高等学校"十二五"规划教材
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功能材料专业英语阅读教程

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副主编　管　婧　丁冬海　孙昱艳

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高等学校“十二五”规划教材

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Functional Materials Speciality English Reading Course

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内容提要

本书分9个单元，分别介绍了具有不同功能的功能材料以及每种功能材料的发展、分类、结构、制备、应用等相关知识。每个单元除一篇主课文外，另编有二~四篇扩展阅读文，并附有单词与短语的介绍和注释。

本书可供功能材料专业、材料物理与化学专业等相关专业的本科生、大专生，以及材料科学与工程专业、高分子科学与工程专业、高分子化学与物理专业的本科生、大专生参考阅读。

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前　　言

功能材料是指具有优良的电学、磁学、光学、热学、声学、力学、化学、生物医学功能，特殊的物理、化学、生物学效应，能完成功能相互转化，主要用来制造各种功能元器件而被广泛应用于各类高科技领域的高新技术材料。当今功能材料层出不穷，无论是国防军事领域还是生活民用方面，都对材料的功能特性提出了更多更高的要求。至今，全国约有27所院校成立了功能材料专业，相对材料科学与工程专业而言，功能材料专业更具有专业性强、新颖度高的特征。功能材料陆续发展已有上百年的时间，而相应的教材偏少或者不全面，缺乏系统性，导致学生的知识体系不全面、不系统。专业外语课是学生必须学习的一门基础课程，专业外语是学生了解世界学术前沿必须掌握的一项基本工具。本书作者经过调研市面上有关材料专业的外语阅读教材，发现相关教材中存在专业领域过窄或过宽的问题，且有关功能材料专业外语教材缺失，在此背景下，本书主编雷西萍副教授，借助多年从事材料专业外语教学的经验，联合本教研室教师共同完成了本教材的编撰工作。

本书共分为九个单元，每单元由一篇主课文和二至四篇扩展阅读构成，共三十五篇课文。主课文是对该领域功能材料的全面介绍，扩展阅读则是对主课文内容的延伸，以丰富学生的知识面。每篇主课文后编有生词、注释和习题，每篇扩展阅读课文后编有生词和注释。每单元最后采用中文对该种功能材料最新研究进展作简要介绍，使学生能够进一步更快、更好地了解该领域功能材料的发展。本书最后附有生词表。第一单元主课文是功能材料的介绍，设有功能材料的分类、梯度功能材料、具有高选择和快速响应性气体识别先进表面声波传感器材料三篇扩展阅读文章；第二单元主课文是电功能材料，设有过渡金属氧化物-电热性能、铁电陶瓷发展历史、制备及应用、本征导电聚合物三篇扩

展阅读文章；第三单元主课文是磁性材料，设有软磁材料、稀土磁性材料生产工艺和高密度磁记录材料三篇扩展阅读文章；第四单元主课文是光功能材料，设有光致变色材料、陶瓷激光材料、LED 荧光材料三篇扩展阅读文章；第五单元主课文是热功能材料，设有热电材料、热电设备、热电材料中的电子传输三篇扩展阅读文章；第六单元主课文是化学功能材料，设有催化多孔材料、聚醚薄膜材料两篇扩展阅读文章；第七单元主课文是生物功能材料，设有石墨生物传感器、刺激性生物变色材料两篇扩展阅读文章；第八单元主课文是能源材料，设有储氢材料、可充式锂电池、硅太阳能电池三篇扩展阅读文章；第九单元主课文是智能材料，设有形状记忆材料、磁致伸缩材料及其效应、磁流变液、智能涂料四篇扩展阅读文章。

本书素材来源于国外专著、期刊、报告等，编著期间得到西安建筑科技大学材料与矿资学院张军战副教授、西安交通大学化学系王栋东讲师的大力帮助，在此，编者对他们一并表示感谢！

本书由雷西萍、管婧、丁冬海、孙昱艳四位教师共同编写。其中，第一、二、九单元由雷西萍老师编写，第四、八单元由管婧老师编写，第六、七单元由丁冬海老师编写，第三、五单元由孙昱艳老师编写。全书统稿、前言和附录的撰写由雷西萍老师完成。由于水平有限，书中的内容较广，若有不妥之处，希望广大读者批评指正。

编　者

2014 年 8 月

目　　录

Unit 1 the Introduction of Functional Materials

During the past two centuries, materials science has witnessed the emergence of a second wave of research and development thrusts which has evolved in parallel with those activities focused on the development of new generations of structural materials. This second thrust has focused on the development of functional materials, namely, materials whose principal functional characteristic exploited is in the fields of science and technology rather than the inherent structural properties of the material.

