

RESEARCH ARTICLE

The Effectiveness of Using Infographics to Visualize Information in The Study of Embryology

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Abstract

This article examines the definition, historical development, and pedagogical applications of infographics in the context of biological education. Particular attention is given to the creation of infographics in biological disciplines and their effective use during lecture sessions. The study focuses on the implementation of histology-based infographics designed for students majoring in Biology Education. These infographics are utilized not only as instructional materials during classroom activities but also as tools for assessing students' knowledge and understanding.

Furthermore, the article highlights the importance of engaging students in the independent development of infographics as part of their self-directed learning. Such activities contribute to the enhancement of visual thinking, analytical skills, and deeper comprehension of complex biological concepts. Experimental findings demonstrate that the integration of infographics into the teaching process significantly improves the quality of learning outcomes, increases students' engagement, and facilitates better retention of information. The results confirm the effectiveness of infographic-based approaches in modern biological education.

KEY WORDS

Infographics, biology education, histology, visualization, learning outcomes, higher education, student engagement, independent learning.

INTRODUCTION

In recent years, higher education has increasingly emphasized the use of innovative and student-centered teaching approaches aimed at improving learning outcomes and enhancing students' cognitive engagement. This shift is particularly important in the field of biological sciences, where the complexity of structures, processes, and terminologies often creates significant learning challenges for students. Disciplines such as histology and embryology require the understanding of microscopic structures and dynamic developmental processes, which are not always easily

conveyed through traditional text-based or lecture-centered instruction.

One of the promising tools that has emerged in response to these challenges is the use of infographics. Infographics are visual representations of information that integrate text, images, symbols, and diagrams to present complex data in a clear and concise manner. The origins of infographics can be traced back to early forms of visual communication, such as maps, charts, and scientific illustrations, which have long been

used to support understanding. With the advancement of digital technologies, infographics have evolved into a powerful educational resource widely applied across various disciplines.

The theoretical foundation for the use of infographics in education is grounded in cognitive and constructivist learning theories. According to cognitive load theory, learners process information more effectively when it is presented in a structured and visually organized format. Similarly, dual coding theory suggests that the combination of verbal and visual elements enhances memory retention and comprehension. In this regard, infographics serve as an effective medium for facilitating meaningful learning, especially in subjects that involve complex and abstract content.

In biological education, infographics are particularly valuable for illustrating hierarchical structures, functional relationships, and developmental stages. In courses such as histology, where students are required to identify and understand microscopic tissues, infographics can simplify visual recognition and conceptual understanding. Moreover, the use of infographics during lecture sessions can increase student engagement, promote active participation, and support better knowledge retention.

In addition to their use as teaching materials, infographics can also be applied as assessment tools and as a form of independent student work. Encouraging students to design their own infographics fosters creativity, critical thinking, and deeper processing of subject matter. This approach aligns with modern educational paradigms that emphasize learner autonomy and the development of transferable skills.

Despite the growing interest in visual learning tools, there remains a need for further research on the effectiveness of infographics in specific domains of biological education. Therefore, this study aims to explore the role of infographics in teaching histology to students in Biology Education programs. It seeks to evaluate their impact on students' understanding, engagement, and overall learning outcomes, as well as to determine the effectiveness of using infographics both in classroom instruction and in the assessment of students' knowledge.

LITERATURE REVIEW

Infographics, as visual representations of data, utilize diverse graphic elements to convey complex information effectively (Bhat & Alyahya, 2023). Toshmanov and Abidova (2026)

define infographics as visual representations that combine diagrams, tables, icons, and maps with concise textual information to present knowledge clearly and efficiently. Their study emphasizes that infographics simplify complex biological content, enhance memorization, and improve students' understanding, particularly in histology education. Furthermore, they highlight that the visual structuring of information facilitates cognitive processing, increases student engagement, and enhances learning effectiveness in both practical and theoretical classes.

One of the primary infographic structures used in biology is the process/flowchart layout, which is essential for mapping metabolic pathways, cellular processes, and experimental methodologies. This structure organizes complex information into interconnected nodes, illustrating sequential steps, cause-and-effect relationships, and systemic functions.

