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A comparative study of experiments in the PEP and the Hong Kong Oxford edition of senior high school biology textbooks—A case study in the “molecules and cells” module of the PEP edition

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Abstract. This paper conducts a comparative analysis of scientific methods and three representative experiments—namely, the identification of organic substances, factors affecting enzyme activity, and factors affecting photosynthesis—in the mainland People’s Education Press (PEP) edition and the Hong Kong Oxford edition of senior high school biology textbooks. It explores the characteristics and differences between the two sets of textbooks in terms of their treatment of scientific methods, definitions of the nature of science, as well as experimental design and the selection of experimental materials. Compared with the PEP edition, the Hong Kong Oxford edition provides a more detailed exposition and analysis of scientific methods and incorporates additional content on the nature of science. Its experimental designs are more flexible, procedures simpler and more feasible, and the number of experiments greater with stronger emphasis on practical engagement. It also places greater emphasis on cultivating students’ abilities in data processing and analysis, as well as in interpreting results and drawing conclusions. These differences offer valuable insights for the future revision of experimental components in PEP biology textbooks.

Keywords: PEP biology textbooks, Hong Kong Oxford biology textbooks, comparative textbook study, biology experiments

1. Introduction

With the promulgation of the *General High School Biology Curriculum Standards (2017 Edition, revised in 2025)* (hereinafter referred to as the "New Curriculum Standards") and the *Compulsory Education Curriculum Standards (2022)*, alongside the continuous advancement of curriculum development and pedagogical reform in secondary education, the importance of biology textbooks in secondary schools has become increasingly prominent. Among these, the experimental components of biology textbooks play a crucial role in cultivating students' scientific literacy and practical competence. At present, there exist certain differences between Hong Kong and mainland China in terms of educational systems and teaching philosophies. These differences are

also reflected in the design of experiments and the selection of experimental materials in biology textbooks. To examine the distinctive features and differences between Hong Kong and mainland senior high school biology textbooks with respect to the fundamental steps of scientific methods, the definition of the nature of science, as well as experimental design and material selection, this study selects two representative textbooks for comparative analysis: *Biology, Compulsory 1*, published in 2019 by the People's Education Press (hereinafter referred to as the "PEP biology textbook"), and *New Senior Secondary Mastering Biology (Third Edition)*, published by Oxford University Press for use in Hong Kong (hereinafter referred to as the "Oxford biology textbook").

The New Curriculum Standards explicitly establish the central role of core competencies in biology, among which the cultivation of scientific inquiry is of particular importance. Students are expected to learn and master the approaches and methods of scientific inquiry, develop a spirit of collaboration, and become adept at exploring or attempting to solve real-life problems from a practical perspective [1]. Accordingly, this study first compares the presentation of scientific methods in the PEP and Oxford biology textbooks. It then takes three experiments—the identification of organic substances, factors affecting enzyme activity, and factors affecting photosynthesis—as case studies, conducting a comparative analysis from the perspectives of experimental principles, materials, methods, procedures, and the interpretation of results and conclusions. The aim is to identify the high-quality features of the experimental modules in the Oxford biology textbook and to provide reference points for future revisions of experimental teaching in the PEP biology textbook.

2. Comparison of scientific methods: emphasizing the scientific rigor and validity

The New Curriculum Standards explicitly define "scientific inquiry" as the ability to identify biological problems in the real world and, in response to specific biological phenomena, to conduct observation, questioning, experimental design, implementation, and the communication and discussion of results [1]. The PEP biology textbook does not present scientific methods in a dedicated section. However, in Chapter 5 of Compulsory Module 1, "*Energy Supply and Utilization in Cells*," specifically in Section 1, "*Enzymes that Lower the Activation Energy of Chemical Reactions*," students are guided through an inquiry experiment on the "factors affecting enzyme activity," which implicitly introduces eight key steps of scientific inquiry: posing questions, making hypotheses, designing experiments, conducting experiments, analyzing results, drawing conclusions and applications, expressing and communicating findings, and further inquiry [2]. In contrast, the Oxford biology textbook explicitly presents scientific methods in Chapter 1, "*Introduction to Biology*," Section 2, "*How to Study Biology.*" Through an analysis of Spallanzani's investigation of bats in 1790, it outlines six fundamental steps of the scientific method (see Figure 1): careful observation, formulation of questions, hypothesis generation, prediction, hypothesis testing, and conclusion [3]. Compared with the PEP textbook, the Oxford edition explicitly incorporates "careful observation" and "making predictions" as essential steps, emphasizing that experimental results should be compared with predictions in order to confirm or refute hypotheses. This highlights the importance of meticulous observation in routine experimental teaching and suggests that predictions should be formulated following the establishment of hypotheses.

