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The Efficacy of Storified Pedagogy in Promoting Collaborative Student Engagement and Facilitating Comprehension of Interconnected Topics in A-level Biology: A Pre-final Exam Study

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Abstract

An adapted, storified pedagogy approach was used to motivate biology A-level students preparing for final exams. This approach aimed to connect 107 learning objectives from 15 different course units into a story that highlights the interconnectedness between seemingly unrelated units in a creative and engaging manner. The aim of the project was to stimulate students' enthusiasm and motivation, to work collaboratively and take ownership of their learning in a fun and memorable way, in preparation for final exams. Twenty-four grade 12 biology students from two different classes formed 9 groups, each chose their own media and presentation style, collaboratively decided on the assessment criteria and collectively agreed on 10-minute presentations. The project took the form of a competition, with the winning group being awarded a prize. Groups were given three 40-minute lessons to plan their stories and prepare their presentations.

The result was 9 detailed stories with links to biological concepts and terminology covering various seemingly unrelated topics from grades 11 and 12 that showcased students' insight and understanding of the interconnectedness of diverse biological processes in a fun and creative way. The stories drew on diverse skills that ranged from a [1] Prezi-based App, hand-drawn detailed biological diagrams, computer-generated presentations with creative acting, video editing, and photography, to very personal interpretations of friendships and sharing insight into the health condition of one student. Groups comprised of persons with greater imagination and creative flair, combined with persons with high academic ability produced stories with most connections between seemingly unrelated topics and provided memorable learning opportunities for developing deeper insight, in preparation for final exams. The timing of the project (2 weeks before final exams), amount of time given for planning, competition-based approach, creative freedom, and freedom to use any medium to communicate their understanding, are all factors which contributed to the success of the project and need to be considered in the future when planning similar projects. The approach was expanded with the next group of students to include creative writing. This activity not only stimulated creative thinking, but provided an opportunity to practice the skill of translating creative thought into text, an essential skill for writing exams.

Keywords: Storified pedagogy, storyline, narrative pedagogy, social constructivist, A-level biology

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1. Introduction

Due to accelerated socio-economic growth in Kazakhstan an initiative by then first president Nursultan Nazarbayev saw the establishment of Nazarbayev Intellectual Schools (NIS) in 2008, as he saw the urgent need for professionals with a high level of technical, managerial and leadership competencies" (Nazarbayev Intellectual Schools/. History. 2022). NIS schools serve as an experimental platform for research and implementation of modern models of educational programs. Teachers at the NIS schools are encouraged and given academic freedom and autonomy to implement innovative educational programs and research projects.

The Cambridge A-level Biology course (grades 11 and 12) offered at NIS schools, covers many seemingly unrelated, divergent topics from various fields of biology, including statistical methods in biodiversity studies, human physiology, plant propagation, muscle contraction, immunology, molecular biology, cancer, aging, biotechnology, and research in recombinant DNA. The course plan document (syllabus/curriculum) has a tabular log frame format indicating the learning units, topics to be covered, and learning objectives per unit. This format presents the course as distinct unrelated units which are taught sequentially during the academic year. After

[1] Prezi is presentation software.

completing a unit of work, students write a summative assessment (SAU) which is then followed by the learning of the next, seemingly unrelated unit. Since biology is taught in English, which is the students' second additional language, a language rarely used in Kostanay, Kazakhstan, the focus in class has been mainly on the acquisition of new terminology, with SAU questions mainly focused on knowledge and understanding (Bloom's taxonomy level 1 and 2). The questions in internal exams are mainly unit based, not highlighting links between different learning units. The Cambridge-based final exam assesses understanding and application of acquired knowledge (Bloom's taxonomy levels 2, 3 and 4) and the links between different learning units, rather than rote learning and basic recall of information. In preparation for the final A-level exit examination, we struggled with the question, "How can we get students to understand the links between the different topics, revise all the topics covered in the two grades, take ownership of their learning, and have fun while doing it in as short a time as possible?".

According to Piiponen and Karlsson (2019) "various authors have referred to stories and storytelling as useful methods to attach meaning to new learning. Parker and Lepper (1992) concluded that "through stories and storytelling new information is made more comprehensible, relatable, and relevant, consequently increasing retention." As teachers attempt to make the learning experience more interactive and engaging, there has been an increased use of serious and educational games, gamification, storification, simulations, game-based learning and role-play amongst other engagement strategies and technologies in the classroom", Aura, A., Hassan, L., and Hamari, J. (2021). After researching the use of storyline and storification as pedagogy, we decided to investigate whether using [2]storyline and storified pedagogy could assist our students in gaining deeper insight into the connections between topics in preparation for the final A-level exams.

2. Conceptual framework and research model

This research is grounded in Piaget's constructivist theory of learning which emphasizes the importance of students actively constructing their own understanding of knowledge and the world around them. It also draws on Vygotsky's socio-cultural theory of learning which emphasizes the role of social interaction, culture, and language in cognitive development. In addition, it incorporates elements of the social constructivist theory of learning, which states that knowledge is constructed through social interaction via dialogue and collaboration with others, shaped by cultural values, beliefs, and practices. "Learning is an active, dynamic, and ongoing process in which the learner creates new schema of understanding by constructing and organizing new knowledge and experiences into mental frameworks or cognitive structures. The learning process is facilitated through various methods including active exploration, inquiry, reflection, and social interaction" (Jonassen, 1999). We decided to investigate how to use storytelling as a method to engage students actively, collaboratively and through reflection, enhance their understanding and experience of the connectedness between different topics in A-level biology, in preparation for the final exams. Storytelling has been used as pedagogy to enhance student collaboration, creativity, and critical thinking through different approaches, including storyline, narrative and storified pedagogy.

Storyline, a method spearheaded in Scotland in the 1980's, is a student-centered interdisciplinary approach that involves creating a fictional or real-life story that connect various subjects and topics together into a cohesive learning experience. The storyline method has been extensively used in primary schools in various countries as a way of integrating different subjects and making learning more engaging for students. The teacher normally creates the basic plot or storyline, and the students work together to fill in the details of the story. As the story develops the teacher assists and gives feedback to groups ensuring that they stay on track and develop their ideas. Storyline method usually takes place over a longer period, usually a few weeks.

Narrative pedagogy is used as a means of complementing a more conventional method of teaching and learning. Practiced widely in nursing education, it focuses attention on the human element of health care, teachers and learners together explore meanings from the interpretation of stories. (Ironside, 2006). Benner (2006) in her paper "Educating nurses: A call for radical transformation- how far have we come", suggests that the use of personal stories can help bridge the gap between theory and practice, enabling students to see the relevance of academic concepts to real world situations. Although narrative pedagogy is practiced mainly in nursing education the approach is relevant for the learning of biology concepts and how it is used to understand complex

[2] *Storyline is a structured approach to learning and teaching that was developed in Scotland. It builds on the key principle that learning, to be meaningful, must be memorable and that by using a learner's enthusiasm for story-making, the classroom, the teacher's role, and learning can be transformed. (The Scottish Consultative Council on the Curriculum)*

interconnected processes in real life.

Storified pedagogy involves the use of stories and narratives to engage students, convey information and facilitate the learning process by capturing attention, stimulating imagination, and promoting deeper understanding and retention of knowledge. A storyline is used to create a story that is presented in a way that connects with students' interests, experiences, and emotions, making the learning experience more relatable and meaningful. According to Yildrim and Cagiltay (2014), storified pedagogy is "a narrative-based approach to teaching and learning in which stories are used to explain, illustrate and contextualize concepts and ideas" (p.1). Storified pedagogy is defined by Kieran Egan (1997) as an approach to education that "uses stories to create a context that makes information meaningful and memorable" (p.92). Egan argues that stories provide a powerful way of organizing information and making it more accessible to learners and that they also help to engage learners' emotions, making learning more enjoyable and effective.
The learning approach employed by the teacher in this case study includes elements of storyline, narrative and storified pedagogy, but differs in the following aspects: -

- It involved A-level students instead of the predominant primary school focus of the storyline approach.
- Instead of a few weeks, the project ran over three 40 min planning sessions and a presentation session.
- The stories included only biology concepts instead of integrating different subjects.
- The storylines were created by the learners instead of the teacher.

All planning was done completely by the learners, without any assistance from the teacher.

2.1 Data collection

The aim of this case study was to investigate how teachers incorporated storification in their pedagogy to assist A-level biology students to revise together and link as many topics as possible over a short period of time. The research approach was inductive; allowing relevant ideas to develop throughout the process and extracting patterns and associations to inform further study. The process involved collecting data through direct observation, interviewing participants, and analyzing PPT's, photographs and video recordings of presentations. The project events that provided opportunities for data generation included the following: -

- introductory lesson on the idea of interconnectedness (links between seemingly unrelated topics and learning objectives)
- Allowing groups, the freedom to create their own storyline and choose their own presentation style.
- Capturing the process and the products on video and photographs.
- Observation of planning sessions and group presentations.
- analysis of video recordings, PPT's, posters and Prezi presentation
- Interviewing teachers and students involved in the project.

The study population was made up of two grade 12 (A-level) biology classes, one with 14 students and the other, with 10 students. The one class formed 6 groups and the other 3 groups. Nine different stories were produced and presented, each with its own unique storyline and presentation style, drawing on specific skills sets uniquely located within each working group.

