FROM DNA TO CHROMOSOME: A VIEW OF BISCUIT PACKAGING

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ABSTRACT

The development of didactic models in the teaching of abstract concepts is proposed, since it allows the assimilation of content in an expanded and three-dimensional view. The present work aimed to develop three-dimensional models in biscuits addressing the packaging of chromatin into chromosomes from DNA. This work presents a qualitative approach research. The activities were developed by students of the 1st period of the Bachelor's Degree in Biological Sciences at the Federal University of Catalão, regularly enrolled in the Cell Biology discipline. Initially, the students participated in a workshop, provided by the teacher, and chose the references that supported (conceptually and pedagogically) the model to be produced and the material to be used. Then, the model was made during part of the practical classes. The proposal instigated the interest of the students. The act of choosing nuclei, position, proportionality and application in the model stimulated interest and curiosity, enabling different ways of learning the compaction of chromatin into chromosomes. I suggest that cookie modeling, with the student as the learning center, be the subject of other biology topics.

Keywords: 3D Modeling. Cellular Biological Teaching. Compaction.

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INTRODUCTION

The abstract nature of chromatin compaction, a topic of study in cell biology, combined with the fact that the discipline is included in the semester in which the student enters higher education, makes the concepts distant from the student's daily life. It is known that teaching, when supported by the process of collective construction and with the effective participation of students, becomes more effective than theoretical classes that develop as a monologue, with students being mere receivers of information. In this context, the development of didactic models, in the teaching of abstract concepts, is presented as a proposal, since it facilitates the assimilation of content in an expanded and three-dimensional view (Wommer, Michelloti, Loreto, 2019; Campos et al., 2023) in addition to enabling the student to think reflectively and autonomously (Campos, Moura, Paula, 2024). Students' participation in the creation of models from a 3D perspective increases the sharing of experiences and ideas aimed at bringing theory and practice closer together (Roque, Will, Caetano, 2020; Carneiro et al., 2016). It is believed that when students actively participate in the construction of educational material, their interest, and critical capacity are awakened. In addition, several studies report the benefits resulting from the use of didactic models, especially three-dimensional ones, in the teaching-learning process in the biological field (Souza et al., 2021; Da Silva, Rodrigues, and Campos, 2021).

The topic of chromosomes and chromatin generates doubts among students. One of the reasons is the way these concepts are addressed in textbooks. Firstly, chromatin and chromosomes are made up of DNA and proteins, but chromatin is found in the interphase nucleus and at the beginning of cell division when it is condensed into a chromosome. On the other hand, chromosomes are present from the condensation of chromatin in the prophase of cell division (Alberts et al., 2017; Junqueira and Carneiro, 2023). From the definition, students, by handling and elaborating the 3D model, follow the process and perceive the modification being constructed.

Modeling represents a promising alternative for teaching concepts related to the theme of chromatin condensation, which is part of the content taught in cell biology (Dantos et al, 2018, Da Silva, Rodrigues, Campos, 2021). However, the use of three-dimensional materials alone does not guarantee innovation; it is necessary to awaken the student's interest to expand their observation and critical capacity. Thus, the present work aimed to elaborate three-dimensional models in biscuits addressing the packaging of chromatin into chromosomes from DNA.

METHODOLOGY

This paper presents a qualitative approach to research, considering the specificities of the process of knowledge acquisition by students in the process of building three-dimensional models addressing the packaging of chromatin into chromosomes, and attempting to understand and describe what happens to students when faced with a problem situation (Lüdke and André, 1986).

The activities were developed by students in the 1st period of the Bachelor's Degree in Biological Sciences at the Federal University of Catalão, regularly enrolled in the Cell Biology discipline. This discipline is the first to address concepts of chromatin and chromosomes in the course and aims to allow students to develop an integrated view of structure and function.

STEPS IN DEVELOPING THE MODEL

After the theoretical class on the subject, the students were taken to the laboratory where they observed, under light microscopy, onion slides containing the phases of mitosis. At that moment, they observed chromosomes and not chromatin. The problem questions “How was the chromosome formed? Where is the chromatin? What is the path to get to the chromosome?” arose and from that moment the class was randomly divided into pairs, trios or individually.