Scholars have provided various definitions of infographics. Smiciklas (2012) defines infographics as visual representations of data or information designed to communicate complex ideas quickly and clearly, emphasizing clarity and efficiency. Krum (2013) describes infographics as a combination of visuals and text that tell a story and present information in an engaging and understandable way, highlighting storytelling and audience engagement. Similarly, Lankow et al. (2012) define infographics as visual explanations that help people understand, find, or do something more easily, focusing on usability and functionality. Few (2009) refers to infographics as graphical displays of information intended to improve cognition through visual perception, while Tufte (2001) conceptualizes them within data visualization as the visual display of quantitative information. Ware (2013) further explains that infographics leverage human perceptual abilities to enhance information processing, linking them to visual cognition.

In Uzbekistan, research on infographics has developed within the framework of digital pedagogy and innovative teaching methodologies. To'g'izboyev (2026) emphasizes that infographics function as intellectual-visual tools that enhance cognitive engagement and learning efficiency through visual-cognitive synthesis, particularly when integrated with artificial intelligence technologies. Abdumo'minov (2025) identifies three key components of infographics: visual elements (color, shape, typography), content (facts and statistics), and knowledge (insights and conclusions), arguing that an effective balance between design and pedagogical meaning is

essential. Ismoilxanov (2024) highlights the practical application of infographics in teaching, demonstrating their effectiveness in lectures, practical sessions, and independent learning, as well as their role in developing students' analytical and creative skills.

METHODOLOGY

This approach transforms complex data into easily digestible formats, thereby enhancing comprehension and retention, particularly in scientific education (Jeyaraman et al., 2024). The increasing complexity of anatomical and developmental biology necessitates innovative pedagogical tools to improve student understanding (Özdamlı et al., 2016). Embryology, in particular, presents significant challenges due to its four-dimensional nature, involving rapid structural changes across spatial and temporal dimensions (Choi et al., 2020; Dueñas et al., 2018). Consequently, it is often perceived as one of the most difficult subjects for medical students, despite its fundamental importance (Abas, 2022; Plunkett et al., 2019).

Traditional teaching methods, which rely heavily on static two-dimensional illustrations, are often insufficient for conveying dynamic three-dimensional transformations (Upson-Taboas et al., 2019). Therefore, there is a growing need for advanced visualization tools capable of accurately representing embryological processes and enhancing knowledge retention (Hull et al., 2021; Marsh et al., 2008). Infographics represent a promising alternative, as they condense complex information into visually engaging and accessible formats (Narayanan & Ananth, 2018). Additionally, limited access to practical materials and specimens further complicates the learning process, highlighting the importance of innovative visual tools (Nawi et al., 2025). The integration of interactive technologies, such as 3D models and virtual reality, further enhances learning by providing immersive educational experiences (Alfalah et al., 2018; Patel et al., 2018).

The effectiveness of infographics is also supported by cognitive principles, such as the picture superiority effect, which suggests that visual information is more easily retained than textual data (Naparín & Saad, 2017). Infographics facilitate deeper engagement, improve long-term retention, and enhance learning outcomes by combining visual and textual elements (Afify, 2018; Alyahya, 2023). Their ability to transform abstract concepts into concrete visual

representations makes them particularly valuable in fields such as anatomy and embryology (Agustini et al., 2020; Tarkhova et al., 2020; Khasawneh & Khasawneh, 2023).

Russian scholars also contribute to the theoretical understanding of infographics. Yermolaeva et al. (2014) define infographics as a synthetic form of organizing information that integrates visual elements with textual explanations. Selemenov (2011) describes infographics as a method of conveying ideas through the visual presentation of information, often quantitative in nature.