2.2 Planning sessions

The concept of interconnectedness of course topics was introduced to each of the two classes starting with a diagram of a cholinergic synapse on the whiteboard. A storyline was developed by sequentially sketching in students' answers to probing questions. *Figure 1*, shows the final whiteboard diagram which was produced using students' answers to probing questions, such as:-

"What is inside the synaptic vesicles? How were the vesicles formed? By which organelle? Where did the ATP come from used by the Na^+/K^+ pump? Made during which process? In which organelle was the ATP produced? What happened before these reactions? How did the glucose land up inside the cell? Where was this glucose before that? If it came from an apple the person ate, was it in the form of glucose or bonded to fructose as sucrose? How did the sucrose land up in the apple? How did the plant produce the glucose and fructose to make sucrose? Was it produced via a C_3 or C_4 pathway? Is this apple tree growing in an area with high or low biodiversity? If you could predict a value for the Simpsons index for this area, what would it be, and why? Did the apple have seeds? If not, how was this seedless apple produced? How can we improve the nutritional value

of these apples using biotechnology?

The storyline was not developed further, due to the size of the whiteboard and the 10-minute time restriction, even though at the end, students were eager to add more links to extra topics covered over the two-year grade 11 and 12 A-level course.

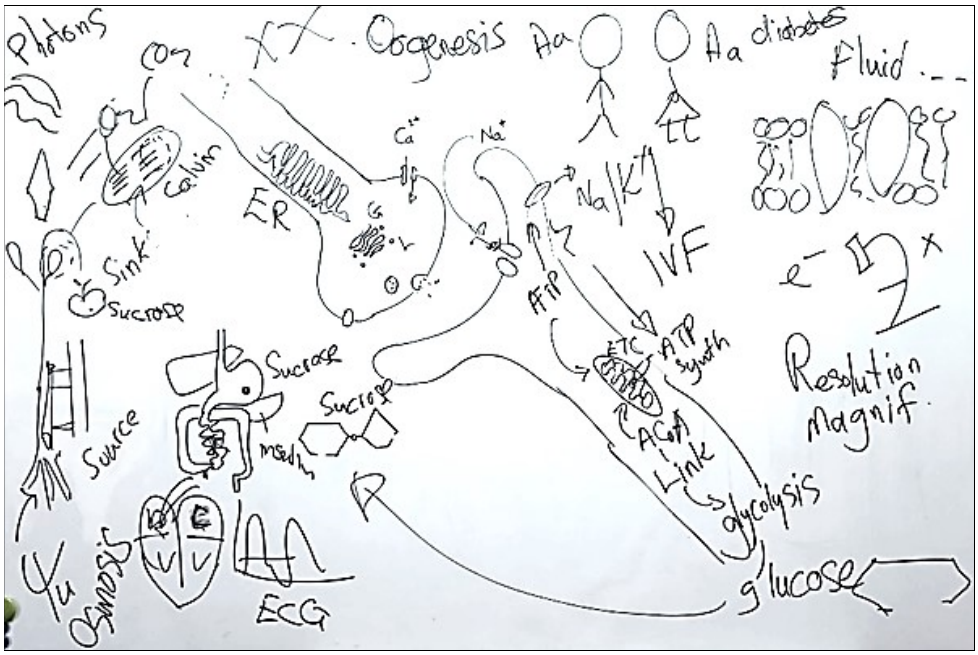


Figure 1. Cholinergic synapse

The final whiteboard diagram at the end of the introductory lesson

On reflection and analysis of the final whiteboard diagram in *figure 1*, the schematic diagram in *figure 2* was generated, showing the different course topics covered and their links (interconnectedness) within the developing story. Starting with only a diagram of a cholinergic synapse, which covers one topic in the course, the students ended up by linking 25 different topics in a developing story showing interconnectedness between seemingly unrelated topics.

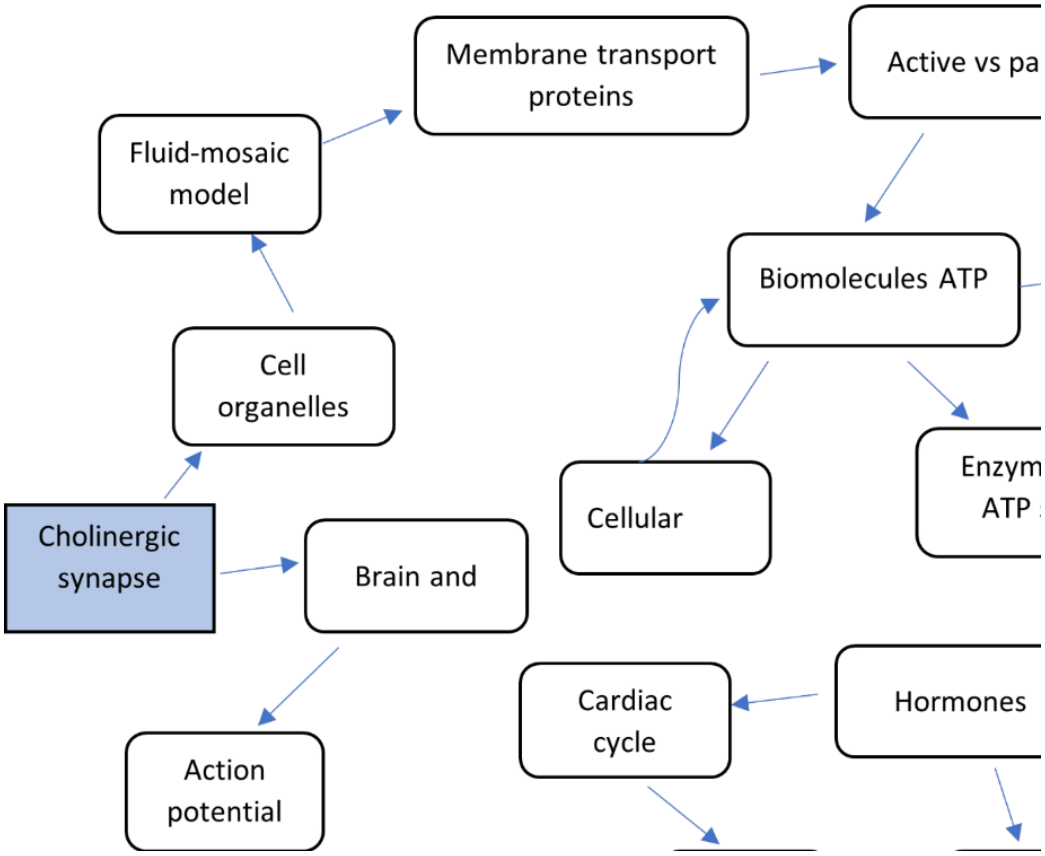


Figure 2. Interconnected biology topics

Schematic diagram showing interconnected topics at the end of the introductory lesson.

After discussing the created story, with its interconnected topics, students selected their own working groups and decided on final presentations to be not more than 10 minutes long. Class A formed 6 groups and class B formed 3 groups. Group members relied on their diverse, non-scientific skills allowing each member to contribute towards their group's creative and engaging presentations. These skills ranged from public speaking, acting, digital media design, visual art, digital video editing, and scriptwriting to mention a few. The groups worked independently, without the help of a teacher for three 40-minute planning sessions drawing on their own study notes, notebooks, and online information. *Figures 3 and 4* show the two classes and the different student groups working independently on their storylines and producing stories containing various biology topics, drawing on a variety of creative skills sets.

Figure 3: Class A planning
Six student groups using diverse skills to plan presentations (Jacobs)

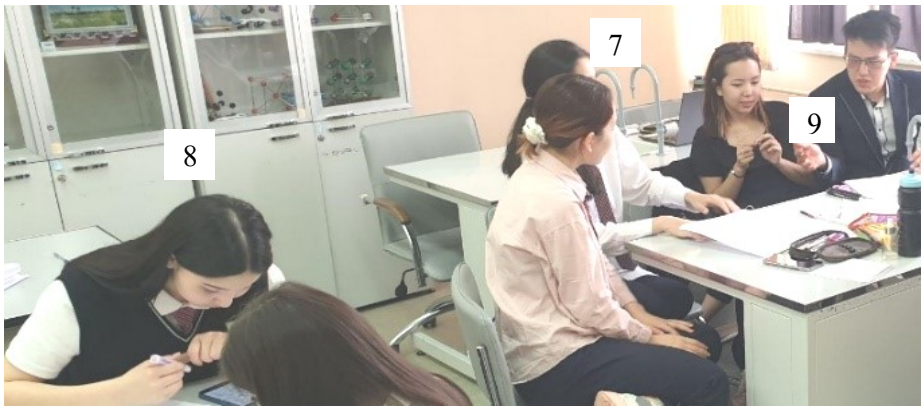


Figure 4: Class B planning
Three student groups working independently preparing different media (Jacobs)

Figure 5: Storyline
The storyline used for the story “When cloning goes wrong!” (Kaztaev et al.)

3. Results and findings

Nine group presentations were produced, ranging from a Prezi-based App, to using a personal health condition, and friendships as the storyline. All groups managed to show meaningful links between seemingly unrelated topics in a creative and fun way. Students were motivated and fully engaged in the activity (process and presentation) and needed no help or assistance from the teacher and were amazed at the standard of their own work. *Table 1* below shows a summary of the work produced by the different groups in the two classes.