As the vehicle for a particular physical property (conveying electricity, light, etc.), the functional material plays a key role in the technical system. Every major technological break through involves devising and using a specific functional material silicon for informatics, optical fibres for telecommunications, catalysts in chemistry, etc. **Thus at any given time, functional materials define the limits within which the technical system can evolve. It is, for example, impossible today to envisage going below a size of 10^{-8} cm^2 for a transistor using silicon technology, and this places a limit on the possibility of miniaturization in informatics. By its very nature, the functional material has a number of specific features which distinguish it from other materials.**

The majority of functional materials are high value-added materials and the market for them is inherently a world market. Insofar as these materials are normally used as components in various industrial systems and articles, they do not directly reflect the tastes and requirements of the ultimate consumer, unlike structural materials. This aspect is enhanced by the fact that a large proportion of these materials are easy to transport because of their small size and that the cost of transport is in any case negligible when compared with the price of the component. Moreover, although they are strategic in their applications, these materials normally account for only a small part of the value of the articles or systems in which they are incorporated ("chips" account for only a few cents in the total value of a computer).

Generally speaking, there is a very limited range of materials able to meet a given physical characteristic. In electronics, for example, only semiconductors (and even then, by no means all of them) are able to provide the "transistor" function; in electricity, there are only a few compounds with suitable superconducting properties for use as high-field magnets; in catalysis, it is rare to find more than two elements able to bring about a reaction in acceptable selectivity conditions. It is this very restricted range which explains the frenzied efforts of both fundamental and applied research to find new compounds able to perform these functions. Controlled microscopic combinations of the 92 natural elements are definite, and it would be very rash to imagine that modern science has catalogued them more or less exhaustively.

This "technical" monopoly of the material is moreover reinforced when the material has established itself in industry. The development of increasingly efficient production processes helps to bring costs down and – when both the technical and economic criteria are taken into account – "protects" the dominant material from its competitors. For example, micro-electronics depend today largely on the use of a single material single crystal silicon because, in addition to the material' s exceptional physical properties, a whole range of production processes (gaseous diffusion, epitaxial techniques, masking, photoetching) have gradually been established which are better and better controlled and have given this material a broad spread of applications.

So any replacement of an industrially established functional material by another material requires a major technological leap. The example of molybdenum-based catalysts replaced by platinum catalysts for petroleum cracking by UOP (United States) just after the second World War is a good illustration of the difficulty of replacing one functional material by another: the obvious technical superiority of platinum (better selectivity, better stability, etc.) had been proven since the end of the 1930s. Yet it was not until the early 1950s that the investment barriers (at the time the amortization of one cracking unit was measured in tens of years) and also entrenched habits (the UOP company even went so far as to install complete platinum-based units in some refineries at its own expense in order to demonstrate their advantages) were overcome. The superiority of platinum having been demonstrated (it is true that the war had weakened resistance to it), and as a result of the decisive economic advantage obtained by the first refineries to be equipped with it, within a decade every refinery in the world had gone over to platinum catalysts (entailing huge investment).

The difficulty of substituting one functional material for another is further compounded by another of their properties, namely complementarily; this is explained below.

A functional material normally establishes itself only in close complementarity with other functional materials. Thus the development of optical fibres is closely linked to that of the materials used in connections (lasers in transmitters and diodes in detectors based on gallium arsenide, for example); similarly, the development of electronics (silicon) is closely linked to that of materials incorporated in terminal equipment (e. g. metallic oxide-based magnetic materials).

For any given type of application, therefore, a coherent set of materials which are compatible with each other gradually comes into being. Once established, that coherent set becomes difficult to "shift". Only in particular cases does a partial substitution, compatible with the rest of the system, prove possible: to some extent the replacement of copper wire by aluminium wire of carrying electricity falls into this category. But the general pattern seems to be a convergence towards complementarity among a given set of materials. This will give a measure of the evident complexity of a move from one system to another, when a major technical change takes over.

More specifically, functional materials are used in accordance with two main classes of application which need to be distinguished:

-components (microprocessors, catalysts, laser diodes, magnetic tapes, optical disks, etc.)

are the key elements used in industrial processes and articles. They are generally characterized by relatively low price as compared to that of the application which they serve.

