping records, but also provides a common basis for communication with other chemists.

When the experiments have been completed and the data have been recorded, the next step in the scientific method is interpretation, meaning that the scientist attempts to explain the observed phenomenon. Based on the data that were gathered, the researcher formulates a hypothesis, a tentative explanation for a set of observations. Further experiments are devised to test the validity of the hypothesis in as many ways as possible, and the process begins anew.

After a large amount of data has been collected, it is often desirable to summarize the information in a concise way, as a law. In science, a law is a concise verbal or mathematical statement of a relationship between phenomena that is always the same under the same conditions. For example, Sir Isaac Newton's second law of motion, which you may remember from high school science, says that force equals mass times acceleration ($F=ma$). What this law means is that an increase in the mass or in the acceleration of an object will always increase its force proportionally, and a decrease in mass or acceleration will always decrease the force.

Hypotheses that survive many experimental tests of their validity may evolve into theories. A theory is a unifying principle that explains a body of facts and/or those laws that are based on them. Theories, too, are constantly being tested.[10] If a theory is disproved by experiment, then it must be discarded or modified so that it becomes consistent with experimental observations. Proving or disproving a theory can take years, even centuries, in part because the necessary technology may not be available. Atomic theory, which we will study later, is a case in point. It took more than 2000 years to work out this fundamental principle of chemistry proposed by Democritus, an ancient Greek philosopher. A more contemporary example is the Big Bang theory of the origin of the universe.

Scientific progress is seldom, if ever, made in a rigid, step-by-step fashion. Sometimes law precedes a theory; sometimes it is the other way around. Two scientists may start working on a project with exactly the same objective, but will end up taking drastically different approaches. Scientists are, after all, human beings, and their modes of thinking and working are very much influenced by their background, training, and personalities.

The development of science has been irregular and sometimes even illogical. Great discoveries are usually the result of the cumulative contributions and experience of many workers, even though the credit for formulating a theory or a law is usually given to only one individual. There is, of course, an element of luck involved in scientific discoveries, but it has been said that "chance favors the prepared mind." It takes an alert and well—trained person to recognize the significance of an accidental discovery and to take full advantage of it. More often than not, the public learns only of spectacular scientific breakthroughs. For every success story, however, there are hundreds of cases in which scientists have spent years working on projects that ultimately led to a dead end. And in which positive achievements came only after many wrong turns and at such a slow pace that they went unheralded. Yet even the dead ends contribute something to the continually growing body of knowledge about the physical universe. It is the love of the search that keeps many scientists in the laboratory.