Table 1: Summary of planning tools and final presentations per group

Class	Group	Number of members	Planning tools and final product	Storyline
A	1	3	PowerPoint with embedded video	The hypothalamus controls it all
	2	2	Prezi app	Prezi based App
	3	3	PowerPoint with trick photography	When human cloning goes wrong!
	4	2	posters/ flashcards	Disturbing the peace goes deep!
	5	2	PowerPoint and digital drawing	Interconnected like the human body
	6	2	PowerPoint	Understanding my gastric disorder
B	7	3	Poster	In vitro is the way to go!
	8	*5	Acting, flashcards, poster	Cloning around is our business!
	9	2	PPT and fancy photography	Strong friendship down to our DNA!

* Group 8 in class B started with three members but ended up with 5 as two students were absent during planning and returned one day before presentations were made.

The following section shows the results of the group presentations in two stages:

3.1. Photographs of the different story presentations
3.2 Narratives of 5 different stories

3.1 Presentations of different stories

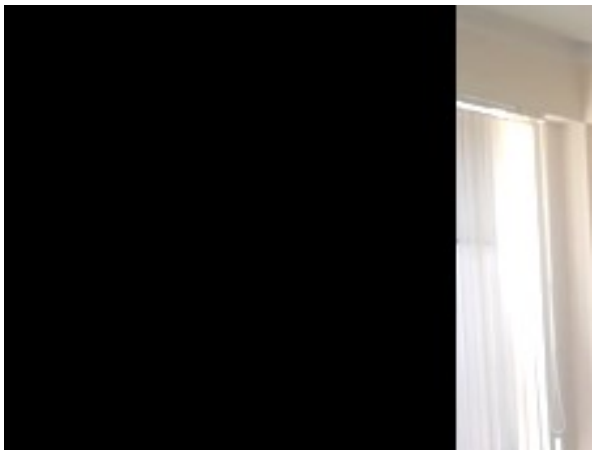


Figure 6: The hypothalamus controls it all.
(Kablakatova et al.)

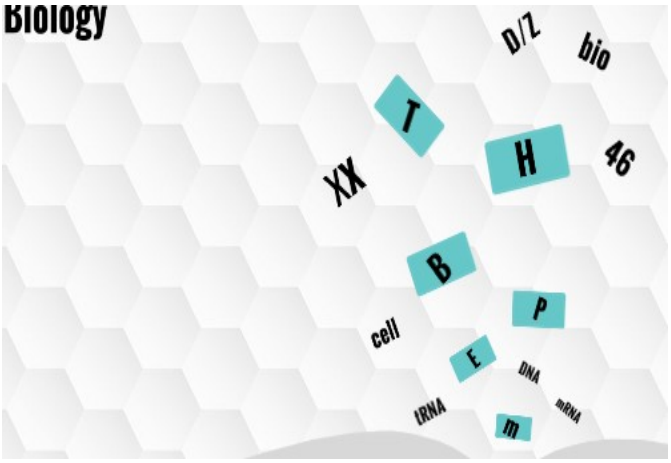


Figure 7: Prezi-based App.
(Alynbayeva & Kazym,)

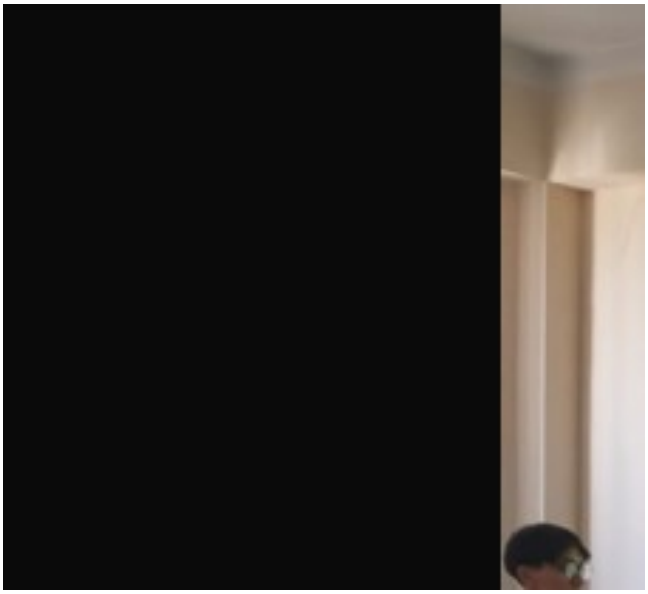


Figure 8: When human cloning goes wrong.
(Didarkovyna et al.)

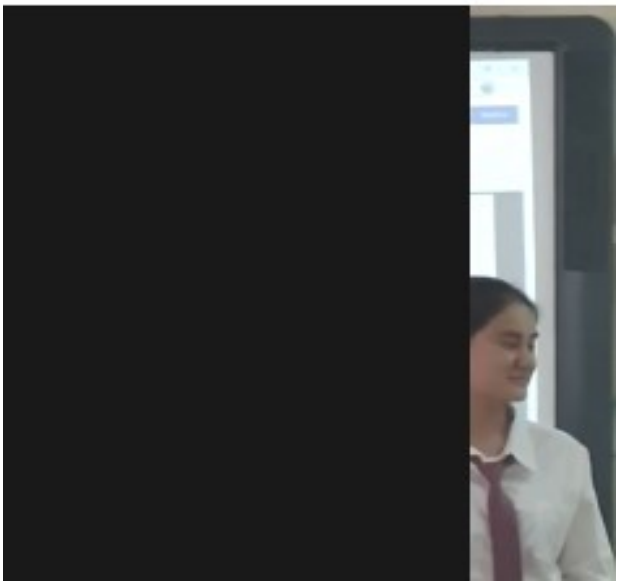


Figure 9: Disturbing the peace goes deep.
(Bulegenova & Chaiparova)

Figure 12: Cloning around is our business!.
(Ispergenova et al.)

Figure 13: In vitro is the way to go!
(Kim et al.)

Figure 11: Understanding my gastric disorder.
(Aldabergenov & Sapa)

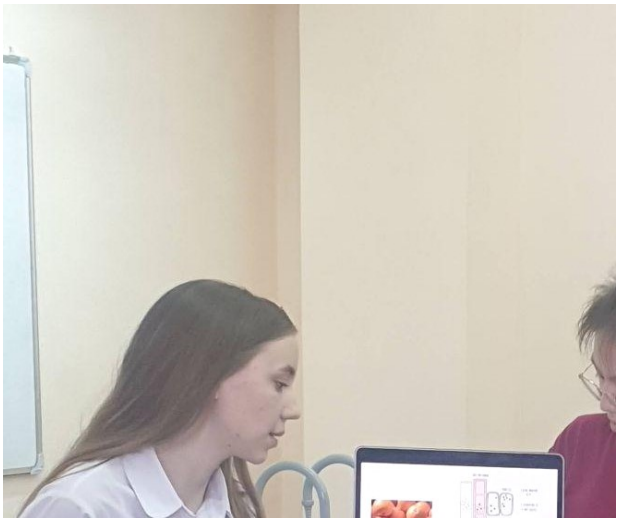


Figure 14: Strong friendship, down to our DNA!
(Fink & Tushinskaya)

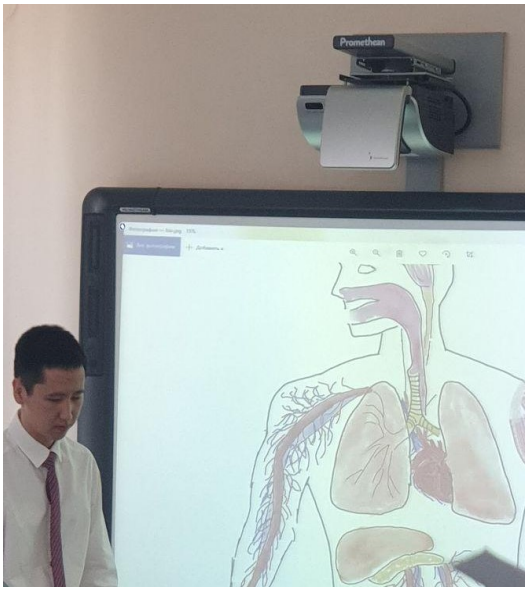


Figure 10: Interconnected like the human body.
(Sarsembina & Aselbayev)

3.2 Narratives of stories

This section captures some group presentations, analyses of the stories, and photographs from presentations to determine the different topics covered in each story and how each group managed to find links (interconnectedness) between different course topics.

3.2.1 Story no 4. Disturbing the peace goes deep!

This story by Chaiparova & Bulegenova started with a peaceful scene of a man fishing next to a lake (*figure 15*) in an area with high biodiversity (species richness and species abundance). A group of students are measuring the species diversity in the area using 50 x 50cm quadrates and random sampling technique to calculate the Simpson's index. They also use a light microscope to identify micro-organisms in the water, which has certain properties making it ideal for life to exist. One of the students decide, using his cerebral cortex, frontal lobe to hit the fisherman and rob him of his catch. This action is brought about when calcium ions are released into the boy's muscles, changing the shape of tropomyosin molecules and causing the formation of cross bridges between actin and myosin heads. The breakdown of ATP to ADP and phosphate creates powerstrokes in the muscle fibers of the student and produces a strong slap on the man's face! The pressure produced causes Pacinian corpuscles in the dermis of the fisherman's skin to deform, allowing sodium protein channels in the sensory neurons to open, sodium ions to flow in and an action potential generated that is transmitted via the spinal cord to the brain. This story continues and manages to draw in aspects from many syllabus topics including transcription, translation, mutagenesis, aging, fluid mosaic model, protein structure and function, genetics, photosynthesis, respiration, nephron structure and function, DNA repair as well as cancer and the cell cycle. The team managed to include all these topics in a 10-minute presentation that was fun and held everyone's attention. *Figure 16* shows the whiteboard and chalkboard at the end of the group's presentation, with hand-drawn diagrams illustrating the various topics included in the story.