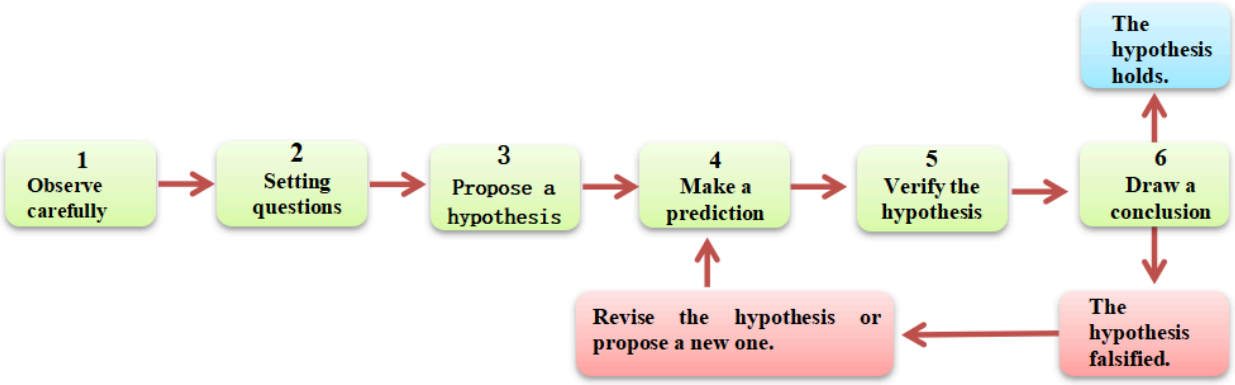

Figure 1. Fundamental steps of the scientific method in the Oxford biology textbook [3]

The PEP biology textbook does not provide a definition of "hypothesis," whereas the Oxford biology textbook defines it as "a reasonable explanation proposed by scientists for a given question, based on their background knowledge, logical reasoning, and imagination," and further emphasizes that a hypothesis must be testable. Moreover, the Oxford textbook clarifies, through the example of "investigating changes in the population of the Chinese white dolphin over the past decade," that inquiries not requiring explanation of observational results do not necessitate the formulation of a hypothesis [3].

Biological science education constitutes an important domain of science education, and science education should inherently reveal and enable students to comprehend the nature of science [4]. Students' understanding of the nature of scientific inquiry fundamentally shapes how they perceive all aspects of inquiry activities [5]. The PEP biology textbook does not explicitly address the "nature of science," mentioning only the "scientific spirit" in certain historical contexts of biology. By contrast, the Oxford biology textbook provides a clear definition in Chapter 1, Section 3, "*The Nature of Science*," describing it as "what science is and how science works." It further guides students' understanding of this concept through the experimental processes of four scientists involved in the refutation of spontaneous generation (see Table 1) [3]. Through engagement with the concept of the nature of science, students develop a more concrete understanding of the relationships among science, technology, and society, which contributes to the cultivation of a rigorous and professional scientific attitude and scientific spirit.

Table 1. Common aspects of the nature of science in the oxford biology textbook and their evidence in the refutation of spontaneous generation [3]

Nature of Science	Evidence
Reasonable skepticism drives scientific progress.	Although the idea of spontaneous generation had persisted for thousands of years, Redi questioned its validity. This skepticism motivated his investigation and contributed to the eventual refutation of the theory.
Experimentation requires creativity and imagination.	Redi devised a method to separate flies from meat in a jar using gauze.
A sound experiment must include one or more well-designed control groups.	Redi set up both open jars containing meat and jars covered with gauze as control conditions.

Table 1. Continued

Science is an ongoing process of inquiry. /Scientific research builds upon the work of others.	Based on Redi's findings, subsequent scientists continued to investigate the validity of spontaneous generation.
Scientists must explore and apply diverse techniques and methods to improve research design.	Spallanzani refined Needham's experiment by extending the boiling time of broth and sealing the flask.
Scientific development is influenced by contemporary technology and equipment.	The invention of the microscope enabled scientists to discover microorganisms in the air.
Scientific knowledge is provisional and subject to change.	Scientists no longer accept that microorganisms arise spontaneously from nonliving matter.

