UNIT 2

The Relation of Physics to Other Sciences

Pre-Reading Activities

Open Questions

Work in groups and discuss the following questions.

1. Some say, "Physics is the most fundamental and all-inclusive of the sciences, and has had a profound effect on all scientific development." Do you agree with this view? Why?
2. Please name five physicists, including at least two from China, who have advanced our knowledge and technology of the world, and discuss their contributions.

Key Names and Concepts

Learn the key names and concepts of the upcoming passage.

1. **Richard Feynman** (理查德・费曼, 1918–1988): American theoretical physicist. Feynman reinvented quantum electrodynamics and changed how we understand the nature of waves and particles. He won the Nobel Prize in Physics in 1965. The problem-solving tools he invented, including pictorial representations of particle interactions known as Feynman diagrams, permeated many areas of theoretical physics.

2. **natural philosophy** (自然哲学): the philosophical study of nature and the physical universe that pre-dated the development of modern science. It is considered as the precursor of natural science. In ancient times, natural philosophy was the common term for the practice of studying nature, until the 19th century, when "science" took its modern form.

3. **inorganic chemistry** (无机化学): the study of materials of non-biological origin, such as metals, salts, and minerals. It focuses on studying and developing catalysts, coatings, fuels, surfactants, materials, superconductors, and drugs. Important chemical reactions include double displacement reactions, acid-base reactions, and redox reactions.

4. **the periodic table** (元素周期表): the organized arrangement of chemical elements in order of increasing atomic number. When the chemical elements are arranged in this way, there is a recurring pattern in their properties, called the "periodic law", in which elements in the same group have similar properties.

5. **Mendeleev** (门捷列夫, 1834–1907): Russian chemist who developed the first periodic table of elements. In his 1871 version of the periodic table, he left gaps in places where he believed unknown elements would find their place. He even predicted the probable properties of three of the potential elements.

6. **quantum mechanics** (量子力学): the science of studying the behavior of matter and light at the atomic and subatomic scale. It attempts to describe and explain the properties of molecules and atoms and their constituents — electrons, protons, neutrons, and other particles such as quarks.

7. **conservation of energy** (能量守恒): the principle of physics that states that the energy of interacting bodies or particles in a closed system remains constant. According to this principle, energy is neither created nor destroyed; it can only be transformed from one form to another or transferred from one system to another.

8. **(Julius Robert) Mayer** (尤利乌斯・罗伯特・迈尔, 1814–1878): German physician and physicist. He is renowned for formulating one of the earliest statements of the conservation of energy. His work laid foundation for the first law of thermodynamics, emphasizing the convertibility of energy between forms.

9. **isotope** (同位素): one of two or more types of atoms of a chemical element with the same number of protons and position in the periodic table and nearly identical chemical behavior, but with different numbers of neutrons and physical properties. Each chemical element has one or more isotopes.

10. **Louis Pasteur** (路易斯・巴斯德, 1822–1895): French chemist and microbiologist. Pasteur pioneered the study of molecular asymmetry, discovered that microorganisms cause fermentation and disease, invented the process of pasteurization, and developed vaccines against anthrax and rabies.

Key Points of the Reading

Refer to the box list for structure and key information of the passage.

Introduction
• Physics is the most fundamental and all-inclusive.

Relations with chemistry

- Inorganic chemistry is important for physics.
- Statistical mechanics helps connect physics and chemistry.
- Organic chemistry is also related to physics.

Relations with biology

- Biology contributes to the discovery of the conservation of energy.
- Physics contributes experimental techniques to biology.

Relations with astronomy

- Physics starts from interest in the motion of the stars and planets, and physics aids astronomy.
- Understanding physics can contribute to understanding astronomy.

Relations with geology

- Physics helps explain how the outside of the earth forms.
- Physics may help explain how the inside of the earth works.

How did it get that way?

- There are no historical questions in physics.
- A glass of wine resembles the relations of different disciplines.

