Scientific and Social Research, 2025, Volume 7, Issue 8
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Practical Understanding of High School Students' Application of AI in Biological Cell Research

Yike Ding*

Victoria Shanghai Academy (VSA), Hong Kong, China

**Author to whom correspondence should be addressed.*

Abstract: With the penetration of Artificial Intelligence (AI) technology into the field of biomedicine, "AI + Biology" has gradually become a new growth point in secondary science education. This article explores the club's teaching cases, analyzing how high school students use AI tools to observe cell morphology, collect statistical data, and explore mechanisms. The study examines the transformation of AI technology in knowledge construction, scientific thinking, and innovative thinking, and discusses the value of this technology in practical biology teaching at the secondary level, providing empirical reference for cultivating the core literacy of biology among secondary students.

Keywords: High school students; AI; Biological cells; Practice

Online publication: September 17, 2025

1. Introduction

Humans are in the technological wave of the 21st century, where the integration of Artificial Intelligence (AI) and biology is pushing the boundaries of scientific research at an unprecedented speed. As high school students, the emerging force of the future scientific community, using AI technology in learning biological cell research and combining education with scientific research innovation, allows people to gain a deeper understanding of knowledge points. This article focuses on "biological cells" and analyzes how high school students apply AI technology to complex problems in cell biology. This reality not only witnesses the popularization of technology and the innovation of education, but also reveals the potential of young students to solve practical health problems, such as identifying key targets for cancer treatment and developing interactive learning resources. These practices enrich adolescents' scientific exploration experiences and bring new developmental enlightenment to traditional education.

2. Practical understanding of high school students' application of AI in biological cell research: A case study based on the biology club of XX High School

2.1. Tool selection

Based on the requirements of biology, the students formed a biology club. During the process of conducting biological cell research, the members selected suitable AI tools through literature research and teacher guidance.

The selected tools include: 1) Cell image recognition tools such as "CellProfiler" and "DeepCell", which can automatically analyze the morphology of cells under the microscope, such as area, roundness, and fluorescence intensity, replacing traditional manual measurement operations; 2) Molecular simulation platforms such as "MolView" and "PyMOL Junior", which can visually present the dynamic interactions of intracellular molecules, helping us understand the cell's metabolic processes; 3) Data statistics and forecasting models, which can be accessed through platforms like "Excel + Python scripts" or "R Language Easy Tutorial." These platforms can process multiple sets of experimental data, generate trend charts based on the data, and predict variable relationships.

2.2. Practical tasks

In this high school club learning task, with the theme of "The Effect of Drugs (such as Paclitaxel) on the Proliferation of Cervical Cancer Cells (HeLa Cells)", practical learning will be conducted in stages:

2.2.1. Stage 1: AI-assisted cell morphology recording

In traditional teaching methods, students need to manually observe and draw cell morphology under a microscope, which is a time-consuming process and susceptible to subjective errors. In practice, the club members use an inverted microscope to capture images of HeLa cells, which are then uploaded to "DeepCell." The platform automatically identifies cell boundaries through a trained Convolutional Neural Network (CNN) model, and generates a "cell area—time change curve." The AI tool can produce results within 1 minute. Based on the results, annotations are made: abnormally shrinking cells may be a signal of apoptosis.

2.2.2. Stage 2: AI simulation of molecular interactions

To explore "how paclitaxel inhibits cell division", in the course of research, the students used the "MolView" platform to build a 3D molecular model of paclitaxel (Taxol) and tubulin. On the model, the students adjusted the molecular conformation to observe binding sites, and combined the theory of "paclitaxel stabilizes microtubules" in the literature, using "PyMOL Junior" to simulate the dynamic changes presented during microtubule polymerization. The students found that through AI simulation, the process of microtubule over-stabilization leading to cell non-separation is far more intuitive and specific than the illustrations in textbooks (**Table 1**).