A previously constructed didactic model was presented. In addition to explaining each part of the model, the teacher informed that the students should not only build a model but also explain how it could be used later in a didactic activity. The model was to be built in part of the practical class, over three weeks.

For this activity, it was necessary to master the content and be supervised by monitors and the teacher in charge. To master the content, the student had to seek support from a theoretical framework, mainly for choosing colors and exploring the structures. In the first week, the students participated in a workshop provided by the teacher and chose the frameworks that supported (conceptually and pedagogically) the model to be produced and the material to be used. The model was made during the second and third weeks of practical classes. Each practical class in the discipline lasts 1 hour and 40 minutes and 50 minutes were used for practical activities. The workshop covered handling biscuits, choosing colors and shapes, as well as complementary subjects.

WORKSHOP OFFERED FOR HANDLING BISCUIT

Biscuit dough was chosen because it is easy to handle, has good durability, and does not alter the model. Even so, before building the models, students participated in the workshop to acquire knowledge about handling biscuits and preserving the models. In the workshop, students had the opportunity to ask questions about the model and colors.

STUDENT SERVICES

Since this is a practical activity, in addition to the classes designed for this purpose and the workshop, there was service by appointment through the Google Meet platform.

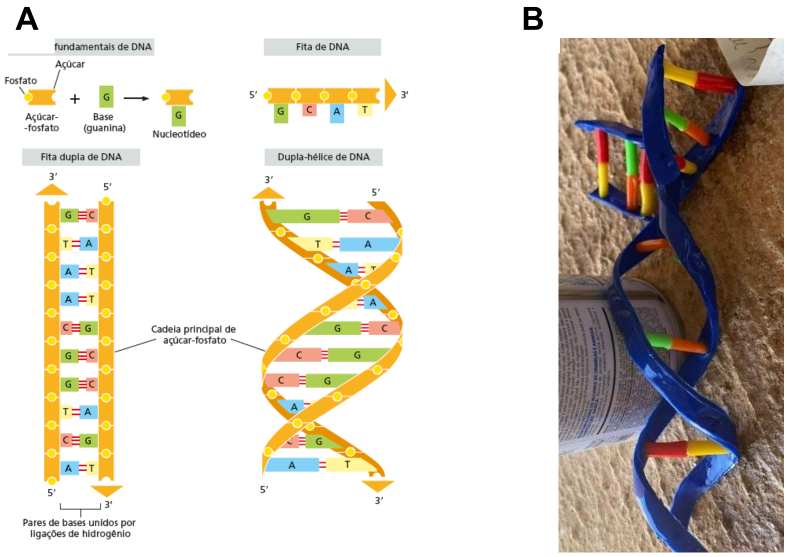
DATA ANALYSIS

For the evaluation, the following data collection instruments were used: dialogues in the classroom, workshops, and services. To analyze the data on the students' impressions regarding the work, only the responses representative of the group were used after self-evaluation and critical evaluation of the other works developed. At the time of the reports, notes were made on the most discussed points and the discursive textual analysis (DTA) proposed by Moraes, Galiazzi, and Ramos (2012) was used. All evaluation criteria were presented to the students beforehand. It is worth noting that, in addition to the presentation of the resource in the classroom and the justification about the educational space, there was a stage in which the students were concerned with developing its evaluation, at least preliminarily, that is, based on the apparent potential of the materials produced, without considering their actual application. The evaluation criteria for the developed model were: applicability, concepts covered, and oral presentation of the model.

RESULTS AND DISCUSSION

In the teaching scenario, group work has proven to be a good strategy to support teaching work. In this study, it was observed that there was a low number of individual works. Knowing the students is essential to promote more accurate group divisions, but how can this understanding be advanced in a class of new students? Immediately after the presentation of the proposal, the students were restless. The idea that everyone does their part and then hands everything over to the teacher would not work in this modeling process. This is because building a three-dimensional model requires everyone's participation and collaboration and is not a combination of parts. During the presentation, it was possible to see that the students created a form of communication between them so that everyone could participate. The individual and group reports showed that having another person to exchange ideas with was important in building the model. Salas (2021) emphasizes that collaboration favors the advancement of learning in group work. According to the author, the group work strategy places the student as the protagonist. During the workshop, the students doubted their ability to handle the material and raised important questions about the model itself. The members who were responsible for building the replicating DNA were the ones who asked the most questions. The doubts focused on the difficulty of representing the nitrogenous bases in three dimensions by fitting them into a twisted model. The 3D visualization of DNA replication made the students uncomfortable. This is partly explained by a certain degree of passivity among students, acting as spectators (Cezar et al., 2010) and the difficulty in establishing a connection with the world around them, a consequence of memorization learning that resulted in the false impression of learning (Ferreira and Almeida, 2013). The structure of DNA, proposed by Watson and Crick in 1972, is presented as a double helix and serves as a model (Figure 1A) for the elaboration of the 3D model (Figure 1B).