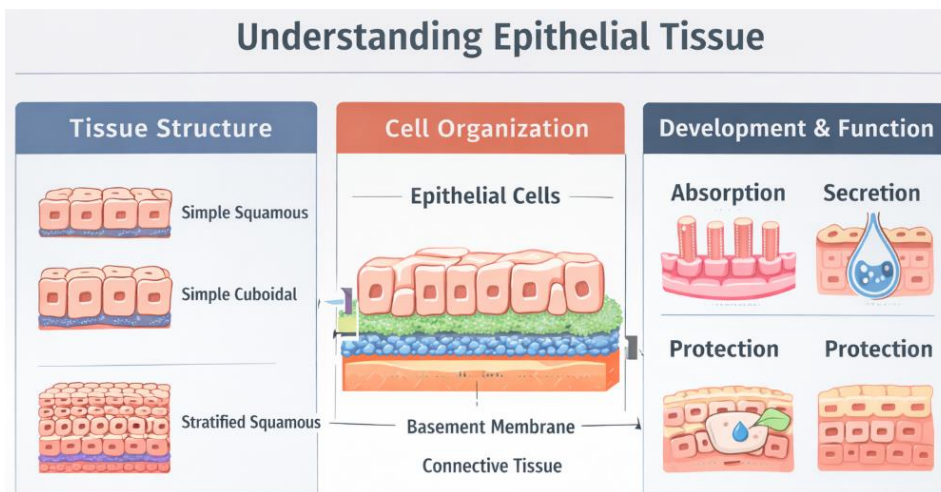
Historically, infographics began to develop in the early nineteenth century. In the 1930s, the "Isotype" method of visual representation gained popularity, initiated by Otto Neurath. In the Soviet Union, infographics were widely used in exhibition design, particularly at the Exhibition of Achievements of National Economy. Later, in 1982, USA Today popularized the modern use of infographics by combining graphics with explanatory text, contributing significantly to their widespread adoption in media and education.

Korepanov and Goncharov (2025) further emphasize the relevance of infographics in modern education, particularly in biology teaching. Their study highlights the importance of adapting instructional methods to contemporary students' information perception styles and demonstrates practical applications of infographics in topics such as ornithology.

RESULTS

The implementation of infographics in the teaching of histology within the Biology Education program demonstrated a positive impact on students' learning outcomes, comprehension, and engagement. The results obtained from classroom application and instructional practice indicate that infographic-based learning significantly improves the assimilation of complex biological information.

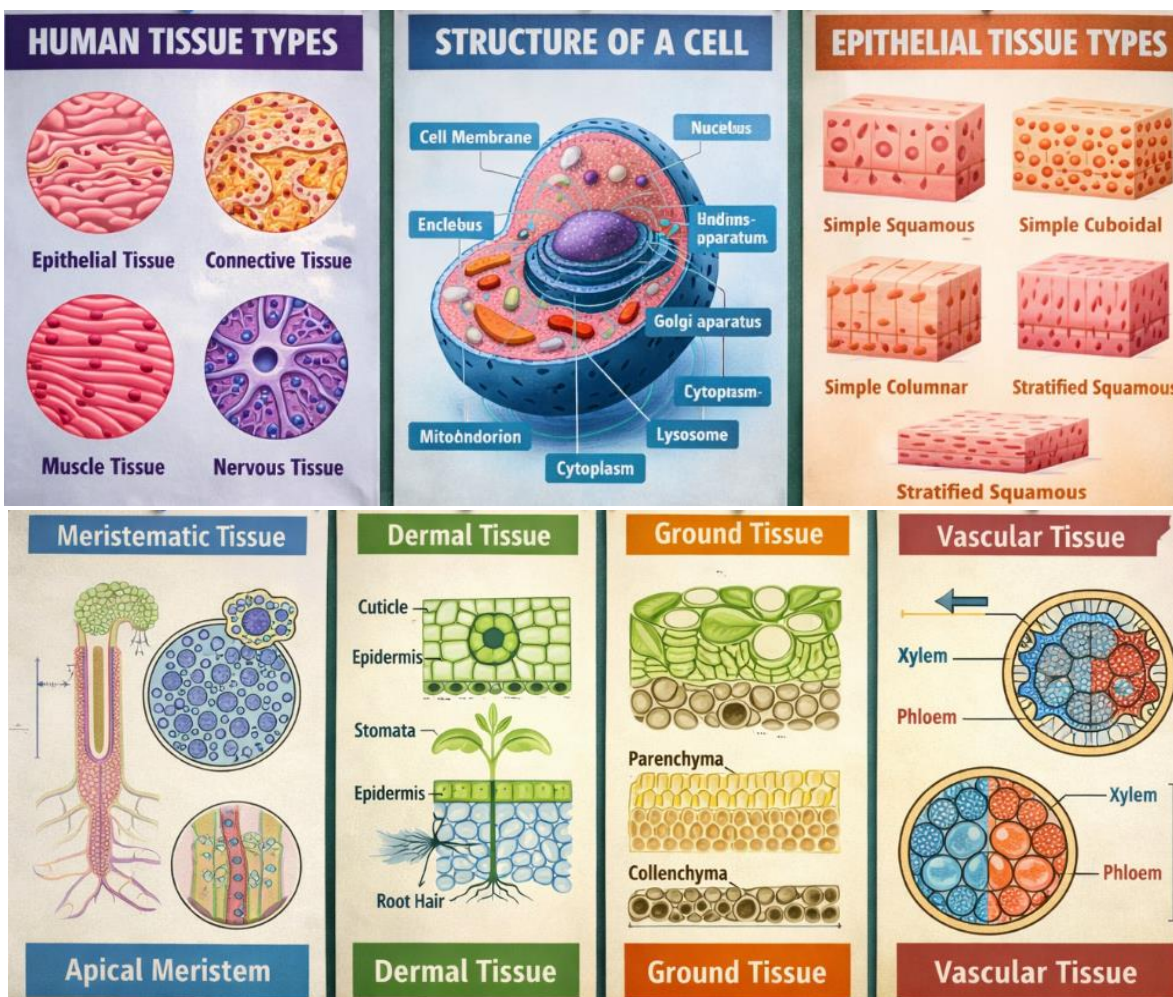
Firstly, students showed a noticeable improvement in understanding histological structures after the introduction of infographic-supported lectures. Visual representation of topics such as tissue structure, cellular organization, and developmental processes allowed learners to better interpret abstract concepts and establish clear relationships between theoretical content and visual models. (1st picture)