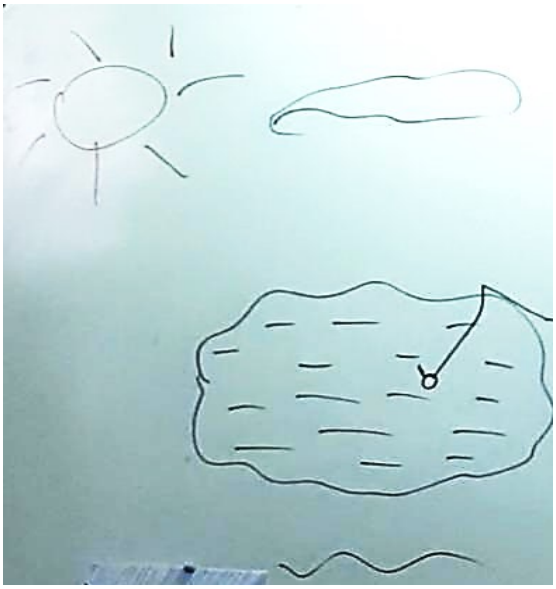


Figure 15. Disturbing the peace runs deep!, Chaiparova, & Bulegenova
The starting scene of the story showing a fisherman in peaceful surrounds.

Figure 16: Disturbing the peace runs deep!, Chaiparova, & Bulegenova
The picture shows the whiteboard and adjacent chalkboard at the end of the 10 minute presentation.

Figure 17 shows a schematic representation of the number of course topics and their links covered and explained by the students. Chaiparova and Bulegenova were able to "observe" through biological lenses and find logical connections between seemingly unrelated topics covered in the grades 11 and 12 course, using what seems to be a non-biology related story. They were able to identify complex biological concepts at both macro and molecular level, and find links to connect the different processes in an everyday real life scenario.

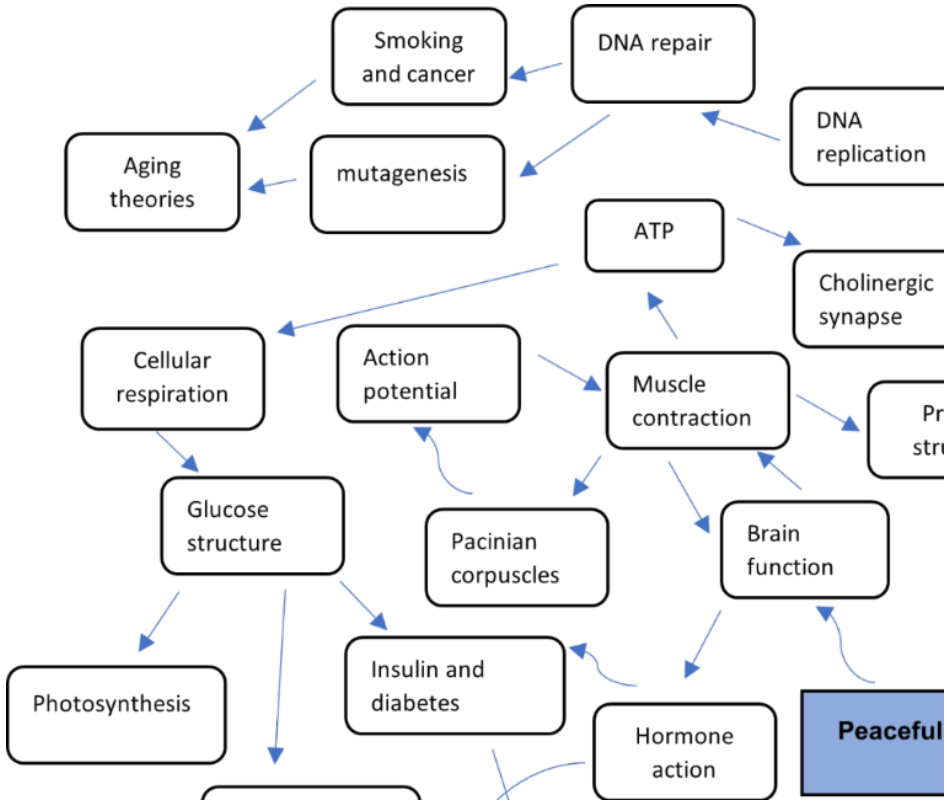


Figure 17: Connected topics in the story “Disturbing the peace goes deep!"
The diagram shows the 34 course topics covered and linked in the story

The diagram on the left (*fig. 18*) was created and used by the two students when presenting their story. It shows the injured fisherman after the confrontation. Students explained in detail the biological processes involved in the picture, including activating stem cells and mitosis (cell cycle), cellular activities involved in producing tears (epigenetic activation of transcription and translation), immune system activation, function of adrenaline, and other hormones, initiation, and transmission of nerve impulses to feelings and memories stored in the frontal lobe of the cerebrum. The red colour on the skin shows inflammatory response due to injury.

Fig.18: Injured fisherman, Chaiparova, & Bulegenova,
Injured fisherman with tears, inflammation, and regeneration of skin with mixed feelings of fright and fear.

By the end of the story the two students managed to include and connect 34 different biology course topics in their 10-minute presentation. The media used and the style of presentation was characteristic of the two students in this group. They possess a flair for visual art and have previous acting experience. Their delivery was captivating, infused with passion and added a delightful and unforgettable spin to studying biology for final A-level exams.

3.2.2 Story no.7. In vitro is the way to go!

The story starts with a single lady, Ainura, who is infertile and decides to have a child by in vitro fertilization (IVF) using a sperm bank and surrogate. She goes through the IVF process, and gives birth to a son, named Amir. As a hard-working single parent in Kostanay, she works two jobs to make ends meet and her son, Amir, develops an eating disorder and eventually diabetes. She approaches a recombinant DNA-based biotechnology company to develop individual-specific insulin for her son using rDNA technology and gene therapy. Her son heals and is consoled by his best friend, Freddie his yellow Labrador dog who was the result of recessive epistasis when mating a heterozygous black dog with a heterozygous chocolate colour one. When Freddie dies due to natural aging brought about by increasing mitochondrial dysfunction, they decide to clone him at the local clone-based company (Clone-it!). Amir sees how profitable and easy cloning can be but working with animals involves too many issues of bioethics. He decides to study micropropagation of plants, particularly the growing of medicinal plants that produce phytochemicals which can be useful in cancer research. The process involves producing callus growths and new plants from cells, without the need for pollination and seed formation. His family business (Micro-prop) thrives, and he manages to help his mother live a better life.

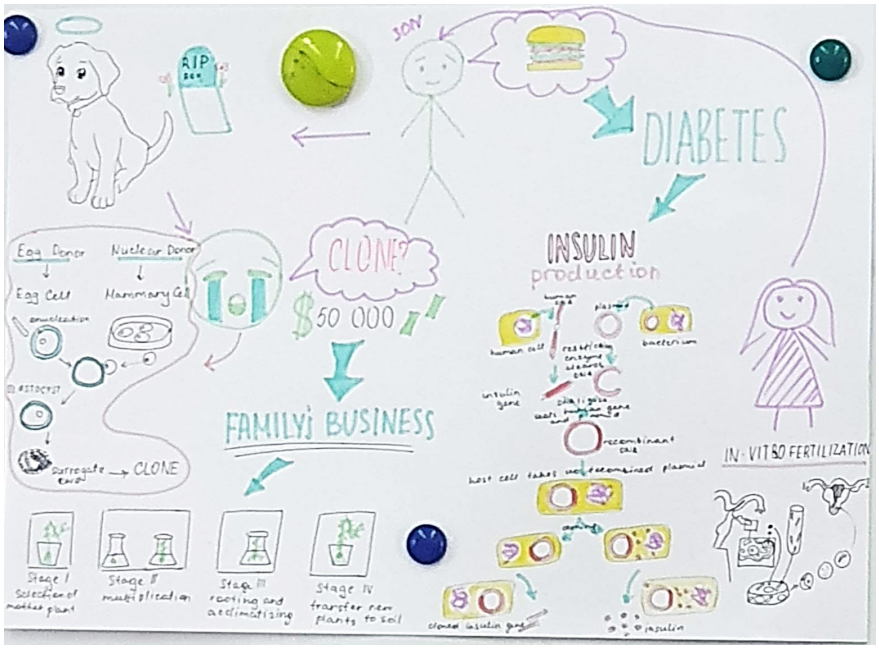


Figure 19. In vitro is the way to go! Ispergenova et al
Poster drawn by one of the team members with input from the other two.