Table 1. Simulated data for high school biology research practice

Research step	AI tools/platforms used	Specific operations and findings
Molecular Structure Visualization	MolView	Constructed 3D models of paclitaxel and β-tubulin, observed paclitaxel binding at the "Taxol binding site" (hydrophobic groove of β-subunit)
Conformational Analysis	MolView dynamic adjustment	Rotating models revealed that the C-13 side chain of paclitaxel forms hydrogen bonds with M-loop residues of tubulin (e.g., His229), restricting microtubule depolymerization
Dynamic Process Simulation	PyMOL Junior	Simulation showed: in the presence of paclitaxel, microtubule fibers (13 protofilaments) remained intact during mitosis without normal depolymerization curves
Cellular Effect Validation	Microscope imaging + AI analysis	Comparison with the control group (untreated HeLa cells) showed: after 24-hour treatment with 10nM paclitaxel, the proportion of cells in mitosis increased by 300%
Dose-Effect Analysis	Excel data modeling	IC50 calculation showed: paclitaxel inhibited 50% of HeLa cell proliferation at 7.8±0.5nM concentration (detected by CCK-8 assay)

2.2.3. Stage 3: AI-driven scientific thinking training

Through practical simulations, the students obtained corresponding experimental data, such as control group experiments, low-concentration drug groups, and high-concentration drug groups. Then, we input these data into a Python script and use linear regression analysis to investigate the correlation between drug concentration and cell proliferation rate. Based on the conclusion the students obtained from practice: "Morphological changes in cells in the low-concentration group precede proliferation inhibition", the students engage in a series of discussions and debates on whether the effect is due to direct drug toxicity or indirect signal interference. Through debate and AI-assisted literature review, the students arrive at the hypothesis that "it may trigger cell autophagy" [1]. This process involves recording experimental data, interpreting data, and verifying conclusions, which cultivates scientific thinking and has a positive effect on scientific thinking training.

3. Practical application of AI in biological cell research by high school students

3.1. Systematic development of knowledge construction

In traditional classrooms, teaching knowledge about cell structures such as mitochondria, endoplasmic reticulum, and their functions often exists in isolation as "knowledge points." The application of AI tools in the new era enables people to build a "structure-function-dynamics" cognitive connection in their minds, achieving systematic development of knowledge structures. For example, when analyzing "mitochondrial morphological changes and apoptosis", through AI image recognition, the students discover that "apoptotic cell mitochondria fragment into pieces." By combining this with observations from a molecular modeling platform, the students see that "cytochrome C is released from mitochondria and activates apoptotic proteins." Finally, a complete logical chain of "mitochondria → functional abnormalities → apoptotic signal transmission" is formed in the mind (**Figure 1**). This helps the students engage in deeper learning, as AI connects static knowledge from textbooks into a dynamic knowledge system [2].