Picture 1. Visual representation of topics.

Secondly, the use of infographics contributed to increased retention of information. Students were able to recall key concepts more accurately during oral questioning and written assessments compared to traditional text-based instruction.

This improvement is associated with the visual organization of information, which facilitates memory encoding and long-term retention. (2nd picture)

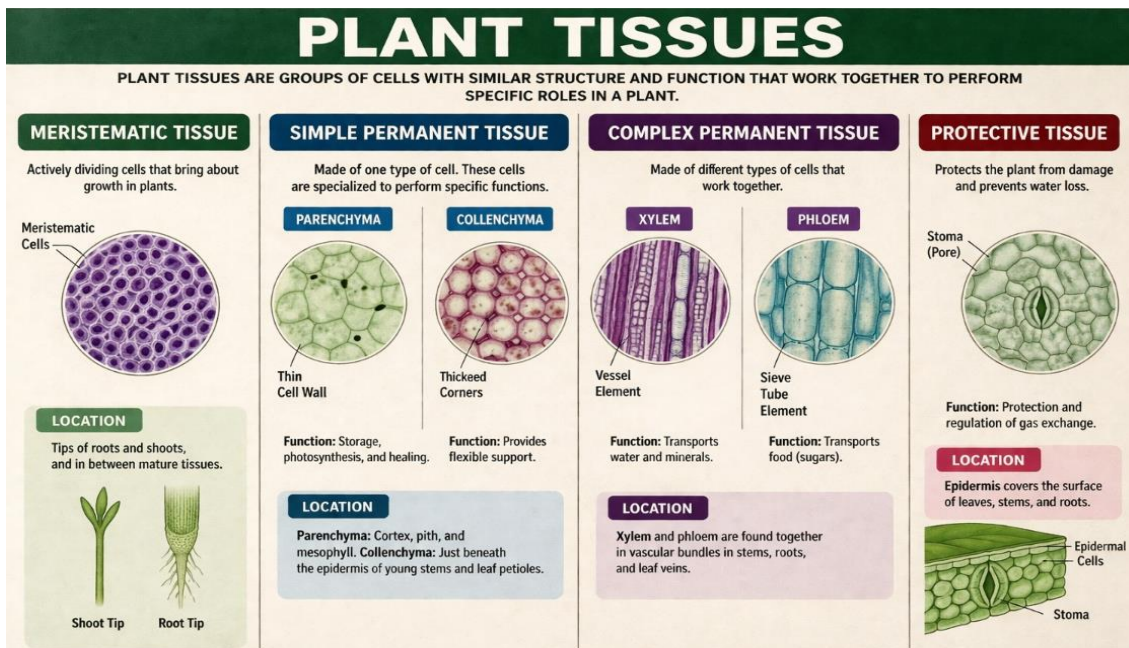


Picture 2. The visual organization of information

Thirdly, the integration of infographics in the learning process enhanced student engagement and motivation. Learners demonstrated higher levels of interest during lectures, actively participated in discussions, and showed greater wilgraphics made complex topics more accessible and less cognitively demanding.(3rd picture)

In addition, the use of infographics as an assessment and

independent learninglingness to interact with learning materials. The visual and structured nature of info tool proved effective. Students who were assigned to create their own infographics as part of independent study tasks developed stronger analytical and creative skills. This activity encouraged deeper processing of content, critical thinking, and the ability to organize scientific information in a structured visual format.