-infrastructure materials (electric wire, optical fibres, etc.) are the links in the networks of energy and information transport. They are generally produced on a large scale and their relative price is an important parameter.

Over and above each specific application, functional materials are closely involved in defining the basis of the technical system in the sense which Bertrand Gille gives to that expression understanding far-reaching changes in the technical system involves understanding interactions between functional materials and other elements in that system-information, energy, biotechnologies. Here again there are complementaries to be considered, but this time the links of complementarity are observed between the major elements in the technical system themselves.

This "key" to interpreting the evolution of functional materials has been adopted in the following paragraphs. In particular, it enables us to underline the strategic aspects of functional materials and their crucial role in all technological development. From this point of view it can be clearly observed that certain functional materials are the starting point for veritable technological routes which can help to restructure a whole area of economic activity and which in turn condition the development of other materials "compatible" with the dominant materials in ensuring coherence in the overall system. In some cases, as in semiconductors in electronics, the impact of developing the basic material is considerable and the resultant technological route causes upheaval throughout the technical system.

Lastly, functional materials are characterized by the importance of fundamental research into them. Any country or group of countries which allowed itself to fall behind in research into functional materials would run the risk of becoming dependent upon its competitors in every application involving them. Recognition of the importance of fundamental research into functional materials is particularly obvious in all the major research projects within the EEC (EURAM, ESPRIT, RACE, BRITE, etc.) which seek to give Europe once again the structures and essential critical mass in fundamental research to withstand competition from the United States (where research into functional materials is heavily supported by the Materials Research Society vis-a-vis the federal authorities) and Japan (with massive intervention by the MITI). Mastering present developments, but also and above all breaking through new technological barriers, will in fact require even more substantial resources and concerted, coherent efforts (synchrotron, high-flux neutron reactor, space laboratory, etc.).

(*selected from Rolf E. Hummel, Understanding Materials Science History · Properties · Applications (Second Edition), Springer-Verlag New York, 2004.*)

******* New words *******

1. convey *v.* 传送；传达；转让

2. silicon *n.* ［化学］硅；硅元素（符号 Si）
3. optical *adj.* 光学的；视觉的
4. fibre *n.* 纤维；纤维制品
5. catalyst *n.* ［物化］催化剂；刺激因素
6. envisage *v.* 正视；想象
7. transistor *n.* 晶体管
8. miniaturization *n.* 小型化，微型化
9. chip *n.* ［电子］芯片；筹码；碎片；*v.* 剥落；削
10. frenzy *n.* 狂暴；狂怒；*v.* 使发狂；使狂怒
11. rash *adj.* 轻率的；鲁莽的
12. catalogue *n.* 目录；*v.* 把……编入目录
13. monopoly *n.* 垄断；垄断者
14. epitaxial *adj.* ［电子］外延的；取向附生的
15. molybdenum *n.* ［化学］钼（符号 Mo）
16. platinum *n.* ［化学］铂（符号 Pt）；白金；银灰色
17. amortization *n.* ［会计］分期偿还
18. crack *v.* 使破裂；*n.* 裂缝
19. entrench *v.* 确立；挖掘；侵犯
20. refinery *n.* 精炼厂；提炼厂；冶炼厂
21. entail *v.* 必需；承担；遗传给；蕴含；*n.* 引起；需要
22. transmitter *n.* ［电讯］发射机；［通信］发报机；传达人
23. diode *n.* ［电子］二极管
24. gallium *n.* ［化学］镓（符号 Ga）
25. arsenide *n.* ［无化］砷化物
26. aluminium *n.* ［化学］铝（符号 Al）
27. convergence *n.* ［数］收敛；集合
28. veritable *adj.* 真正的，名副其实的
29. upheaval *n.* 剧变；隆起；举起
30. synchrotron *n.* ［核］同步加速器
31. flux *n.* ［流］［机］流量；变迁；不稳定；*v.* 熔化；流出
32. neutron *n.* ［核］中子

Notes

1. Thus at any given time, functional materials define the limits within which the technical system can evolve. It is, for example, impossible today to envisage going below a size of $10^{-8}cm^2$ for a transistor using silicon technology, and this places a limit on the possibility of miniaturization in informatics. By its very nature, the functional material has a number of specific features which distinguish it from other materials.