Text Reading

The Relation of Physics to Other Sciences

By **Richard Feynman**

Introduction

[1] Physics is the most **fundamental** and **all-inclusive** of the sciences, and has had a **profound** effect on all scientific development. In fact, physics is the present-day **equivalent** of what used to be called **natural philosophy**, from which most of our modern sciences **arose**. Students

fundamental *adj.* central; forming the necessary basis of sth 基础的；基本的

all-inclusive *adj.* including everything or everyone 包括一切的；无所不包的

profound *adj.* great; felt or experienced very strongly 巨大的；深远的

of many fields find themselves studying physics because of the basic role it plays in all phenomena. In this passage we shall try to explain what the fundamental problems in the other sciences are, but of course it is impossible in so small a space to deal with the complex, **subtle**, beautiful matters in these other fields.

Relations with chemistry

[2] The science which is perhaps most deeply affected by physics is chemistry. Historically, the early days of chemistry dealt almost entirely with **inorganic chemistry**. This early chemistry was very important for physics. The interaction between the two sciences was great because the theory of atoms was **substantiated to** a large **extent** by experiments in chemistry. The theory of chemistry, i.e., of the reactions themselves, was summarized to a large extent in **the periodic table** of **Mendeleev**, which brings out many strange relationships among the various elements, and it was the collection of rules as to which **substance** is combined with which, and how, that **constituted** inorganic chemistry. All these rules were **ultimately** explained in principle by **quantum mechanics**, so that theoretical chemistry is in fact physics. On the other hand, it must be emphasized that this explanation is in principle. It turns out to be very difficult to predict **precisely** what will happen in a given chemical reaction; nevertheless, the deepest part of theoretical chemistry must end up in quantum mechanics.

[3] There is also a branch of physics and chemistry which was developed by both sciences together. This is the method of **statistics** applied in a situation in which there

equivalent *n.* a thing or amount that is equal to sth else 相等的东西；对应词

arise *v.* to happen; to start to exist 发生；产生

subtle *adj.* not very obvious or easy to notice 不易察觉的；微妙的

substantiate *v.* to provide information or evidence to prove that sth is true 证实

to... extent 在…程度上

substance *n.* a type of solid, liquid or gas that has particular qualities 物质

constitute *v.* to be the parts that together form sth 组成；构成

ultimately *adv.* in the end; finally 最终

precisely *adv.* exactly 准确地

statistics *n.* a branch of mathematics concerned with the study of information that is expressed in numbers 统计学

are mechanical laws, which is **aptly** called statistical mechanics. In any chemical situation a large number of atoms are involved, and we have seen that the atoms are all **jiggling** around in a very random and complicated way. If we could analyze each **collision**, and be able to follow in detail the motion of each molecule, we might hope to figure out what would happen, but the many numbers needed to keep track of all these **molecules** **exceed** so enormously the capacity of any computer, and certainly the capacity of the mind, that it was important to develop a method for dealing with such complicated situations. Statistical mechanics, then, is the science of the phenomena of heat, or **thermodynamics**. Inorganic chemistry is, as a science, now reduced essentially to what are called physical chemistry and quantum chemistry; physical chemistry to study the rates at which reactions occur and what is happening in detail, and quantum chemistry to help us understand what happens in terms of the physical laws.

[4] The other branch of chemistry is organic chemistry. Organic chemistry obviously has a close relationship to biology which supplies its substances, and to industry, and furthermore, much physical chemistry and quantum mechanics can be applied to organic as well as to inorganic **compounds**. However, the main problems of organic chemistry are not in these aspects, but rather in the analysis and **synthesis** of the substances which are formed in biological systems, in living things. This leads **imperceptibly**, in steps, toward biochemistry, and then into biology itself, or **molecular** biology.