Picture 3. The integration of infographics in the learning process

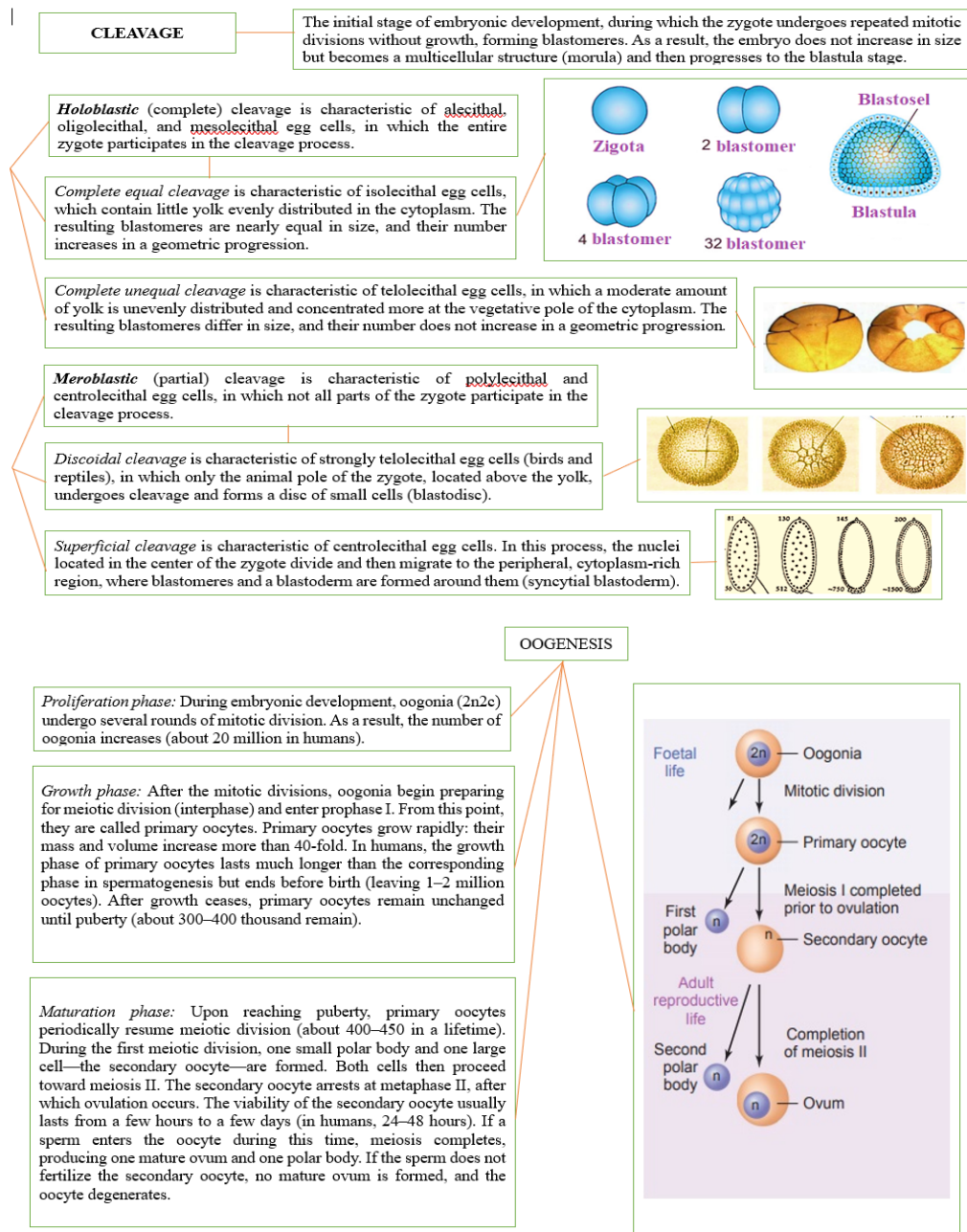
Overall, the results confirm that infographic-based instruction improves the quality of learning in histology by enhancing comprehension, increasing retention, and promoting active student participation. The findings support the integration of infographics into modern biological education as an effective pedagogical strategy for visualizing complex scientific content.