因此在任何阶段，功能材料界定了其在技术体系发展的局限性。例如，人们至今难以想象利用硅技术制备的传感器尺寸可小于 10^{-8} cm^2，并且它限制了信息器件小型化的可能性。从本质上来说，功能材料具有区别于其他材料的众多特征。

2. Generally speaking, there is a very limited range of materials able to meet a given physical characteristic. In electronics, for example, only semiconductors (and even then, by no means all of them) are able to provide the "transistor" function: in electricity, there are only a few compounds with suitable superconducting properties for use as high-field magnets; in catalysis, it is rare to find more than two elements able to bring about a reaction in acceptable selectivity conditions.

一般情况下，直接获得具有某种物理特性的材料是受限的。例如在电子领域中，仅有半导体材料（甚至绝不仅仅是它们）能够提供给"传感器"功能：在电子领域中，仅有那些具有适宜的超导性能的复合材料才能作为高场磁体的复合材料；在催化领域中，人们很少能在所提供的可选条件下发现超过两种元素发生反应。

3. Over and above each specific application, functional materials are closely involved in defining the basis of the technical system in the sense which Bertrand Gille * gives to that expression understanding far-reaching changes in the technical system involves understanding interactions between functional materials and other elements in that system-information, energy, biotechnologies.

除过每种特殊应用之外，贝特朗·吉勒认为在技术体系中该表述具有深远意义，且针对这种变化的理解还包括了对功能材料和在系统信息、能源、生物技术领域中其他所用元素之间相互作用的理解。

* Bertrand Gille（1920 年 3 月 29 日～1980 年 11 月 30 日，出生于巴黎）是法国档案保管员和技术历史学家。虽然他以技术工作著称，但他也撰写一些不同的题材包括法国等级制度史和俄国经济史。自从他在大学从教之后，成为了 École pratique des hautes études 系主任，并在第一巴黎大学 Panthéon-Sorbonne 教授技术历史学的课程。

Exercises

1. Reading comprehensions

①Every major technological break through involves devising and using some materials **EXCEPT** ______ .

a. a specific functional material silicon for informatics

b. optical fibers for telecommunications

c. catalysts in chemistry

d. X-ray for medicals

②This aspect is enhanced by the fact that a large proportion of these materials are easy to transport because of ______ .

a. their large size and high cost of transport

b. high value of the articles or systems

c. their small size and the cost of transport is in any case negligible

d. low density of the articles

③The obvious technical superiority of platinum had been proven since ______.

a. the second World War

b. the end of 1930s

c. the early 1950s

d. 1920s

④The superiority of platinum is due to some reasons, EXCEPT ______.

a. its low toxicity

b. its better stability

c. its betters electivity

d. economic advantage

⑤Function materials are used in accordance with two main classes of application, which include ______.

a. microprocessors and catalysts

b. lasers diodes and magnetic tapes

c. optical fibers and electric wire

d. components and infrastructure materials

⑥Which can be observed from this point of view according to the interpreting of "key" ? ______

a. Functional materials has a very important role in all technological development.

b. Certain functional materials are the starting point for veritable technological routes.

c. The impact of developing the basic material is considerable.

d. The resultant technological route causes upheaval throughout the technical system.

⑦Why does any country or group of countries think they run the risk of becoming dependent upon its competitors in every application? ______

a. They allow themselves to fall behind in research into functional materials.

b. Recognition of the importance of fundamental research into functional materials is particularly obvious in all the major research projects.

c. They will require more substantial resources.

d. They will require more concerted, coherent efforts.

2. Translations

①Materials are properly more deep-seated in our culture than most of us realize. Transportation, housing, clothing, communication, reaction and food production-virtually every segment of our everyday lives is influenced to one degree or another by materials. Historically, the development and advancement of societies have been intimately tied to the members' abilities to produce and manipulate materials to fill their needs.

②The development of many technologies that make our existence so comfortable with the accessibility of suitable materials. Advancement in the understanding of a material type is often the forerunner to the stepwise progression of a technology.

③Materials that are utilized in high-technology (or high-tech) applications are sometimes termed advanced materials. By high technology we mean a device or product that operates or functions using relatively intricate and sophisticated principles; examples include electronic equipment (camcorders, CD/DVD players, etc.), computers, fiber-optic systems, spacecraft, aircraft, and military rocketry.

④With the advent of scanning probe microscopes, which permit observation of individual atoms and molecules, it has become possible to manipulate and move atoms and molecules to form new structures and, thus, design new materials that are built from simple atomic-level constituent.