aptly *adv.* in a way that is appropriate in the circumstances 适当地

jiggle *v.* to quickly move up and down or from side to side 抖动

collision *n.* an encounter between particles resulting in exchange or transformation of energy 碰撞

molecule *n.* the smallest unit, consisting of a group of atoms, into which a substance can be divided without a change in its chemical nature 分子

exceed *v.* to be greater than a particular number or amount 超过

thermodynamics *n.* the science that deals with the relations between heat and other forms of energy 热力学

compound *n.* a substance formed by a chemical reaction of two or more elements in fixed amounts relative to each other 化合物

synthesis *n.* the natural chemical production of a substance in animals and plants 合成

imperceptibly *adv.* in a small way that cannot be seen or felt 不知不觉地；察觉不到地

molecular *adj.* relating to molecules 与分子有关的

Relations with biology

[5] There was an interesting early relationship between physics and biology in which biology helped physics in the discovery of the **conservation of energy**, which was first demonstrated by **Mayer** in connection with the amount of heat taken in and given out by a living creature.

[6] If we look at the processes of biology of living animals more closely, we see many physical phenomena: the **circulation** of blood, pumps, pressure, etc. There are **nerves**: we know what is happening when we step on a sharp stone, and that somehow or other the information goes from the leg up. In their study of nerves, the biologists have come to the conclusion that nerves are very **fine tubes** with a complex wall which is very thin; through this wall the cell pumps **ions**, so that there are positive ions on the outside and negative ions on the inside, like a **capacitor**. Now this **membrane** has an interesting **property**; if it "**discharges**" in one place, i.e., if some of the ions were able to move through one place, so that the electric **voltage** is reduced there, that electrical influence makes itself felt on the ions in the neighborhood, and it affects the membrane in such a way that it lets the ions through at neighboring points also. This in turn affects it farther along, and so there is a wave of "**penetrability**" of the membrane which runs down the **fiber** when it is "excited" at one end by stepping on the sharp stone. Of course the electrical effects **associated with** this nerve **impulse** can be picked up with electrical instruments, and because there are electrical effects, obviously the physics of electrical effects has had a great deal of influence on understanding

circulation *n.* continuous movement around a place or system （液体或气体）环流，循环

nerve *n.* the fibers that carry messages between the brain and the body 神经

fine *adj.* very thin or narrow 纤细的；很细的

tube *n.* a long and hollow pipe 管子，管状物

ion *n.* an atom or a molecule with a positive or negative electric charge caused by its losing or gaining one or more electrons 离子

capacitor *n.* a device used to store an electrical charge 电容器

membrane *n.* a very thin layer in the structure of sth 薄膜

property *n.* a quality or characteristic that sth has 性质；特性

discharge *v.* to release force or power 发（力）；放（电）

voltage *n.* electrical force measured in volts 电压；伏特数

penetrability *n.* the quality of allowing sth to be pushed into or through it 穿透性

fiber *n.* thin threads that form body tissue and natural materials（身体及天然物质的）纤维

associate with 与…联系在一起

impulse *n.* a force or movement of energy that causes sth else to react 冲动；脉冲

the phenomenon.

[7] Physics is of great importance in biology and other sciences for another reason, that has to do with experimental **techniques**. The reason is that the most useful tool of all for analyzing this fantastically complex system is to label the atoms which are used in the reactions. Thus, if we could introduce into the cycle some carbon dioxide which has a "green mark" on it, and then measure after three seconds where the green mark is, and again measure after ten seconds, etc., we could **trace** out the **course** of the reactions. What are the green marks? They are different **isotopes**. The chemical properties of atoms are determined by the number of **electrons**, not by the **mass** of the **nucleus**. But there can be, for example in carbon, six **neutrons** or seven neutrons, together with the six **protons** which all carbon nuclei have. Chemically, the two atoms ^{12}C and ^{13}C are the same, but they differ in weight and they have different nuclear properties, and so they are **distinguishable**. By using these isotopes of different weights, or even **radioactive** isotopes like ^{14}C, which provide a more sensitive means for tracing very small quantities, it is possible to trace the reactions.