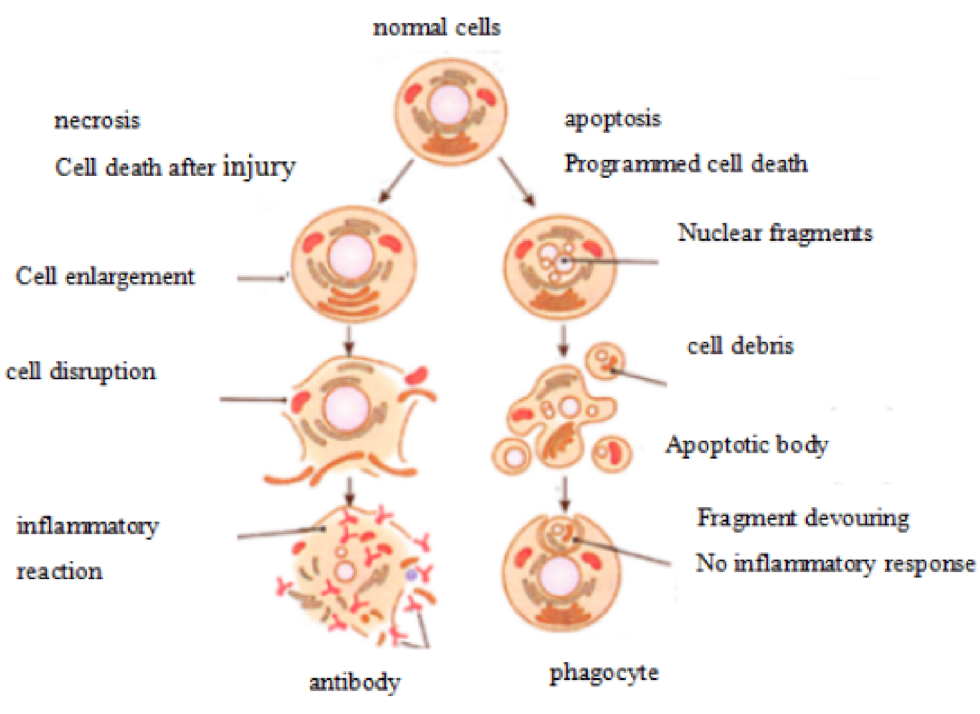

Figure 1. Comparison between apoptosis and necrosis

3.2. Cultivating scientific thinking and achieving active inquiry

AI tools possess the characteristic of "explainability", such as confidence scores in image recognition and parameter adjustments in simulation processes. This allows theoretical knowledge to be visualized, providing people with the practice of "validating hypotheses and refining models". When completing a project, the students initially hypothesized that "higher drug concentrations lead to faster cell death". However, AI statistical conclusions showed that "cells in the high-concentration group died faster". Upon re-examining the experimental steps, the students discovered that high-concentration drugs might cause immediate cell shrinkage due to excessive toxicity, which was not correctly identified under the microscope. This made the students aware that "experiment design" needs to consider the precision of tool assistance. Based on this idea, the students improved the experimental method after consulting with the teacher. This process of "trial and error + correction" was enabled with the assistance of AI technology, allowing the students to truly understand that "scientific conclusions are based on evidence-based reasoning."

3.3. Cultivating innovative thinking

In practical learning in biology, besides utilizing the ready-made functions of AI tools, students can also leverage them for "secondary development". For instance, to address the issue of "DeepCell" being unable to recognize cells with uneven staining, students can write a simple script in Python and add a "color normalization" step for image preprocessing, which enhances the model's accuracy [3]. Another group of peers designed an EXCEL prediction table based on the knowledge of "cell cycle regulation." The table content focuses on the "drug exposure time—cell cycle arrest point", providing theoretical knowledge for experiment conduction. Such "micro-innovations" in the teaching process are not complex but demonstrate the transition from being mere "technology users" to "technology improvers."

3.4. Foster a sense of collaboration and achieve interdisciplinary cooperation

The application of AI tools in biology breaks the traditional solo operation mode of biological practices, providing a feasible path for collaborative experiments. Image recognition in AI tools requires a combination of biological knowledge and transformation capabilities, while molecular simulation necessitates a collaboration between chemical knowledge and spatial imagination. During the practical learning process, community members are divided into different groups, such as the biological observation group, data programming group, and literature search group. Group members hold weekly meetings to discuss learning content. Conducting biological scientific research in this way enables students to deepen their understanding of knowledge points, enhance disciplinary thinking, and cultivate comprehensive literacy. AI modeling and models can help us grasp and understand the essence of life, promoting the development of scientific thinking in modern society [4].

4. Challenges for high school students in applying AI to biological cell research

Currently, the challenges faced by high school students in using AI technology for biological cell research include technical thresholds and time costs, data privacy and ethical risks, and limitations in tool applications (**Figure 2**). Among the students, some are not proficient in Python programming and the operation of molecular simulation software, requiring additional time investment to meet the demands of technical applications. When using real cell images, patients' tumor cells are often involved, and students lack awareness of "data ethics" during this process. Besides, AI technology is not omnipotent. Some AI models have relatively low accuracy when used in complex samples, such as mixed cell lines, and often require teachers' guidance for verification.