Figure 1- DNA model (A) proposed by Watson and Crick (Alberts, 2017) and the model (B) built by the students.



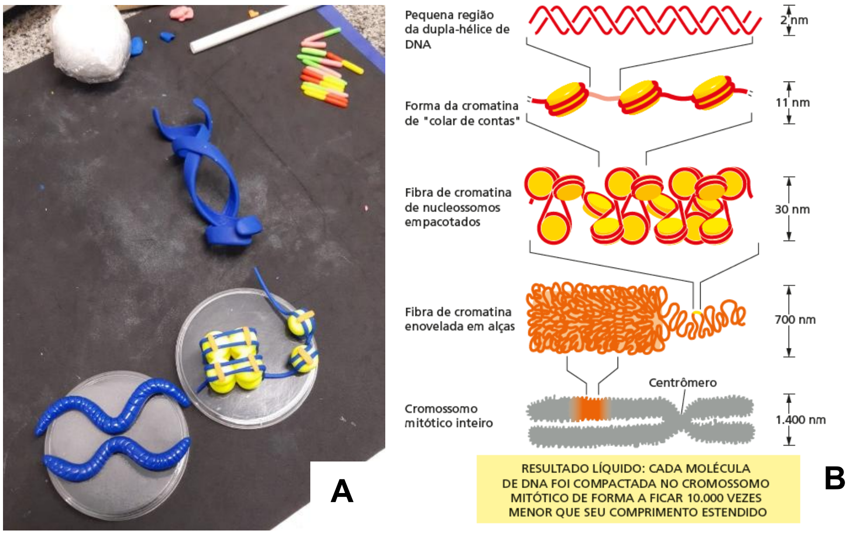
During the activity, the students themselves began to make suggestions about their models and those of other groups. This exchange of ideas was beneficial to the process of developing the model. In this study, discussion and pedagogical support using books were essential to transfer the 1D image into a 3D model. For some of the students who at a certain point wanted to give up, intervention with encouraging dialogue was necessary. This type of situation shows how difficult it is to leave the “comfort zone” and have to participate in the learning process (Duso, 2013). In addition, other authors report on the importance of relating theory and practice to enhance access to information to acquire knowledge (Campos et al., 2003, Carneiro et al., 2016; Paula et al., 2017).

The models were built in parts, initially the chromosome and chromatin. After each part was created, it was placed on cardboard where spray varnish was applied to better preserve the models (Figure 2).

Figure 2- Chromosome model being developed after application of varnish.

When preparing the initial chromatin packaging, doubts focused on the role of histone H1 and the lack of visualization of non-histone proteins. At this point, the students sought support in the theoretical material and raised a discussion about whether it would be interesting to present the proteins in a highlighted format. Some students tried to represent the proteins and observed that the model would have too much information. They decided to keep the model without indicating the proteins; such indication should be made at the time of explaining the model. The model developed for chromatin compaction (Figure 3A) was based on the image (Figure 3B) do Alberts et al., 2017).