3. Comparison of organic substance identification experiments: emphasizing experimental flexibility

The experiment on "Food Substance Testing" in Chapter 5, "*Food and Humans*," of the Oxford biology textbook [3], and the experiment on "*Detection of Sugars, Lipids, and Proteins in Biological Tissues*" in Chapter 2, "*Molecules that Make Up Cells,*" of Compulsory Module 1 in the PEP biology textbook [2], share substantial similarities. Both focus on the identification of organic substances and include tests for starch, reducing sugars, lipids, and proteins. However, the Oxford biology textbook extends this scope by additionally incorporating the testing and identification of glucose and vitamin C. Meanwhile, notable differences exist between the two textbooks in terms of experimental materials, methods, and results.

With respect to experimental materials, both textbooks emphasize accessibility and low cost. The Oxford biology textbook, however, further includes the preparation of glucose and vitamin C solutions and employs edible oil as a testing material for lipids through the grease-spot test.

In terms of experimental methods, the PEP biology textbook uses Fehling's reagent to identify reducing sugars, whereas the Oxford biology textbook employs Benedict's solution. In Benedict's solution, sodium citrate replaces sodium hydroxide in combination with copper sulfate, allowing the reagent to be used without the need for fresh preparation. For lipid detection, the PEP biology textbook adopts Sudan III staining combined with microscopic observation, while the Oxford biology textbook utilizes the grease-spot test (see Figure 2). For protein identification, the PEP biology textbook uses the Biuret reagent, whereas the Oxford biology textbook employs protein test strips. In addition, the Oxford textbook uses glucose test strips to detect glucose and DCPIP solution to test for vitamin C.

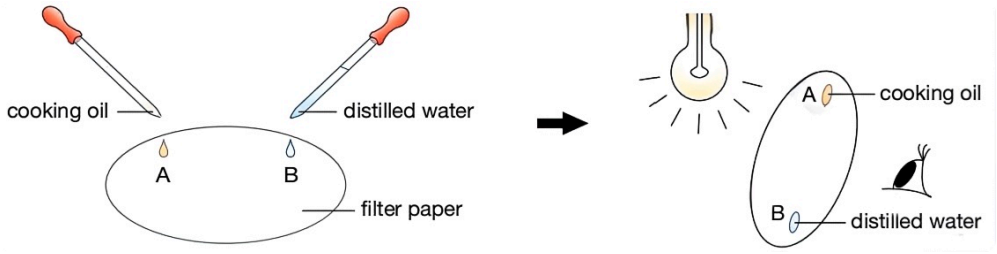

Figure 2. Procedure of the grease-spot test in the Oxford biology textbook [3]

Regarding experimental results, in the PEP biology textbook, lipid detection with Sudan III produces orange-colored fat droplets observable under a microscope. In contrast, in the Oxford biology textbook's grease-spot test, a drop of edible oil placed on filter paper produces a translucent bright spot under light; further investigation involves immersing the filter paper in an organic solvent (such as ethanol), after which the translucent spot disappears. The Oxford biology textbook also employs protein and glucose test strips, which yield results through observable color changes. When testing vitamin C with DCPIP solution, the result is a color change from blue to colorless.

From the above comparative analysis, it can be observed that, relative to the PEP biology textbook, the Oxford biology textbook features more flexible experimental design and more life-oriented experimental methods. This approach effectively narrows the distance between the textbook and students, fostering greater interest and engagement in experimental activities, and thereby enhancing students' hands-on operational skills and their capacity for experimental design.

4. Comparison of experiments on factors affecting enzyme activity: emphasizing the cultivation of students' abilities in result analysis and conclusion drawing

A comparative analysis is conducted between the inquiry experiment "*Factors Affecting Enzyme Activity*" in Section 1, "*Enzymes that Lower the Activation Energy of Chemical Reactions*," of Chapter 5, "*Energy Supply and Utilization in Cells*," in Compulsory Module 1 of the PEP biology textbook [3], and the experiments "*Investigating the Effect of Temperature on Enzyme Activity*" and "*Designing an Experiment to Investigate the Effect of pH on Enzyme Activity*" in Section 3, "Factors Affecting Enzyme Activity," of Chapter 4, "Enzymes and Metabolism," in the Hong Kong Oxford biology textbook [2] (see Figure 3). The two sets of experiments differ in several respects, including experimental design, materials, and procedures.