3. Discussions

①Talk about what is your comprehension on functional materials and give a brief introduction in which you are interested mostly.

②What is advanced functional materials? Please give some examples.

Further reading 1 Classification and Characters of Functional Materials

A major distinction has progressively emerged in materials science and engineering, between ***structural materials*** and ***functional materials.*** Structural materials are selected for their load-bearing capacity, functional materials for the nature of their response to electrical, magnetic, optical or chemical stimuli; sometimes a functional material is even chosen for aesthetic reasons. It is much harder to define a functional material accurately than it is to distinguish a structural material.

Electrical phenomena The first observations involving electrical phenomena in materials probably began when static electricity was discovered. (Lightning, of course, preceded these experiments, but this could not be controlled by man.) Around 600 B. C., Thales of Miletus, a Greek philosopher, realized that a piece of amber, having been rubbed with a piece of cloth, attracted feathers and other light particles. Very appropriately, the word "electricity" was later coined by utilizing the Greek word electron, which means amber. It was apparently not before 2300 years later that man again became seriously interested in electrical phenomena. In 1729, Stephen Gray (a British Chemist) found that some substances conducted the "effluvium" of electricity whereas others did not. In 1733, C. F. Du Fay (a French scientist) postulated the existence of two types of electricity, which he termed glass (or vitreous) electricity and amber (or resinous) electricity, depending on which material was rubbed. Benjamin Franklin later designated to them the plus and the minus sign, implying that one type of electricity would cancel the other. His ideas were based on his famous kite experiments in 1752 in which he demonstrated "the sameness of electrical matter with that of lightning." This classification was expanded almost 100 years later to include five kinds of electricity, namely, frictional, galvanic (animal), voltaic, magnetic (by induction), and thermal.

Magnetism Magnetism (or, more precisely, ferro- or ferrimagnetism), that is, the mutual attraction of two pieces of iron or iron ore, was likewise already known to the antique world. The term "magnetism" is said to have been derived from a region in Turkey (or northern Greece?), called Magnesia, which had plenty of iron ore. Now, iron does not immediately attract another piece of iron. For this, at least one of the pieces has to be magnetized, that is, simply said, its internal "elementary magnets" need to be aligned in parallel. Magnetizing causes no problem in modern days. One merely places a piece of iron into a wire coil through which a direct current is passed for a short time. (This was discovered by the Danish physicist Hans Christian Oersted at the beginning of the 19^{th} century.) But how did the ancients do it? There may have been at least two or three possibilities. First, a bolt of lightning could have caused a magnetic field large enough to magnetize a piece of iron or iron ore. Once one magnet had been produced and identified, more magnets could have been obtained by rubbing virgin pieces of iron with the first magnet. There could have been another possibility. It is known that if a piece of iron is repeatedly hit very hard, its "elementary magnets" will be "shaken loose" and will align in the direction of the earth' s magnetic field (which is quite weak, i. e. , only about half a gauss) . An iron hammer, for example, is north magnetic on its face of impact in the northern hemisphere. Could it have been that a piece of iron was used as a hammer and thus became a permanent magnet? A third possibility is that iron- or nickel-containing meteorites responded with an alignment of their "elementary magnets" in an electromagnetic field during their immersion into the earth' s atmosphere.

One of the major applications of magnetism was the compass which is said to have been invented independently in China (before A. D. 1100, possibly before 1040) and in Western Europe (about A. D. 1187) . **Other sources emphasize that the Chinese, as early as A. D. 80 (or even earlier), had a device called a sinan, which consists of a piece of iron ore carved (by a jade cutter) into the shape of a ladle; see Fig. 1. 1. When placed on a polished plate of bronze, called the "earth plate," the spoon swiveled until the handle pointed to the south which was considered by the Chinese rulers to be the imperial direction toward which all seats had to face.** The ladle resembles the Big Dipper (or great bear) whose pointer stars point to the Polaris or North Star. Another device, the iron fish compass, described in A. D. 1044 in a Chinese book was fabricated by allowing molten iron rods to solidify in the north-south direction that is, in the earth magnetic field which induces permanent magnetism in the metal (thermo remanence) . The fish-shaped leaf was placed on water where it floated on the surface while the fish' s head pointed to the south. A Chinese book printed in 1325 describes a wooden turtle, containing a loadstone and a needle as its tail, pointing to the south. There are no reports that the Chinese used these devices for navigation probably because China was a land-based culture. They were probably used instead to align the edges of pyramids, etc. , along the north-south axis or as described above.