New Words and Expressions

primitive [ˈprimitiv] *adj.* 原始的，远古的，粗糙的，简单的
convenience [kənˈviːnjəns] *n.* 便利，方便，有益，有用的用具、机械、安排等
sophisticated [səˈfistikeitid] *adj.* 精密复杂的，富有经验的，老练的，高度发展的
naked [ˈneikid] *adj.* 肉眼的，裸体的，无遮盖的
pivotal [ˈpivətəl] *adj.* 枢轴的，关键的
frontier [ˈfrʌntiə] *n.* 前沿，[常用复] 尚待开发的领域，尖端，新领域
sanitation [sæniˈteiʃən] *n.* 卫生，卫生设施
infectious [inˈfekʃəs] *adj.* 有传染性的，易传染的，有感染力的
anesthesia [ˌænisˈθiːzjə] *n.* 麻醉，失去知觉，麻醉手术
inflamed [infleiˈmid] *adj.* 发炎的；红肿的
appendix [əˈpendiks] *n.* 阑尾
vaccine [ˈvæksiːn] *adj.* 疫苗的，牛痘的；*n.* 疫苗
antibiotic [ˌæntibaiˈɔtik] *n.* 抗生素；*adj.* 抗生的
inheritance [inˈheritəns] *n.* 遗传，遗产
fibrosis [faiˈbrəusis] *n.* 纤维症，纤维化
cystic fibrosis *n.* 囊肿性纤维化（属遗传性胰腺病）
microbe [ˈmaikrəub] *n.* 微生物，细菌
hemophilia [ˌhiːməˈfiliə] *n.* 血友病
inborn [ˈinˈbɔːn] *adj.* 天生的，生来的，先天的
ailment [ˈeilmənt] *n.* 疾病，不宁，不安
arthritis [ɑːˈθraitis] *n.* 关节炎
impairment [imˈpεəmənt] *n.* 损害，损伤
decoding [diˈkəudiŋ] *n.* 译码，解码
genome [ˈdʒiːnəum] *n.* 基因组，染色体组
pharmaceutical [ˌfɑːməˈsjuːtikəl] *n.* 药物
transplant [trænsˈplɑːnt] *v.* 移植，移种，移民，迁移；*n.* 移植，被移植物
viable [ˈvaiəbl] *adj.* 能养活的，能生育的，可行的
greenhouse gas 二氧化碳、甲烷等导致温室效应的气体
fossil [ˈfɔsl] *n.* 化石，僵化的事物；*adj.* 化石的，陈腐的，守旧的
uranium [juəˈreiniəm] *n.* 铀
harness [ˈhɑːnis] *vt.* 利用（河流、瀑布等）产生动力（尤指电力）
photovoltaic [ˌfəutəuvɔlˈteiik] *adj.* 光电池的，光致电压的，光电的
fission [ˈfiʃən] *n.* 裂变；*v.* （使）裂变
drastically [ˈdræstikli] *adv.* 激烈地，彻底地
emission [iˈmiʃən] *n.* （光、热等的）散发，发射，喷射
prevalent [ˈprevələnt] *adj.* 普遍的，流行的
ceramics [siˈræmiks] *n.* 制陶术，制陶业
adhesive [ədˈhiːsiv] *n.* 黏合剂；*adj.* 带黏性的，胶黏
latex [ˈleiteks] *n.* 乳汁，乳胶，橡胶
superconductor [ˌsjuːpəkənˈdʌktə] *n.* 超导（电）体
levitate [ˈleviteit] *v.* 使升空，使飘浮
microprocessor [maikrəuˈprəusesə（r）] *n.* 微处理器，单片机
laptop [ˈlæptɔp] *n.* 便携式电脑

budget [ˈbʌdʒit] *n.* 预算；*vi.* 做预算，编入预算
irrigation [ˌiriˈgeiʃən] *n.* 灌溉，冲洗
pesticide [ˈpestisaid] *n.* 杀虫剂
infestation [infesˈteiʃən] *n.* （害虫，盗贼等）群袭，出没，横行
indiscriminate [ˌindisˈkriminit] *adj.* 不加选择的，不分皂白的
detrimental [ˌdetriˈmentl] *adj.* 有害的
caterpillar [ˈkætəpilə] *n.* 毛虫
incorporate [inˈkɔːpəreit] *vi.* 合并，混合，组成公司
pesky [ˈpeski] *adj.* 烦恼的，麻烦的，讨厌的；*adv.* 极端地
pheromone [ˈferəməun] *n.* 信息素
sterile [ˈsterail] *adj.* 不育的，贫脊的，不结果的，消过毒的
leaven [ˈlevən] *vt.* 使发酵
vinegar [ˈvinigə] *n.* 醋
poach [pəutʃ] *vt.* 水煮（荷包蛋），把……踏成泥浆
interpretation [inˌtəːpriˈteiʃən] *n.* 解释，阐明，口译，通译
hypothesis [haiˈpɔθisis] *n.* 假设
unify [ˈjuːnifai] *vt.* 统一，使成一体
disprove [disˈpruːv] *v.* 反驳，驳斥，证明……为误
Democritus [diˈmɔkritəs] 德谟克利特（约公元前 460—公元前 370，古希腊哲学家）

Phrases

plunge into　投入，跳入，开始
not only ... but also ...　不但……而且……
break down　分解
be delivered to　被输送到
carry out　完成，实现，贯彻，执行
keep in mind　谨记
in addition　另外
in store　贮藏着，保存着，准备着
interfere with　妨碍，乱动，干涉，干扰
trick sb. into　欺骗，坑人
take full advantage of　充分利用

Affixes

anti- [ˈænti] 表示“反对，抵抗”之义 antibiotics；antibody；antilogarithm.
in- [in] 不，表示“否定，与……相反”之义，在字母 l 之前常用 il-，在字母 r 之前常用 ir-，在字母 b，m，和 p 之前常用 im-。如：indiscriminate，inability，inaccurate。