In terms of experimental design, the PEP biology textbook approaches the experiment on temperature effects within the framework of the eight-step scientific inquiry process. It guides students to independently design experiments through a sequence of structured questions, thereby fostering their scientific inquiry competence. By contrast, the Oxford biology textbook organizes the same experiment into three sections: introduction, procedure, and results and discussion. In the procedure section, it provides detailed operational steps accompanied by schematic illustrations, which effectively reduces the difficulty of experimental execution.

Regarding experimental materials, in the experiment on the effect of pH on enzyme activity, the PEP biology textbook recommends the use of catalase, whereas the Oxford biology textbook suggests using an amylase solution. Furthermore, the PEP textbook prepares solutions of different pH values using 0.01 mol/L hydrochloric acid, 0.01 mol/L sodium hydroxide, and buffer solutions. In contrast, the Oxford textbook directly employs citrate–phosphate buffer solutions of specified pH values (pH 5, 6, 7, 8, and 9), simplifying the preparation process.

In terms of experimental procedures, for the investigation of temperature effects on enzyme activity, the Oxford biology textbook explicitly instructs that 1 cm^3 of amylase solution and 5 cm^3 of starch solution should first be placed in water baths at different temperatures for 10 minutes before being mixed. This ensures that the reaction mixture reaches the designated temperature prior to the start of the reaction. The PEP biology textbook does not explicitly specify this step, nor does it provide sufficiently detailed procedural guidance, requiring teachers to supplement instructions during classroom teaching, which may increase the difficulty for students.

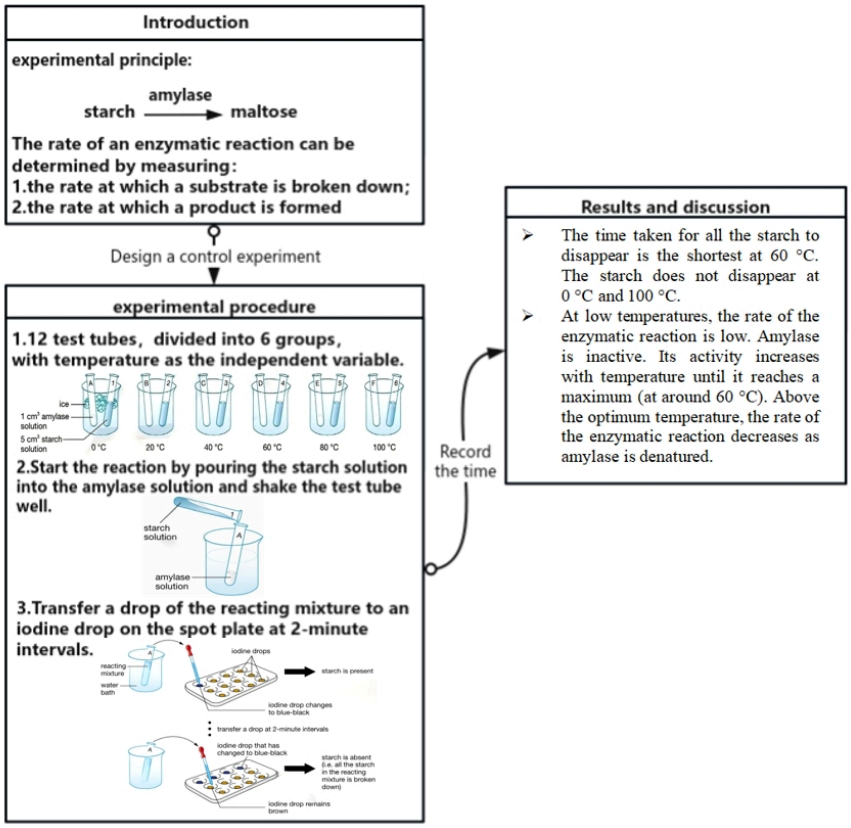

Figure 3. Experimental design for "Investigating the Effect of Temperature on Enzyme Activity" in the Oxford biology textbook [3]

From the above comparison, it can be seen that the PEP biology textbook emphasizes collaborative learning by encouraging students to "formulate group experimental plans through discussion" and, after drawing conclusions, to "communicate with other groups" and "respond to inquiries from peers" [6]. This reflects a strong focus on cultivating students' scientific inquiry abilities through cooperation and interaction, albeit with relatively higher operational difficulty. In contrast, the Oxford biology textbook reduces experimental difficulty by providing explicit procedures and visual guides, while placing greater emphasis on developing students' abilities in analyzing experimental results and formulating conclusions.