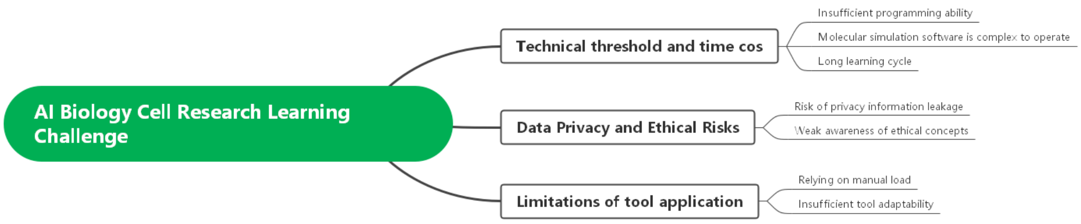

Figure 2. Challenges in AI-assisted biological cell research and learning

5. Practical optimization of high school students' use of AI in biological cell research

Firstly, tiered training and learning are conducted. For students in the basic tier, the focus is on "basic operation of AI tools and corresponding understanding of biological issues." For example, through "micro-videos and step-by-step demonstrations", students are helped to understand the installation of cell recognition tools, learn basic steps such as uploading images and setting parameters. For students with a certain theoretical foundation, the focus is on the application of "data statistics and simulation platforms." They are taught basic Python syntax in teaching, guided to write simple scripts to generate trends, and interpret meanings. For students who are deeply interested and have outstanding subject abilities, the focus of training is on "secondary development of AI tools and interdisciplinary integration." Students are encouraged to improve the limitations of existing tools, innovate, and write preprocessing scripts to enhance their innovation abilities [5]. Tiered training can improve the participation rate of club members, and during club activities, students can find corresponding learning goals based on their own levels, reducing technical anxiety.

Secondly, considering that data privacy and research ethics may be involved in learning, students integrate science and technology ethics education into discussions to cultivate a disciplinary attitude of "having bottom lines and being able to reflect" (**Figure 3**) [6]. For example, group debates and role-playing are introduced in teaching to guide peers to think about: "Which data can be used? How to avoid AI 'bias'?" Adding ethical self-examination steps to each link of the experiment allows students to form the habit of "reflecting while operating". Later, under the guidance of teachers, students write an "AI Experimental Ethics Log", using a diary to explain the ethical issues involved in the operation, and try to make suggestions for improvement. This process of continuous learning through reflection plays an important supporting role in students' future learning and growth [7].