This story draws on common lived experience of many young women in the rural village communities in Kazakhstan, namely single mothers, infertility, the pressure on women to have children and the difficult financial burden associated with such a lifestyle. The group used their understanding of acquired biology knowledge from grades 11 and 12 to creatively produce a storyline that reflects the future hopes and dreams of a single parent family. The dreams and future aspirations of the three learners are embedded within this story; two students are business minded and went on to study business management and entrepreneurship at university while the third went on to study medical technology. The three students were able to meaningfully and logically connect 17 different, seemingly unrelated topics from grades 11 and 12, including explanations of the various biological concepts within their created story.

The schematic diagram below (*figure 20*) shows how Ispergenova et al. were able to make meaningful links between topics and explain the biological concepts within their locally relevant story.

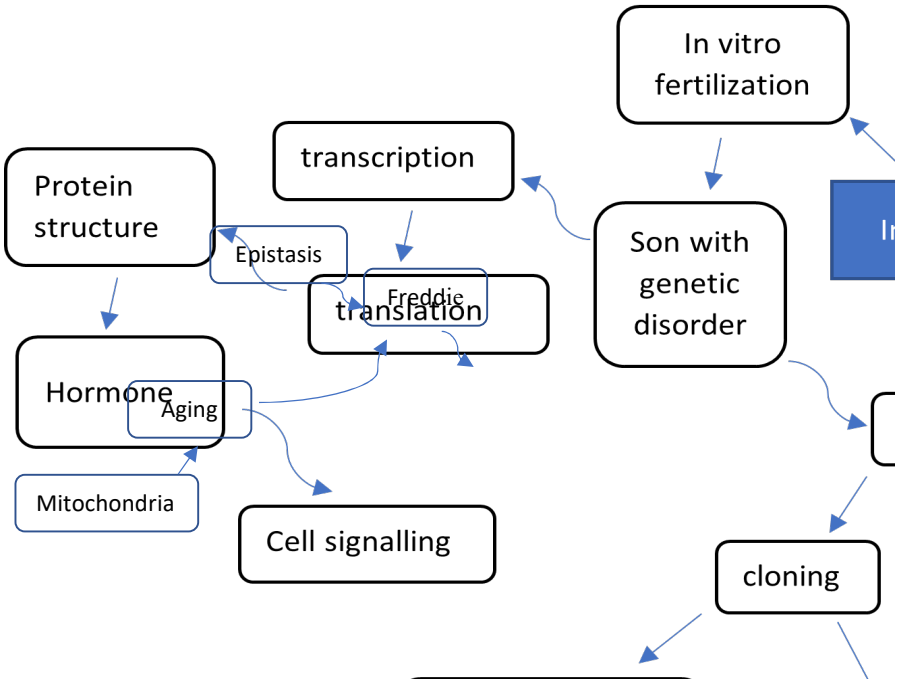
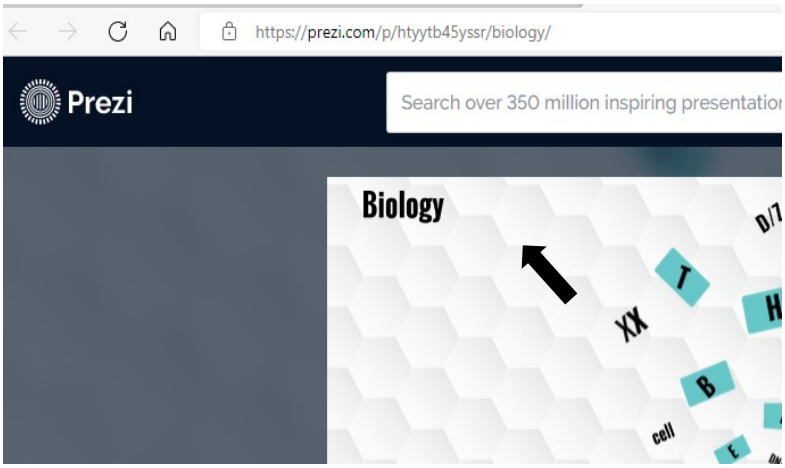


Figure 20: In vitro is the way to go! Ispergenova et al
Diagram showing interconnected topics in the story "In vitro is the way to go!"

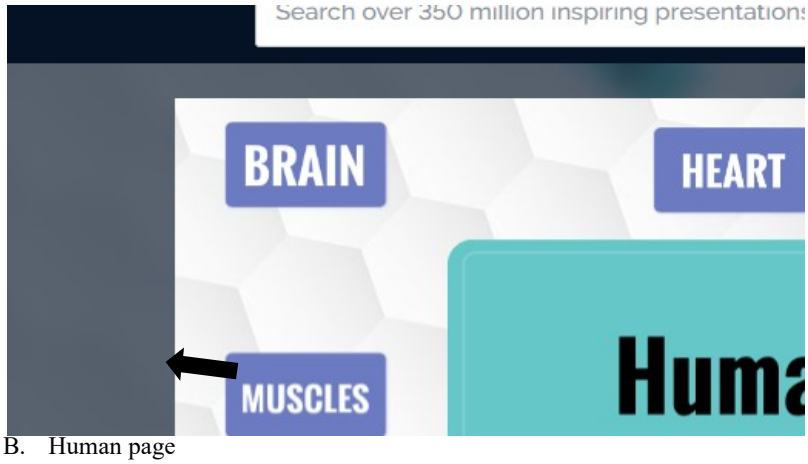
3.2.3 Story no.2. Prezi presentation with links to all units

Kazym and Alynbayava produced a Prezi[3]-based application that works as a virtual textbook with chapters that open specific presentations with the click of a mouse. The chapters of the book do not follow the course plan but rather integrates various topics under an umbrella chapter title, for example the chapter entitled "Human" incorporates physiology, cell biology and evolution. The two students cleverly combined different topics into central chapters showing their understanding of the interconnectedness of topics not in a story, but rather into a book called A-level biology. The book covers all topics from the grades 11 and 12 course but does not follow the typical course outline sequence of units, showing the students' understanding of interconnectedness of diverse seemingly unrelated units and topics. *Figure 21* shows the opening page of this computer application. When one clicks on the link with the capital H, the page with the heading "human" appears. This page has various links including heart, mitosis, gametogenesis, evolution, cell, mutation muscles and brain, some topics that are seemingly not related to the page heading. The "mutation" link opens the "chromosomal mutations" page. Clicking on the "gene mutation" link then opens the molecular (DNA) basis of mutation and DNA repair mechanisms. The course plan does not have a unit called human, or human anatomy and physiology. In their presentation though, the two students explained the links between the seemingly unrelated topics in a meaningful and logical way, showing their insight into the interconnectedness between the different topics such as gametogenesis, mutation, brain and cell function.

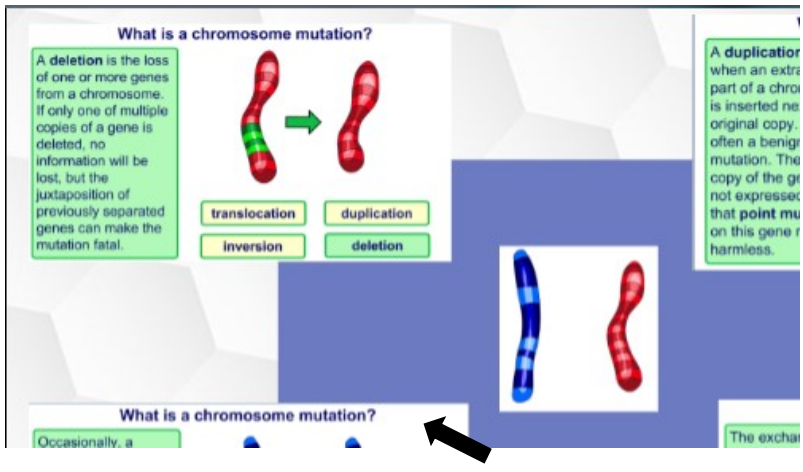
Figure 21. Screenshots of the Prezi opening page and 3 links following the H link.



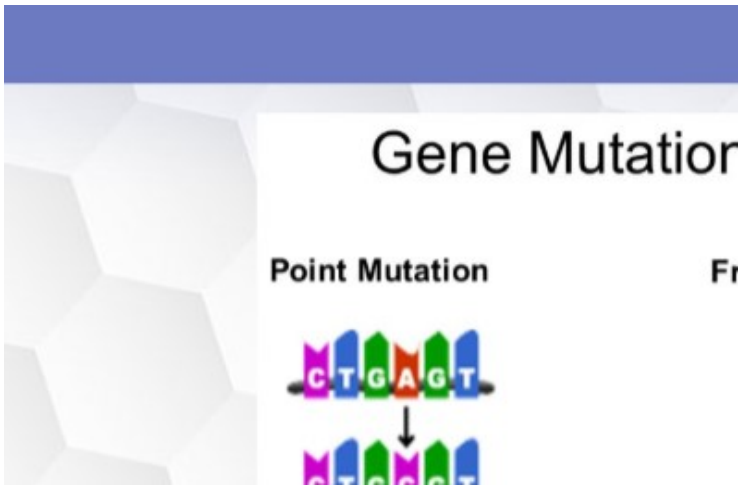
A. Opening page of the application



B. Human page



C. Mutation page



D. DNA mutation page

This work was greatly influenced by the two students' interest in computers and business management. The application is a useful tool for revision for all A-level biology students and, if developed further (instead of over three 40- minute lessons), could become an income generating creation.