5. Comparison of experiments on factors affecting photosynthesis: emphasizing the development of students' data processing and analytical skills

A comparative analysis was conducted between the experiment "*Investigating the Effect of Environmental Factors on Photosynthesis Intensity*" in the "*Application of Photosynthesis Principles*" module of Section 4, "*Photosynthesis and Energy Transformation*," Chapter 5 of Compulsory Module 1 in the PEP biology textbook [2], and the experiment "Investigating the Effect of Light Intensity on Photosynthetic Rate" in Section 6, "*Factors Affecting Photosynthesis,*" Chapter 20, "*Photosynthesis*," of the Hong Kong Oxford

biology textbook [7]. Both experiments examine how light intensity influences photosynthesis, but they differ in experimental principles, materials, methods, and the handling of results and conclusions.

Regarding experimental principles, the PEP biology textbook relies on the principle that oxygen release during photosynthesis causes small circular leaf discs to float. The number of floating discs is recorded to determine the photosynthetic intensity under different light conditions. In contrast, the Oxford biology textbook measures the volume of oxygen released per unit time using a pipette to track changes in liquid level, thereby calculating the photosynthetic rate at different light intensities.

In terms of experimental materials, the PEP biology textbook uses green leaves from plants such as spinach or spider plants. Circular leaf discs are punched out, and existing gases within the discs are expelled using a syringe. The Oxford biology textbook uses *Chlorella* (green algae) as the experimental material.

For experimental methods, the PEP biology textbook employs a 5 W LED lamp as the light source and adjusts light intensity by changing the distance between the lamp and a small beaker, setting up three experimental groups: strong, medium, and weak light. The Oxford biology textbook uses a desk lamp as the light source and places a water bath between the lamp and the beaker to eliminate the influence of heat from the lamp (see Figure 4). The lamp is positioned at distances of 0.1 m, 0.2 m, 0.3 m, 0.4 m, and 0.5 m from the *Chlorella*, creating five experimental groups for comparison.

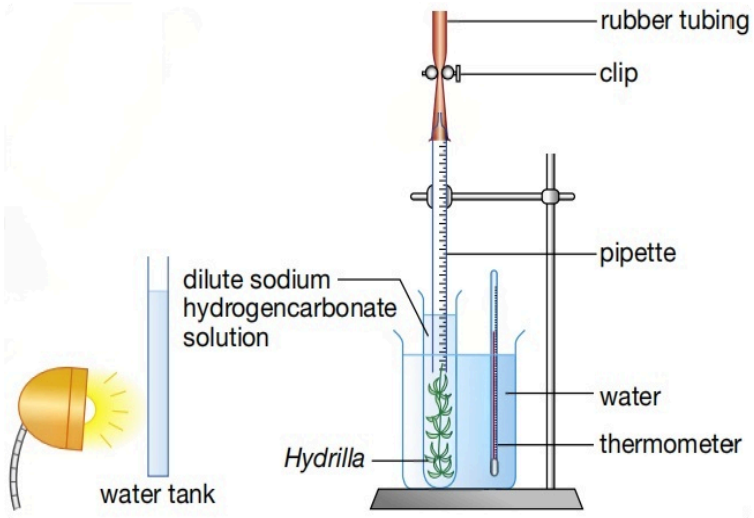

Figure 4. Experimental setup for investigating the effect of light intensity on photosynthetic rate in the Oxford biology textbook [7]

In terms of results and conclusions, the PEP biology textbook records the number of floating leaf discs under strong, medium, and weak light to assess photosynthetic intensity. By contrast, the Oxford biology textbook calculates photosynthetic rate based on the volume of oxygen released per unit time by *Chlorella* under different light intensities. The results are presented in tables (Table 2) and plotted in graphs (Figure 5), providing a more intuitive visualization of how light intensity affects photosynthesis, facilitating more accurate conclusions.