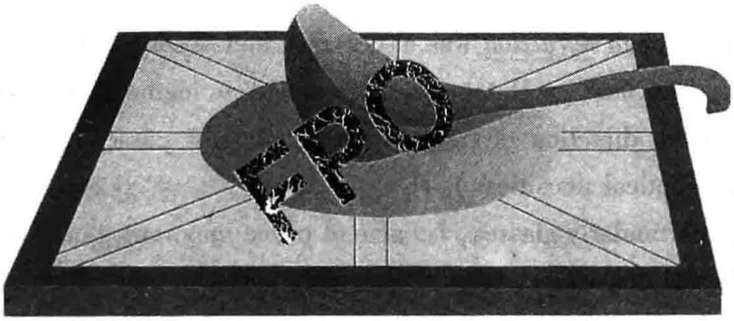

Fig. 1. 1 Depiction of an ancient Chinese compass called a *sinan* (or *Zhe' nan*, *Zhe*=point; *nan*=south)

(The spoon-shaped device was carved out of a lodestone and rested on a polished bronze plate. The rounded bottom swiveled on the "earth plate" until the spoon handle pointed to the south)

In the western world, on the other hand, the first mention of a compass was by an English Augustian monk (Alexander Neckam, 1157 - 1217) in his book entitled "De Naturis Rerum." There is also a document by an Arab writer who, in 1242, reports that a magnetic needle floating on water on top of a wooden splinter points to the north star. The bishop of Acre, Jaques Vitry, wrote in 1218 that the compass is a necessary instrument for navigation on the seas. Around 1300 the south Italian mariners of Amalfi are said to have perfected to some degree the compass from a needle floating on water to a round box (called later a "bussola") in which a compass card with a wind rose, divided into 32 points, is attached to the rotating needle. During the 15th century it was realized that the compass needle does not point to true north but assumes an angle, called variation (or declination), with the meridian. Magnetism is also mentioned in poetic works such as the Divine Comedy by Dante (written between 1310 and 1314) or in La Bible by the French monk Guyot de Provins (written about 1206). Magnetism was (and occasionally still is today) considered as a repellent against witchcraft and most anything, to heal madness and insomnia, and as an antidote against poison.

The modern compass consists quite similarly to the bussola of a pivoted bar magnet whose tip, which points to the general direction of geographic north, is called the "north-seeking pole" or simply the north pole. The bowl is suspended in gimbals, that is, in rings, pivoted at right angles to each other so that the compass is always level. Around 1500, the term lodestone appears in the literature when referring to magnetized iron ore, that is, iron oxide, particularly when used in a compass. This word is derived from the old English word lode, which means to lead or to guide.

Optical Phenomena The study of **optical** phenomena likewise goes back to antiquity. Interestingly enough, there used to be an intense debate whether in vision something moves from an object to the eye or whether something reaches out from the eye to an object. In other words, the discussions revolved around the question of whether vision is an active or a passive process. Specifically, Pythagoras, a Greek philosopher and mathematician (living during the 6th century B. C.), believed that light acts like feelers and travels from the eyes to an object and that the sensation of vision occurs when these rays touch that object. *Euclid*, a Greek mathematician, recognized at about 300 B. C. that light propagates in a straight line. Further, he related that the angle of *reflection* equals the angle of incidence when light is imping the surface between two different media. Even though *refraction* was also known and observed in the antique world, it was not before 1821 when *W. Snell*, a Dutchman, formulated its mathematical relationship. (Refraction is the change in the direction of propagation when light passes the interface between two media having different optical densities.)

Optical materials, particularly glasses, became of prime importance once the refractive power of transparent materials was discovered. This found applications in magnifying glasses and notably in telescopes. Plane and convex mirrors, as well as convex and concave lenses, were known to the Greeks and the Chinese. Their knowledge probably went back to a common source in Mesopotamia, India, or Egypt. There is written evidence that the telescope was invented independently many times before Galileo built his version in 1609. He observed with it the craters of the moon, the satellites of Jupiter, and the orbiting of Venus around the sun, thus shattering the Ptolemaic theory ($\approx$ A. D. 150). As we shall describe in Chapter 15, glass was known to the Egyptians as early as 3500 B. C., and crude lenses have been unearthed in Crete and Asia Minor that are be-