3.2.4 Story no. 6. Understanding my gastric disorder.

This presentation was made by two close friends, one who suffers from a gastric disorder. They took the opportunity to create their story around the student's gastric disorder and connected it to his lifestyle and stress while practicing, and when participating in chess championships. The presenters detailed the epigenetic role of lifestyle on triggering the disorder, cytological and molecular level manifestation, current medication and how it affects gene expression, delaying the possible onset of cancer, due to disruption of the cell cycle and finally hopes of reversing the progression of the metabolic disorder by using stem cells and gene therapy, ensuring not only the health of the friend, but ensuring the health of the friends' future offspring. In the story, the one friend decides to study biotechnology and particularly gene therapy which he eventually uses to develop and administer a designer drug to cure his friend and prevent the disorder from manifesting in the friend's possible future generations.

The story combines the personal experiences and prior knowledge of the two students, application of their acquired knowledge from grades 11 and 12 and their real-life aspirations of contributing to society through their interest in medicine and medical biotechnology. The scheme below shows the different topics incorporated and connected within the story. Sapa and Aldagergenov managed to include and logically connect 14 different topics in their story as shown in the schematic diagram, *figure 22*.

Figure 24: Different topics included and connected in the story, “Understanding my gastric disorder”

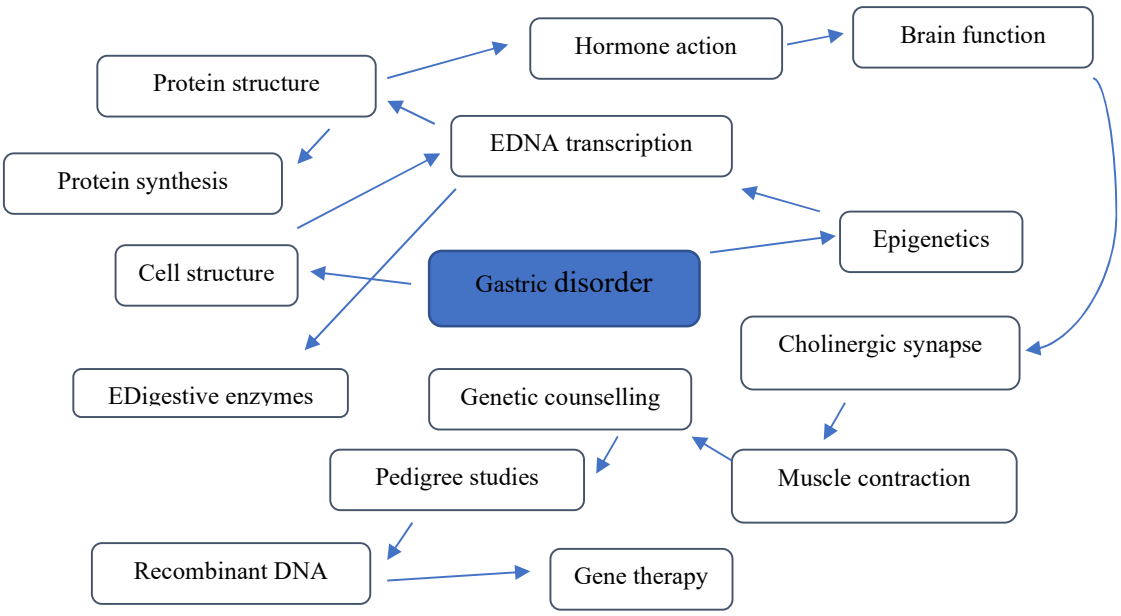


Figure 25: Understanding my gastric disorder, Sapa & Aldabergenov
The slide shows the students’ analysis of the factors that contributed to the gastric disorder.

3.2.5 Story no. 9. Strong friendship down to our DNA!

This presentation was made by two students who both aspire to be successful medical doctors one day. Their story involves two good friends who could not be separated. Due to different lifestyles though, certain genes of the one friend get methylated and the result, revealed by a brain scan, shows that she suffers from chronic depression. An explanation of neurotransmitters, recombinant DNA and biotechnology leads to the non-depressed friend's DNA being used in vitro, to insert the specific neurotransmitter gene into neural stem cells from the depressed friend's brain. The modified cells are then cultivated in a specific culture medium and transferred into the brain of the friend who suffers from chronic depression. The new genetically modified stem cells produce no adverse immunological problems for the friend, as her own stem cells were used. Fink and Tushinskaya were able to include and logically connect 13 topics from grades 11 and 12 in their story.

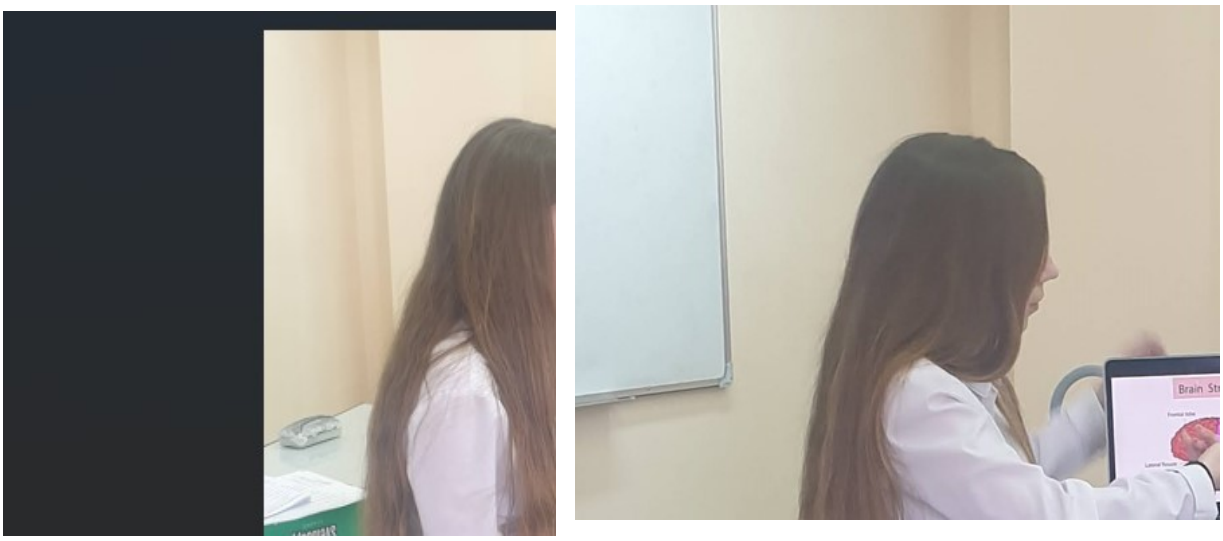
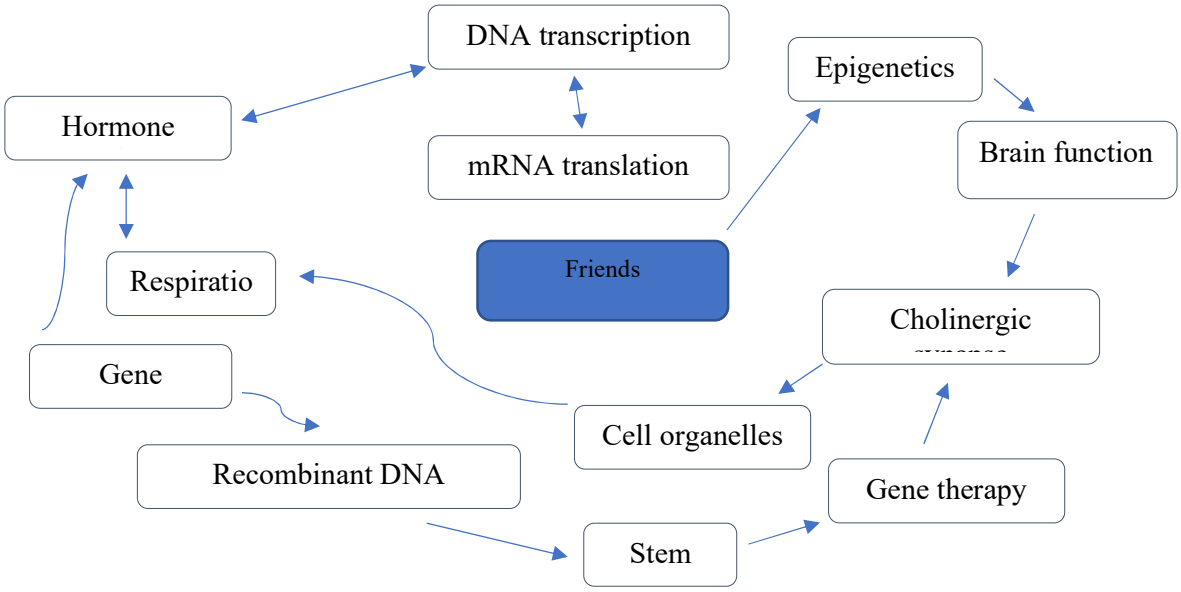


Figure 26: Good friends down to our DNA! Fink and Tushinkaya
Slides show brain scans of the two friends with an explanation of the problem with the friend's brain

The storyline leans heavily towards the medical and human physiology side, which bears witness to the two student's passion for pursuing careers in the medical field. Both students ended up studying medicine at two different universities. The diagrams in *fig.26* shows the different topics included and logically connected within the story by Fink and Tushinkaya.