The two textbooks therefore differ in experimental principles, materials, methods, and result handling. While the PEP biology textbook experiment is easier to perform, the low power of the 5 W LED lamp may lead to unclear differentiation between light intensities and greater measurement error, making data interpretation relatively subjective [8]. The Oxford biology textbook experiment is slightly more complex, but the ability to display data in tables and graphs allows students to directly observe the impact of light intensity

on photosynthetic rate, emphasizing the development of students' data processing and analytical skills. This comparison highlights that while the PEP biology textbook prioritizes operational simplicity, the Oxford biology textbook better cultivates students' abilities to process and analyze experimental data, thereby reinforcing critical scientific skills.

Table 2. Experimental results for the effect of light intensity on photosynthetic rate in the Oxford biology textbook [7]

Distance (d, m)	Light Intensity ($1/d^2$)	Gas Volume Released in 5 min (cm^3)				Photosynthetic Rate ($cm^3 \cdot min^{-1}$)
		Reading 1	Reading 2	Reading 3	Mean	
0.1	100	0.26	0.25	0.24	0.25	0.05
0.2	25	0.24	0.26	0.25	0.25	0.05
0.3	11	0.22	0.23	0.21	0.22	0.04
0.4	6	0.14	0.15	0.16	0.15	0.03
0.5	4	0.06	0.04	0.05	0.05	0.01

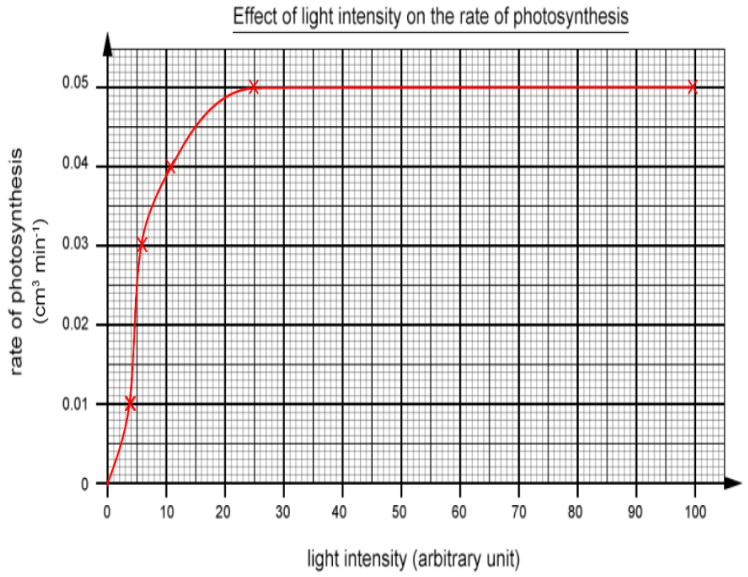

Figure 5. Graph showing the effect of light intensity on photosynthetic rate in the Oxford biology textbook [7]

6. Conclusion and outlook

In summary, the PEP high school biology textbook from mainland China places greater emphasis on the logic of scientific inquiry, focusing on cultivating students' logical thinking, experimental skills, and other abilities. Its experimental design is more laboratory-oriented, highlighting laboratory safety and the protection of students' personal safety. In terms of teaching methods, it stresses systematic knowledge and the scientific structure of content. The Hong Kong Oxford high school biology textbook, on the other hand, features a larger number of experiments that are more flexible in content arrangement and closely linked to daily life. Its experimental designs are more practical; for example, the oil spot experiment can be conducted and observed by students at home, emphasizing the cultivation of students' observational and comparative thinking skills in daily life. The textbook also emphasizes rigor and scientific accuracy, particularly in the setup of experimental

and control apparatus to ensure reliability. Furthermore, the handling of experimental results and conclusions focuses on developing students' abilities to process data, analyze results, and draw conclusions. Additionally, the Oxford textbook generally presents experiments that are easier to perform, with clear operational steps, diagrams, and specific apparatus setups, making the procedure straightforward and transparent.

Based on the above comparative analysis, future revisions of the PEP biology textbook could include detailed operational steps, diagrams, and specific apparatus setups to reduce experimental difficulty and make experiment design more accessible, thereby enhancing feasibility. In selecting experimental materials and designing experiments, greater flexibility could be introduced to bring experiments closer to students' everyday experiences, enhancing their observational skills, problem-posing abilities, and hands-on understanding of biological science.

This study is based on the analysis of selected experiments from the PEP and Hong Kong Oxford biology textbooks. The selection of experiments has certain limitations, the scope of the research is restricted, and the methodology is relatively singular. Future comparative studies could expand the range of experiments analyzed and further investigate the effectiveness of experimental teaching.

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