DISCUSSION

The findings of this study confirm that the integration of infographics into histology instruction significantly enhances the effectiveness of the teaching and learning process. The results demonstrate improvements in students’ comprehension, retention, and engagement, which are consistent with both theoretical frameworks and previous

empirical studies.

The following infographic provides information on the types of fractionation as an example. This infographic provides a definition of fractionation and examines the types of fractionation. The definitions and descriptions of crushing types are illustrated with drawings that visualize these processes. Placing the terms presented in the infographic in the form of figures (squares) facilitates the assimilation of information through visual analysis and is well-remembered. At the same time, the terms complement the knowledge gained by students in secondary school on fractionation, which increases the relevance of presenting information in a more accessible and understandable form. (5th picture)

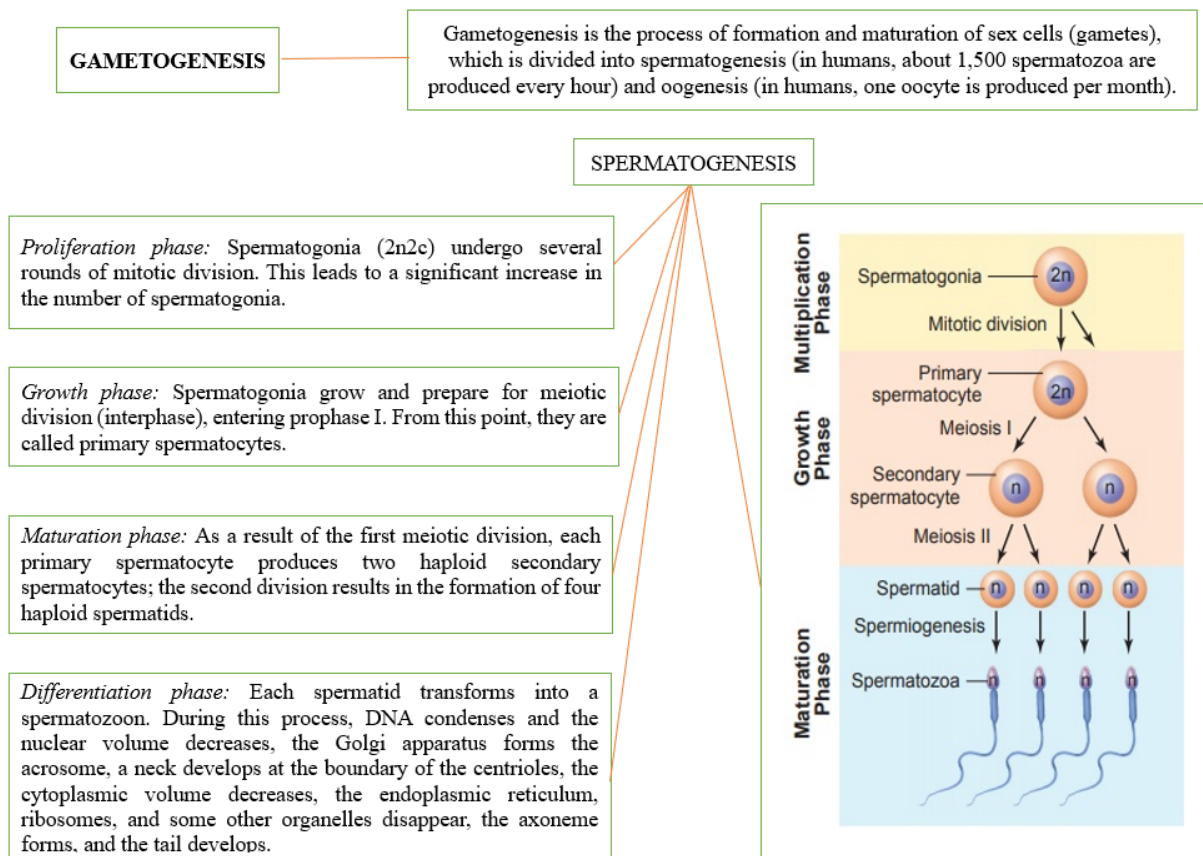


Picture 5. Infographic on crushing types.