Figure 27. Connected topics in the story "Good friends, down to our DNA", Fink & Tushinkaya



4. Discussion

This section includes a discussion and general interpretation of 5 stories as well as excerpts from the 4 other stories, not captured in this article.

4.1 Enabling understanding of interconnectedness of A-level biology topics.

The practice of wrapping the different units and topics into a relatable story that can easily be remembered enabled students to find logical connections between seemingly unrelated topics. The storyline in *fig. 28* from the story, "*When cloning goes wrong!"* Didarkyzy et al. (2022) shows a simple, typical day in a village. The group managed to find and logically connect diverse biology topics using the village-based storyline, indicating insight, and understanding of the topics, as well as its application in real life situations. Although the scene involves human health, it incorporates and logically connects diverse topics, such as biodiversity, statistics in biology, recombinant DNA, C_3 vs. C_4 photosynthesis and plant micro-propagation. The group managed to incorporate 15 different topics and logically link the topics within their story. The story was easy to remember and could serve well as a simple way for students to recall concepts and topics during exams. This story showed both the presenters and the student audience possible exam questions that would require knowledge of more than one topic to answer. An example is the way Didarkyzy et al. linked recombinant DNA, IVF, genetics, and enzyme function within their story.

The group was able to look at a typical day in a rural village and identify a more complex array of interconnected biological processes at play, revealing their increased insight and awareness of the living world as a set if intricately interconnected and inter-dependent life processes at macro, micro and molecular levels.

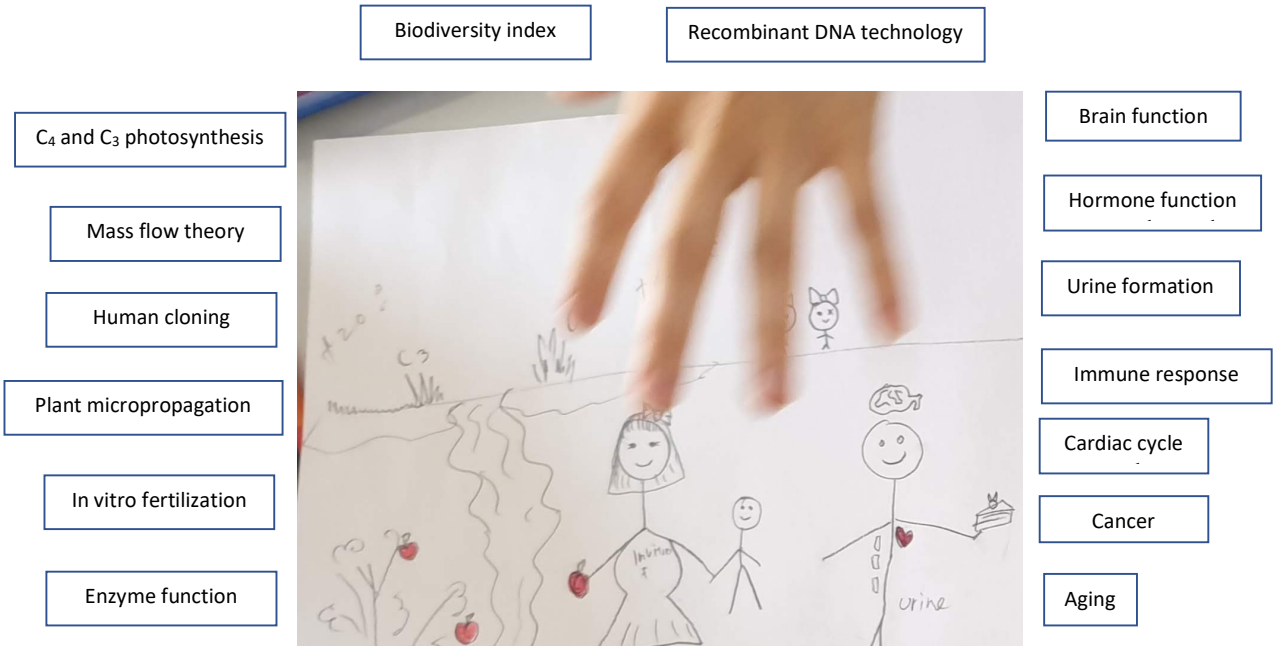


Figure 28: When cloning goes wrong! Didarkyzy et al.
Drawing shows the storyline and different topics included within the story

The work of Chaiparova & Bulegenova showcased their insight and understanding of the different biological processes at play in a simple scene of a man fishing in a lake in a bio diverse area in Kazakhstan, where a group of A-level biology students are conducting a survey of the area. The 34 course topics which were covered were much easier understood and remembered because it was all wrapped in a simple story.

Table 2 shows a summary of the number of interconnected topics that were covered by each of the stories. The most creative story, "*Disturbing the peace goes deep!"* (Chaiparova, & Bulegenova) managed to include and logically link the most diverse topics (34) while the story, *Understanding my gastric disorder* (Aldabergenov & Sapa, R.) incorporated 14 different topics, since it was a more focused story. It seems that the more elaborate and creative storylines can incorporate more diverse, seemingly unrelated topics into the story. Groups that included students with acting and movie scriptwriting backgrounds were able to connect more course topics if they included an academically strong member in their team. The project enabled students who normally would not engage actively in class discussions to get actively involved and contribute to the presentations, since the work required not only academic skills but equally important was creative thought and imagination.

Table 2: Number of topics and connections made in each story.

Class	Group	Title of the story	Number of topics in story
A	1	The hypothalamus controls it all	16
	2	Prezi based App	20
	3	When human cloning goes wrong!	22
	4	Disturbing the peace goes deep!	34
	5	Interconnected like the human body	19
	6	Understanding my gastric disorder	14
B	7	In vitro is the way to go!	17
	8	Cloning around is our business!	15
	9	Strong friendship down to our DNA!	13

4.1.2 Seeing interconnected biology topics in everyday life

It is evident from various groups that there exists a high level of insight into the interplay between interrelated biological processes in the web of life. Chaiparova & Bulegenova in their story, "Disturbing the peace runs deep!" could see interconnections between diverse biology topics like statistical methods in biodiversity studies, muscle contraction, stem cells and the role of carcinogens in smoke in the mutation of tumor suppressor genes giving rise to early aging and cancer in a drawing of a man fishing along a typical lake in Kazakhstan with surrounding natural beauty.

Aldaberenov and Sapa used a known personal experience of a gastric disorder and managed to include topics of ecology, cellular function, molecular control of transcription, recombinant DNA technology and stem cell research to express hope for a lasting cure for the disorder.

Finck and Tushinkaya's story was based on a real life experience of depression. Their story explored topics ranging from brain structure and function, hormone activity at molecular level, gene regulation, stem cell technology, epigenetics and smart pharmaceuticals and individualized therapy through recombinant DNA technology.

Ispergenova et al. drew from their real-life experiences with single-parent families in Kazakhstan and their impact on home-alone children. They integrated these experiences into a narrative encompassing diverse topics such as in vitro fertilization, animal cloning, hormone action, transcription and translation, recombinant DNA technology, and micro plant propagation. The story concludes with the depiction of a well-managed ethical cloning business.
The real-life stories presented by the students served as useful tools for remembering many topics during the exams

4.1.3 Enabling independent, collaborative student engagement

The groups drew on a variety of skill sets to put together their creative and informative presentations. Here we will highlight how collaboration allowed for each student to be valued for the unique skills they added to the production of their final work.

4.1.3.1 Diverse skills

The PowerPoint slide in *fig. 29*, from the story, "*When human cloning goes wrong!*"(Didarkyzy, Kaztaev, & Azhmedzhanova), shows the product of human cloning but also shows what happens when an academically strong member, who dreams of being a medical doctor, teams up with an artistically strong student, who dreams of being a film director. The knowledge of embryo splitting technology and the creativity of the aspirant film director combined perfectly in making this slide, showing the effect of environmental factors on the epigenetic expression of genes. The one twin has normal eyesight while her genetically identical sister suffers from myopia.
The discussions that went into the final creation of this slide involved an explanation of human cloning by embryo splitting as well as the effect of environmental factors on the methylation of DNA and histone tail polypeptides. The conversation was not mediated by a teacher and was entirely the product of independent student collaboration.