Notes

1. Although chemistry is an ancient science，its modern foundation was laid in the nineteenth century，when intellectual and technological advances enabled scientists to break down substances into ever smaller components and consequently to explain many of their physical and chemical characteristics. “although”引导的是让步状语从句；“when”引导的定语从句修饰先行词“century”. 参考译文：虽然化学是一门古老的科学，但是其现代基础却是在 19 世纪才建立起来的，当时科学和技术的进步使科学家们对物质的认识进入更微观的世界，从而能更深入的揭示物质的物理和化学性质。

2. Whatever your reasons for taking introductory chemistry，a good knowledge of the subject will better enable you to appreciate its impact on society and on you as an individual. 参考译文：无论促使你学习基础化学的原因是什么，拥有丰富的化学知识将使你能更好的理解其对社会及你个人的影响。

3. The decoding of the human genome，which comprises all of the genetic material in the human body and plays an essential part in gene therapy，relies largely on chemical tech-

niques. which 引起的非限制性定语从句，对主句“The decoding of the human genome”起进一步解释和说明作用；非限制性定语从句与主句间要用逗号隔开。参考译文：破译人类基因组的工作很大程度上依赖于化学技术，这些基因组包括人体所有的基因材料，它们是基因诊断治疗技术最根本之所在。

4. Chemists in the pharmaceutical industry are researching potent drugs with few or no side effects to treat cancer, AIDS, and many other diseases as well as drugs to increase the number of successful organ transplants. as well as 是表示联合关系的连词，意思是“以及”。参考译文：制药行业的化学家们正在研发用于治疗癌症、艾滋病等疾病的副作用小或无副作用的特效药，以及能提高器官移植成功率的药物。

5. Solar energy promises to be a viable source of energy for the future. Every year earth's surface receives about 10 times as much energy from sunlight as is contained in all of the known reserves of coal, oil, natural gas, and uranium combined. 参考译文：太阳能有望成为未来可能的能量来源。每年，地球表面接受到来自太阳的能量是已知储量的煤、石油、天然气和铀中能量总和的 10 倍。

6. Although our understanding of the scientific process of converting solar energy to electricity has advanced, the technology has not yet inproved to the point where we can produce electricity on a large scale at an economically acceptable cost. although 引导的是让步状语从句。参考译文：虽然人类对将太阳能转换为电能的科学知识已经很丰富，但目前的技术还不能够用可接受的成本进行大规模的商业化生产。

7. The advantages are that certain molecules can be made to respond to light, rather than to electrons, so that we would have optical computers rather than electronic computers. “rather than”的意思是“是……，而不是……”。参考译文：好处在于可以制备某种对光而不是对电子发生响应的分子，这样就可以制造出取代电子计算机的光学计算机。

8. These techniques can be applied to many different farm products, not only for improved yields, but also for better frequency, that is, more crops every year. “not only ... but also...”是表示联合关系的并列连词，其意思是“不仅……而且……”。参考译文：生物技术可用于多类农产品，不仅可以提高产量，而且还可提高收获次数，即提高年种植次数。

9. For example, it is known that a certain bacterium produces a protein molecule that is toxic to leaf-eating caterpillars. Incorporating the gene that codes for the toxin into crops enables plants to protect themselves so that pesticides are not necessary. 参考译文：例如，众所周知，某种细菌能合成一种对吃叶的毛虫有毒的蛋白质。把编码这种毒素的基因合并到作物上去，将会使植物能保护自己而不必再使用杀虫剂。

10. Hypotheses that survive many experimental tests of their validity may evolve into theories. A theory is a unifying principle that explains a body of facts and/or those laws that are based on them. Theories, too, are constantly being tested. 参考译文：经过多次实验来验证其正确性的假说可能最终会变成理论。理论是对解释大量事实和/或基于这些事实的规律所进行的原理的统一。而且，理论总是不断地被验证着。

2. What is Chemical Engineering?

Is there a simple definition of chemical engineering?

Chemical engineering is the study and practice of transforming substances at large scales for the tangible improvement of the human condition. Such transformations are executed to produce other useful substances or energy, and lie at the heart of vast segments of the chemical, petroleum, pharmaceutical, and electronic industries.

Chemical engineering differs from chemistry mainly in the focus on large scales. The definition of "large" is a bit arbitrary, of course, but is set mainly by the scale of useful commercial production. Typically, this scale ranges from barrels to tank cars, whereas the chemist tends to be concerned sizes closer to vials to beakers.

Is chemical engineering an old discipline?