[8] Certainly no subject or field is making more progress on so many fronts than biology, and if we were to name the most powerful assumption of all, which leads one on and on in an attempt to understand life, it is that all things are made of atoms, and that everything that living things do can be understood in terms of the jigglings and **wigglings** of atoms.

technique *n.* a particular way of doing sth 技艺；工艺

trace *v.* to find sb/sth by looking carefully 找到；追踪

course *n.* the way sth develops or should develop 进程；进展

electron *n.* a substance with a negative electric charge in all atoms 电子

mass *n.* the quantity of material that sth contains 质量

nucleus *n.* (pl. nuclei) the part of an atom that contains most of its mass and that carries a positive electric charge 核；原子核

neutron *n.* a substance with no electric charge that forms part of the nucleus of an atom 中子

proton *n.* a substance with positive electric charge that forms part of the nucleus of an atom 质子

distinguishable *adj.* different or separate from other things or people in a way that is easy to notice or understand 可辨识的；可以区别开的

radioactive *adj.* sending out harmful radiation caused when the nuclei (= central parts) of atoms are broken up 放射性的

wiggling *n.* a small movement from side to side or up and down 摆动，扭动，起伏

Relations with astronomy

[9] In this **rapid-fire** explanation of the whole world, we must now turn to astronomy. Astronomy is older than physics. In fact, it got physics started by showing the beautiful simplicity of the motion of the stars and planets, the understanding of which was the beginning of physics. But the most remarkable discovery in all of astronomy is that the stars are made of atoms of the same kind as those on the earth. How was this done? Atoms **liberate** light which has definite frequencies. With a **spectroscope** we can analyze the frequencies of the light waves and in this way we can see the very tunes of the atoms that are in the different stars. As a matter of fact, two of the chemical elements were discovered on a star before they were discovered on the earth. **Helium** was discovered on the sun, whence its name, and **technetium** was discovered in certain cool stars. This, of course, permits us to make headway in understanding the stars, because they are made of the same kinds of atoms which are on the earth. Now we know a great deal about the atoms, especially concerning their behavior under conditions of high temperature but not very great **density**, so that we can analyze by statistical mechanics the behavior of the **stellar** substance. Even though we cannot reproduce the conditions on the earth, using the basic physical laws we often can tell precisely, or very closely, what will happen. So it is that physics aids astronomy.

[10] One of the most impressive discoveries was the origin of the energy of the stars, that makes them continue to burn. It is the nuclear "burning" of **hydrogen** which supplies the energy of the sun; the hydrogen is **converted**

astronomy *n.* the scientific study of the sun, moon, stars, planets, etc. 天文学

rapid-fire *adj.* (of questions, comments, etc.) spoken quickly, one after the other 接二连三的

liberate *v.* to release (gas or energy) as a result of a chemical reaction or physical decomposition 释放

spectroscope *n.* a piece of equipment for forming and looking at spectra 分光镜

helium *n.* a very light gas that does not burn 氦；氦气

technetium *n.* a chemical element found as a product of uranium 锝

density *n.* the thickness of a solid, liquid or gas measured by its mass per unit of volume 密度

stellar *adj.* connected with the stars 星的；恒星的

hydrogen *n.* the lightest gas 氢；氢气

convert *v.* to change or make sth change from one form, purpose, system, etc. to another （使）转变，转换，转化

into helium. Furthermore, ultimately, the manufacture of various chemical elements proceeds in the centers of the stars, from hydrogen. The stuff of which we are made was "cooked" once in a star and spit out. How do we know? Because there is a clue. The proportion of the different isotopes — how much ^{12}C, how much ^{13}C, etc., is something which is never changed by chemical reactions, because the chemical reactions are so much the same for the two. The proportions are purely the result of nuclear reactions. By looking at the proportions of the isotopes in the cold dead **ember** which we are, we can discover what the **furnace** was like in which the stuff of which we are made was formed. That furnace was like the stars, and so it is very likely that our elements were "made" in the stars and spit out in the explosions which we call **novae** and supernovae. Astronomy is so close to physics that we shall study many astronomical things as we go along.