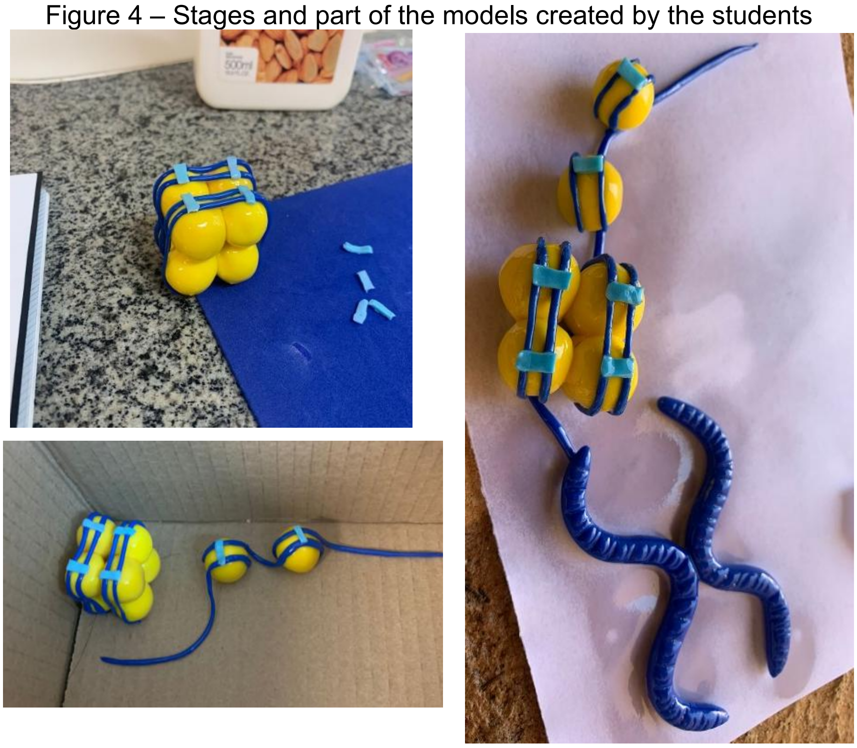
Figure 3 - Chromatin compaction to the chromosome

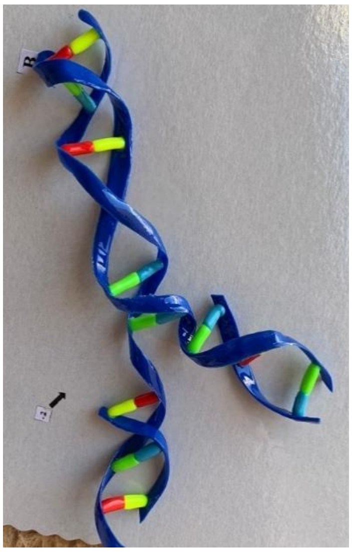


It was observed, from this stage, that from the moment the student felt safe and stimulated, the interest in constructing learning was easier and more enjoyable. The application of play as a complement to theory contributes to more efficient teaching because it places the students in the lead. Thus, students are more committed and motivated to carry out the task, both as a team and individually (Camargo and Rosa, 2013).

In the subject of cell biology, students have difficulty understanding the mechanism of the processes. During the presentation of the models, the students explained how the model was made, what it is about, where and how it occurs, in addition to the importance of the event. To complement the model and facilitate its applicability, an explanatory folder was created where the students took a photo of the model and added theoretical information and tips on how to use it (data not shown). It was noted that, when the students did not participate in the workshops, or services or did not exchange experiences with their colleagues, they had difficulty explaining and understanding the process. To make the models, students needed to understand the content, have a sense of responsibility, and follow all the steps, as already pointed out by Soares et al. al*.* (2021).

Figure 4 – Stages and part of the models created by the students




The development of teaching models by students, as reported by Da Silva et al. (2021), helped in understanding and learning how a biological process works, in addition to stimulating curiosity and active participation. This is because the simple handling of the raw material until obtaining the pieces during the activity constitutes a form of interaction between the student and the object of knowledge (Matos, 2009). The development of models by students enabled the sharing of experiences and ideas aimed at integrating theory with practice, enabling more attractive classes than when approached in a predominantly theoretical way (Roque et al., 2020).

CONCLUSION

The proposal described above aroused the interest of students and played an important role in filling the gaps that persisted after remote teaching. The act of choosing colors, position, proportionality, and application in the model stimulated interest and curiosity, enabling different ways of learning the compaction of chromatin into chromosomes. Another point to consider with this work was the possibility of obtaining educational material, without involving digital technology, which stimulated learning enjoyably with concrete visualization of the concept studied in theory. The digital device was used only for research and image capture. In this sense, it is suggested that biscuit modeling, with the student as the center of learning, be contemplated in other curricular components.

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