Chemical engineering has been practiced in rudimentary form since at least the great Roman road-building projects that began about 300 B. C. The cement used for pavement was based on the contemporary Hellenistic formula employing lime, a calcined (heated) form of calcium carbonate. However, academic programs in the US formally called "chemical engineering" or something similar originated only near the start of the 20^{th} Century.

Equipment used to make thin films of semiconducting materials for microelectronics applications. The methodology is called "chemical vapor deposition," and heating is accomplished by banks of lamps (e. g., upper right). Chemical engineers help to design and operate such equipment.

What do practicing chemical engineers typically do?

For many years, most chemical engineers took jobs in the oil or petrochemical industry. Job functions typically involved the development or operation of processes to convert oil-based feedstocks into energy or other useful chemical products ranging from fibers for clothing to lubricants to fertilizers. [1] In recent decades, however, job descriptions have become far more diverse. Chemical engineers often develop or operate processes to create products ranging from integrated circuits to disease-fighting drugs to fuel cells. Some recent graduates use a chemical engineering Bachelor's Degree as a launching pad for careers as physicians or patent attorneys.

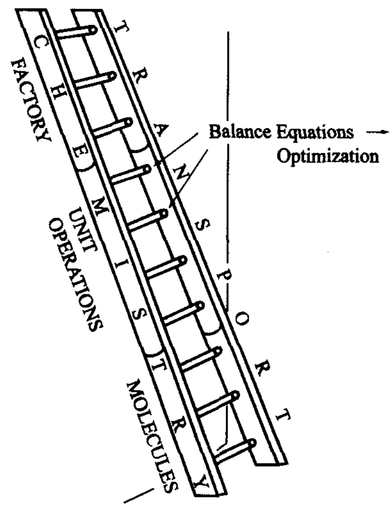
How do chemical engineers think?

The unique focus perspective of this discipline can be represented by an extension ladder, shown in the figure. The two uprights of this very useful tool represent the two primary physical foundations upon which all of chemical engineering rests: chemistry and transport. Here, "chemistry" refers to the rates and extents of transformation among substances. "Transport" refers to the movement of mass, energy or momentum.

The rungs of the ladder represent the mathematical balance equations that connect chemistry and transport. The balance equations can be time-dependent or steady state. Whatever their nature, however, these balance equations are rarely written in their own right; they are almost always written to optimize or control some variable within them. [2] The rungs therefore also represent the use of balance equations for the optimization and control of useful commercial processes.

Chemical engineering embraces an enormous range of size scales in a fully integrated way—commonly ranging from atoms to oil tankers. The figure represents this notion by three extension segments, representing length scales corresponding to the microscopic, the bench scale (or "unit operation" in the lingo of the discipline) and the factory. At the molecular level, the balance equations might incorporate variables like temperature or pressure. At the unit operation level, the key variables might be flow rate or controller gain. At the factory level, the variables might be operating cost or overall production rate.

The ladder idea provides more than a simple picture of the conceptual structure of chemical engineering. However, the idea also illustrates an important point about the use of this structure. Consider how a house painter uses a ladder. The skilled painter moves continually up and down the rungs as circumstances dictate. When carrying materials and brushes to the third floor, the painter may climb rapidly, covering a great deal of territory. When scraping the stubborn shavings from an old window, however, the painter may need to stay on one particular rung for a long time. Good painting requires a constellation of climbing skills integrated judiciously: Knowing when to climb, when to descend, when to overlap ladder segments, how to lean, how to reach. Although these skills can be described and listed, they cannot be used algorithmically. Judicious ladder use requires judgment and experience, i. e., "ladder wisdom."



An extension ladder can represent important aspects of how chemical engineers think.

In a similar way, when we want to transform chemical substances, the "ladder" of chemistry/transport, balances, and optimization offers a versatile tool. The skilled chemical engineer moves continually over the span of length scales from atomic to factory-level as circumstances dictate. When designing or optimizing an overall process flow, the chemical engineer may move rapidly up and down the span of length scales. When troubleshooting a particular unit operation, however, the chemical engineer may need to stay at that level for a long time with just a few balance equations. Good chemical engineering requires a constellation of intellectual skills integrated judiciously: knowing what kind of balance equation to write, what control volume to use, what terms to neglect, when to overlap tools from different length scales, what mathematics to use. Although these skills can be described and