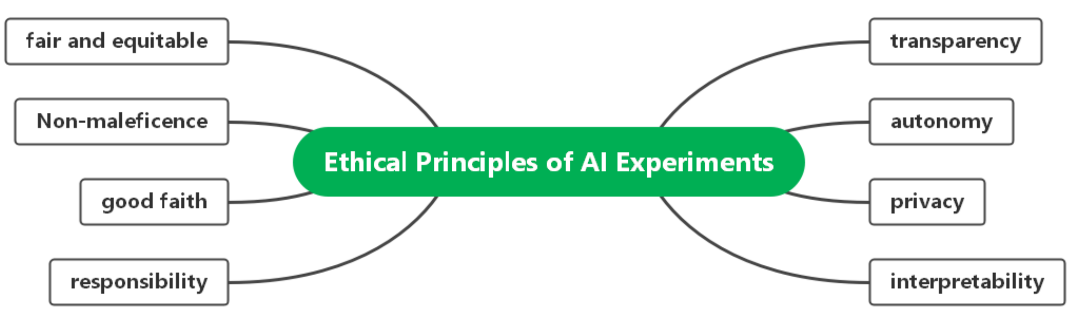

Figure 3. Ethical principles of AI experiments

Finally, build a collaborative teaching network of "AI + teachers + students" [8]. Because AI-enabled cell research involves different disciplines such as biology, programming, and chemistry, it is necessary to establish a collaborative system in this context. Teachers can help us screen reliable AI tools. As the learning subjects, students can take the lead in various aspects such as experimental design, tool operation, and conclusion analysis to achieve interdisciplinary collaboration [9]. External experts mainly compensate for the limitations of school resources. In the new era, a normalized "online + offline" communication mode can be established to actively provide feedback on problems and share achievements, promoting continuous optimization through the "display—feedback—iteration" process, thus achieving the desired teaching effect [10]. For example, organize an "AI + Cell Research" achievement exhibition to showcase reports written during the experimental process, AI improvement tools, reflection logs, etc., and then invite school experts to review and improve them. Through this approach, AI tools can be fully utilized as auxiliary teaching tools, thereby facilitating the transformation of achievements into practice.

6. Conclusion

In summary, as high school students engaged in practical teaching activities of biological cell research utilizing AI, the implementation of such activities not only represents the application of modern technology but also embodies the "cognitive revolution." Through the empowerment of AI tools, students can achieve a leap towards "dynamic connectivity" in knowledge construction and drive breakthroughs and transformations in tool creation in terms of innovation. In the new era, educators must consider the risks and challenges faced in the application of AI tools, such as ethical issues, to ensure their proper use. As AI technology continues to evolve in the future, the deep integration between AI technology and high school biology education will facilitate normalized experimental practices in the new era. Information technology will promote the development of thinking, which will be greatly beneficial for future progress.

Disclosure statement

The author declares no conflict of interest.

References

[1] Jurinsky J, George SS, Riccio AA, et al., 2025, Recovery Capital, the Recovery Ecosystem, and Substance Use among Recovery High School Students. Frontiers in Adolescent Medicine, 2025(3): 1567567.

[2] Wang CR, Lipin ID, Swoboda KT, et al., 2025, Adolescent-specific Risk and Protective Factors of Substance use among High School Students in the United States: A Cross-sectional Study. Clinical Child Psychology and Psychiatry, 30(3): 13591045251344043.

[3] Sun X, Zou Y, 2025, Study on Ethical Dilemmas and Coping Strategies of Gene Editing Technology in High School Biology Teaching. Exploration of Educational Management, 2025(3): 5.

[4] Dagne AG, 2025, Bayesian Spatial Mapping of Rates of Substance Use among High-school Students in Florida. Journal of Substance Use, 30(3): 428-433.

[5] Kemnitz J, Linke J, Goetz L, et al., 2025, Impacts of Medical Education in High School on Healthcare Career Determination. South Dakota Medicine: The Journal of the South Dakota State Medical Association, 78(suppl 5):

s26.

[6] Lin, BM, 2025, Innovative Practice of Life-oriented Homework in Junior High School Biology Based on the 3C Model: A Case Study of “Home-made Yogurt”. Education Research and Innovation, 2025(1): 5.

[7] Zhang X, 2025, Exploring Innovative Approaches to Cultivating Higher-order Thinking Skills in High School Biology Teaching from the Perspective of Interdisciplinary Integration. Probe—Environmental Science and Technology, 2025(7): 1.

[8] Cong D, Kai Z, 2025, Exploration of the Integration of STEM Education Concept into High School Biology Teaching. International Education Forum, 3(3): 1–7.

[9] Chen H, Shi S, Zhu L, et al., 2025, Analysis of Knowledge Points and Test Points Related to “Temperature” in Senior High School Biology. Higher Education and Practice, 2025(2): 4.

[10] Chen H, Yang C, Zhu L, et al. Investigation and Analysis on the Integration of Chinese Excellent Traditional Culture into High School Biology Teaching in Ethnic Minority Areas. Higher Education and Practice, 2025(2): 4.