ember *n.* a piece of wood or coal that is not burning but is still red and hot 余火未尽的木块或煤块

furnace *n.* a space surrounded on all sides by walls and a roof for heating metal or glass to very high temperatures 熔炉

nova *n.* a star that suddenly becomes much brighter for a short period 新星

erosion *n.* the process by which the surface of sth is gradually destroyed through the action of wind, rain, etc. 侵蚀

Relations with geology

[11] We turn now to what is called earth sciences, or geology. The question basic to geology is, what makes the earth the way it is? The most obvious processes are the **erosion** processes of the rivers and the winds. It is easy enough to understand these, but for every bit of erosion there is an equal amount of something else going on. Mountains are no lower today, on the average, than they were in the past. There must be mountain-forming processes. But what pushes, and why? The theory is that there are currents inside the earth — circulating currents, due to the difference in temperature inside and outside — which, in their motion, push the surface slightly. Thus if

there are two opposite circulations next to each other, the matter will collect in the region where they meet and make belts of mountains which are in unhappy stressed conditions, and so produce volcanoes and earthquakes.

[12] What about the inside of the earth? A great deal is known about the speed of earthquake waves through the earth and the density of distribution of the earth. However, physicists have been unable to get a good theory as to how dense a substance should be at the pressures that would be expected at the center of the earth. In other words, we cannot figure out the properties of matter very well in these circumstances. We do much less well with the earth than we do with the conditions of matter in the stars. The mathematics involved seems a little too difficult so far, but perhaps it will not be too long before someone realizes that it is an important problem, and really works it out. The other aspect, of course, is that even if we did know the density, we cannot figure out the circulating currents. Nor can we really work out the properties of rocks at high pressure. We cannot tell how fast the rocks should "give"; that must all be worked out by experiment.

How did it get that way?

[13] There is a kind of problem in the sister sciences which does not exist in physics: the historical question. How did it get that way? If we understand all about biology, we will want to know how things on the earth got there. There is the theory of evolution. In geology, we not only want to know how the mountains are forming, but how the entire earth was formed in the beginning. How did the stars evolve? What were the initial conditions? That is

the problem of astronomical history. There is no historical question being studied in physics at the present time. We do not have a question, "Here are the laws of physics, how did they get that way?"

[14] A poet once said, "The whole universe is in a glass of wine." It is true that if we look at a glass of wine closely enough we see the entire universe. There are the things of physics: the twisting liquid which **evaporates** depending on the wind and weather, the reflections in the glass, and our imagination adds the atoms. The glass is a **distillation** of the earth's rocks, and in its composition we see the secrets of the universe's age, and the evolution of stars. There are the **ferments**, the **enzymes**, the **substrates**, and the products. There in wine is found the great generalization: all life is fermentation. Nobody can discover the chemistry of wine without discovering, as did **Louis Pasteur**, the cause of much disease. If our small minds divide this glass of wine, this universe, into parts — physics, biology, geology, astronomy, psychology, and so on — remember that nature does not know it! So let us put it all back together, not forgetting ultimately what it is for. Let it give us one more final pleasure: drink it and forget it all!

(2,229 words)

evaporate *v.* to change into a gas, especially steam（使）蒸发，挥发

distillation *n.* the process of making a liquid pure by heating it 蒸馏

ferment *n.* a living organism (such as a yeast) that causes fermentation by virtue of its enzymes 酵素

enzyme *n.* a substance that helps a chemical change happen or happen more quickly, without being changed itself 酶

substrate *n.* a substance or layer which is under sth or on which sth happens, for example the surface on which a living thing grows and feeds 培养基，基质，基层

Online Exercises

Post-Reading Activities

SECTION ❶
Reading Comprehension

1 True or False Questions

Decide if each of the following statements is TRUE or FALSE.