Some terms presented in the infographic may be unfamiliar to students and they may encounter them for the first time, as they have not encountered these terms in high school or these terms may have been presented differently. The infographic provides explanations for these terms, which facilitates the formation of new concepts for students.

The following infographic provides information on the process of gamete formation – gametogony. At the beginning of the

infographic, a definition of gametogenesis is provided, and below, information is provided regarding spermatogenesis and oogenesis. At the same time, the stages of spermatogenesis and oogenesis are provided in the left part of the infographic, and the processes occurring in each stage are described in detail. The right side of the infographic features a schematic representation of these processes, which increases the efficiency of information presentation through its visualization. Here, too, the text is placed inside the figures. (4th picture)



Picture 4. The process of gamete formation – gametogony

From a cognitive perspective, the effectiveness of infographics can be explained by their ability to combine visual and textual information in a structured format. This supports the principles of multimedia learning and dual coding, according to which information presented simultaneously through visual and verbal channels is more easily processed and retained. The improved academic performance observed in this study aligns with earlier findings reported by Richard E. Mayer (2009) and Allan Paivio (1986), who emphasized the importance of integrated visual-verbal learning.

The results also support the conclusions of Nizom Toshmanov and Sadokat Abidova, who highlighted that infographics facilitate the simplification of complex biological information and improve memorization in histology classes. Similarly, the findings are consistent with the work of To'g'izboyev Faxriddin Ulashovich (2026), who described infographics as intellectual-visual tools that enhance cognitive engagement and learning efficiency.

A biology teacher cannot convey biological information (the structure or function of objects) to students without understanding its essence, that is, without being able to represent it. When the teacher fully understands the material

(has an idea of it), they organize the lesson based on the terms students use most often and by providing examples from events they frequently encounter. This leads to high learning efficiency.

Infographics can be used not only in lectures but also as a creative activity for students' independent work. In this case, the student independently masters the topic being studied and creates an infographic based on the acquired knowledge. This forms various skills in the student regarding the topic being studied. Simultaneously, the student begins to develop pedagogical skills based on explaining the infographic they have created. Placing a large amount of information in a single infographic requires knowledge, design skills, and the ability to synthesize large volumes of material from the student. Infographics can help students determine their knowledge, skills, and competencies. In this case, an infographic is created for the student on a specific topic or chapter (section). It should contain necessary terms for testing knowledge and illustrations that define skills. Repeatedly explaining information in infographics contributes to the development of a student's competencies.

For 1st and 2nd-year master's students in the "Methodology

of Teaching Exact and Natural Sciences (Biology) " specialty, histology classes were organized based on infographics, an explanation of infographic information was included in the current control forms, and an assignment was given to create infographics for some independent study topics. As a result, it was established that the effectiveness of studying histology has increased compared to the previous academic year. Organizing classes using this infographic will contribute to the formation of knowledge, skills, and qualifications in students while simultaneously enhancing their overall competence.

In addition, the study was conducted within a limited academic context (histology course), which may affect the generalizability of the results to other disciplines. Future research should explore the use of infographics in other areas of biological sciences, such as embryology, genetics, and physiology, as well as investigate long-term learning outcomes.

CONCLUSION

This study demonstrates that the use of infographics in teaching histology significantly enhances the effectiveness of the educational process in higher education. The visual integration of diagrams, symbols, and concise textual explanations enables learners to process information more efficiently and establish meaningful connections between theoretical knowledge and visual representation. The practice of designing infographics as part of independent work encourages deeper cognitive processing and enhances students' ability to organize and present scientific information. The results of this study are consistent with both international and Uzbek research, which emphasize the cognitive and pedagogical advantages of visual learning tools. In conclusion, the integration of infographics into biological education, particularly in subjects such as histology and embryology, represents an effective and innovative teaching strategy. It is recommended that educators actively incorporate infographic-based approaches into their teaching practice to improve learning outcomes and meet the demands of modern higher education.

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