1) According to the author, the discipline of physics is all-encompassing of other subjects and is thus superior to other disciplines.
2) The difference between inorganic and organic chemistry is that the former can be investigated through physical chemistry and quantum chemistry while the latter cannot.
3) According to the passage, neural responses and blood circulation, despite topics in biology, can be understood from the perspective of physics.
4) The passage suggests that physics and astronomy are related because both the universe and mankind use helium, technetium and hydrogen as the primary source of energy.
5) While physics helps explain many geological processes, the existing knowledge and techniques of physics are insufficient for us to understand the processes inside the earth.

2 Language in Focus

Paraphrase the following sentences.

1) ... but the many numbers needed to keep track of all these molecules exceed so enormously the capacity of any computer, and certainly the capacity of the mind, that it was important to develop a method for dealing with such complicated situations.

____

____

2) Of course the electrical effects associated with this nerve impulse can be picked up with electrical instruments, and because there are electrical effects, obviously the physics of electrical effects has had a great deal of influence on understanding the phenomenon.

____

____

3) Now we know a great deal about the atoms, especially concerning their behavior under conditions of high temperature but not very great density, so that we can analyze by statistical mechanics the behavior of the stellar substance.

3 Translation

Translate the following sentences into Chinese.

1) The interaction between the two sciences was great because the theory of atoms was substantiated to a large extent by experiments in chemistry.

2) The chemical properties of atoms are determined by the number of electrons, not by the mass of the nucleus.

3) By using these isotopes of different weights, or even radioactive isotopes like ^{14}C, which provide a more sensitive means for tracing very small quantities, it is possible to trace the reactions.

4) The theory is that there are currents inside the earth — circulating currents, due to the difference in temperature inside and outside — which, in their motion, push the surface slightly.

5) However, physicists have been unable to get a good theory as to how dense a substance should be at the pressures that would be expected at the center of the earth.

SECTION ❷
Putting It Together

A poster for an exhibition in a science museum

The science museum in your city is hosting an exhibition called “Physics Milestones: A Chinese Journey” to introduce key figures and development of the field in China to the public. The museum invites college students to contribute educational posters. You and your team decide to participate in this activity and create a poster for it.

Following are steps to help you accomplish this activity.

Step 1. Team up

Form small groups to combine diverse skills and ideas.

Step 2: Pick a topic

Choose an aspect to focus on, for example, a notable Chinese physicist, a significant theory/discovery, or a future prospect in physics.

Step 3: Gather information

Conduct research on your topic using reliable sources in order to gather key details and intriguing facts.

Step 4: Outline your poster

Decide on the main points to cover: a brief introduction, main content (biography, theory, impact), and an engaging fact or quote.

Step 5: Design your poster

Draw your poster, or use a simple tool like Canva or PowerPoint to complete the poster, focusing on a clear layout, readable text, and relevant images or diagrams.

Tips:

Keep language clear and straightforward, use visuals to explain complex ideas, and add an interactive element, like a QR code, to make your work more interesting.

SECTION ❸
Self-Reflection

Check to what degree you have achieved the following goals.

Language	
Vocabulary	• I can understand and spell the new words highlighted in the text. • I can use the new words to make sentences.
Key concepts	• I can translate the key concepts from English to Chinese and vice versa. • I can explain the key concepts in English.
Sentences	• I can understand most sentences in the text. • I can translate most sentences in the text.
Text Reading	
Skills	• I can distinguish between the main idea and supporting details in the text.
Comprehension	• I can draw a mind map to illustrate the structure of the text.
Critical thinking	• About the topic, I have my own view and can justify my view with relevant information.
Putting It Together	
Skills	• I can design and create an educational poster using precise and accurate language.
Structure	• I can organize the content of the educational poster in a logical and effective manner to enhance the viewers' understanding.
Integrated use	• I can clearly articulate a central message in my poster and back it up with succinctly presented, relevant information and visual aids.