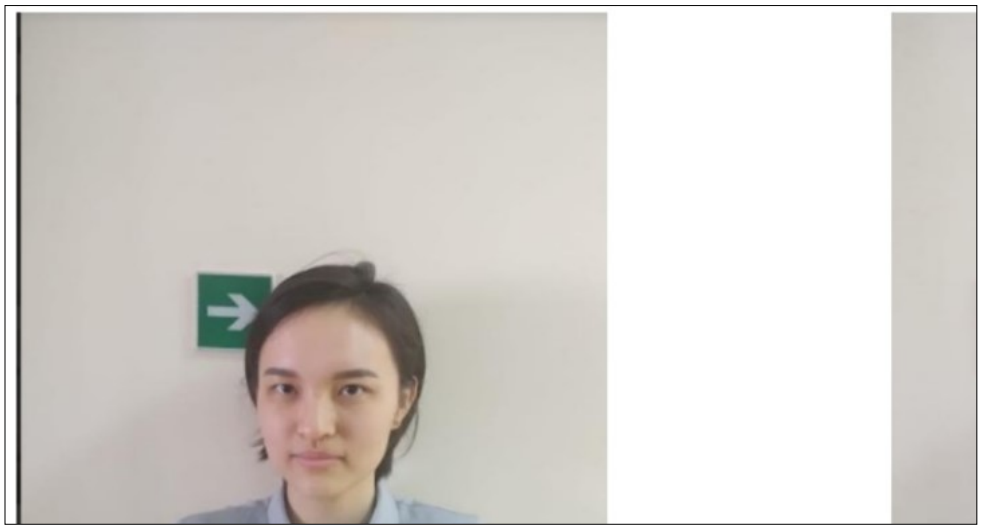


Figure 29**:** Didarkyzy, et al. When cloning goes wrong!

Kazym and Alynbayava used the academic strengths of one partner and the computer skills of the other to develop their Prezi application, which covered a number of topics, given the short time allowed for preparation. Given more time, they would easily have completed pages and hyperlinks to each of the topics covered in the A-level course plan.

4.1.3.2 Creativity and biology combined.

The PowerPoint slide in *fig. 30* shows the group's hypothesis for the one cloned sister being born with an extra finger (polydactyl), while the other sister is born with normal hands. The creativity involved in the production of this slide is evident but would be meaningless without the use of the explanation of polydactyly being caused by a mutation. The group's deeper understanding of the scientific process and the possible molecular level cause of change in the sister's DNA is evident in their explanation of point mutations.

This slide is evidence of how storification of the embedded biological concepts allowed students to show deeper understanding of interconnected topics in a more creative and memorable way. Not only were biological facts discussed during the production of the slide, but at the end of the presentation the student audience were unanimous in praising the group for making seemingly distant topics so much fun and easy to understand and remember for exams.

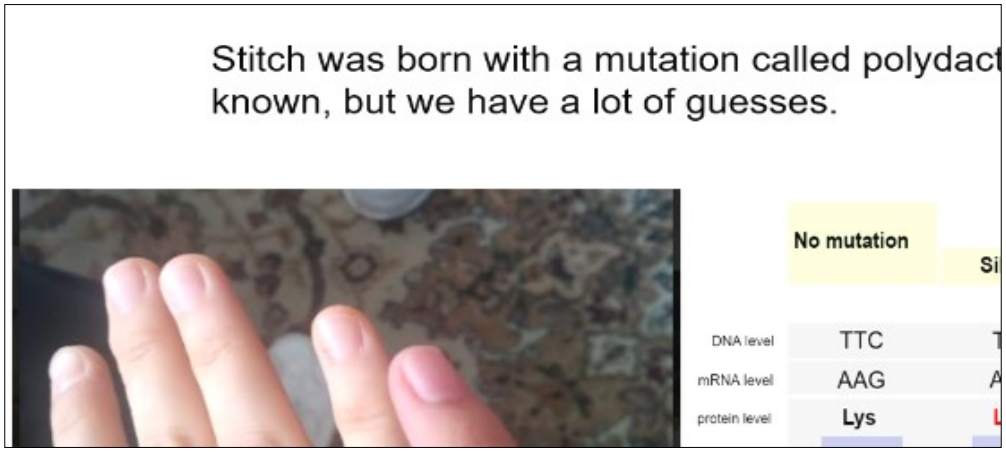


Figure 30: When cloning goes wrong! Didarkyzy, et al

The creative digital drawings of the various organ systems of the human body done by Sarsembina and Aselbayev is another good example of creativity and biology knowledge coming together. The two students had to have a thorough knowledge of how the organ systems function at macro, micro and molecular level, and explain how the nutrients produced in the digestive system by hydrolytic enzymes, is absorbed into the bloodstream, which flows because of the way the heart functions, absorbing oxygen in the lungs to produce ATP for energy to actively remove toxins in the kidneys, while re-absorbing water under the influence of antidiuretic hormone (ADH) which is secreted by the pituitary gland in the brain. In addition to this detail the student who has the digital drawing skills had to draw the diagrams layered in the correct sequence for the presentation to run smoothly with the click of a mouse.

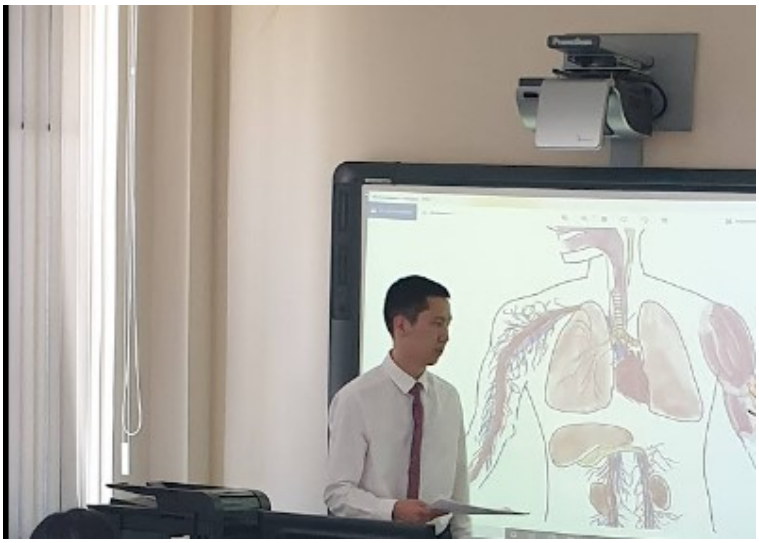


Figure 31. Digital artwork and biology come together on a smart board.

Figure 32 Face of the fisherman before and after the fight

The drawings by Chaiparova & Bulegenova, shown in Figure 32, showcase the artistic ability of one student. Upon closer inspection, it becomes evident that much discussion and debate about different biological processes preceded the drawing on the right. It illustrates tear production (transcription, translation, and protein synthesis), the effect of a peptide hormone, skin repair (stem cell specialization), inflammation, the immune response, and the formation of memory in the frontal cortex of the brain. The artistic flair of one student blended well with the academic strength of the other, and this combination was brought to life memorably through their acting skills when presented.

4.4 Enhancing deeper understanding during exam revision.

Each of the stories provided a unique way to understand and remember the various biological concepts and topics. The stories themselves acted as hooks onto which the different terms and concepts were attached. Students were unanimous in agreeing that the presentations enabled them to form new insight and deeper understanding of seemingly unrelated topics. Each story, with its unique media and props left lasting memories with students and allowed for the development of deeper insight into the interconnectedness of biological phenomena, which is a key feature of the final A level Cambridge examinations.

5. Knowledge contribution

The results of this research project add value to the ongoing efforts of countless teachers who are looking for captivating ways of facilitating active learning in higher grades, in this case A-level. Storified pedagogy, and the storyline approach has been extensively employed in schools in the lower grades and narrative pedagogy within the nursing education field. The results of this research show that storified pedagogy has the potential to be used at A-level: -

1. To enhance deeper understanding of complex biological concepts and the interconnectedness of different biology topics. (Chaiperova & Bulegenova, *Disturbing the peace goes deep,* Kablakatova et al., *The hypothalamus controls it all,* Kim et al., *Cloning around is our business!*
2. Increasing students' ability to apply new knowledge in personal real-life stories. (Aldabergenov & Sapa, *Understanding my gastric disorder),* as well as Finck et al., *Good friends, down to our DNA!*
3. Reflect on the new knowledge gained and its relevance to improving livelihoods. (Ispergenova et al., *In vitro is the way to go!*), and (Kim et.al, *Cloning around is our business!).*

6. Limitations of the study

This was a once-off study over a very short period (5 days), yet the results show potential usefulness as a

reflection and revision tool at A-level. The study was conducted with students who had worked together for more than two years, and therefore had established relationships, and sufficient trust to be willing to share personal stories and experiences within the group. The positive, established working relationship between teacher and students could also have been a factor that contributed to the results of the study.

7. Conclusion and recommendations for further study

The following recommendations are proposed flowing from results of this study: -

- Instead of leaving the instructions too open-ended, give each group a set number of learning units to work with to create their stories around.
- Start the storyline at the end of term 1, allow students to add to the storyline at the end of each term, gradually incorporating the term's learning units into the story. At the end of term 4 the entire story can be captured, recorded, and presented in various media formats, drawing on students' creative skills.
- Allow group 1 to start the story given a few learning units; groups 2 continue the story where group 1 ends using their given learning topics; group 3 continues the story where group 2 ends, using the learning units given to them. The last "episode" of the story is created by each of the groups independently, allowing for different perspectives and increased creativity.
- Include a creative writing element to the project .This will develop the skill of presenting creative thought and understanding of biological concepts through text, a skill that is needed in answering structured questions in the exams.

8. Extending the project to include creative writing

The second and especially the third component of the A-level exams has a focus on critical thinking and analysis. Critical thinking and other higher order cognitive skills however, needs to be articulated in text, which is an essential skill for answering these type of questions. To stimulate creative writing skills, students were asked to create and write a story that showcases Kazakh culture and tradition, but with a biology focus that includes various topics from the A-level course. *Figure 33* shows an extract from the created story, called *"The last wild apples of Almaty.*"

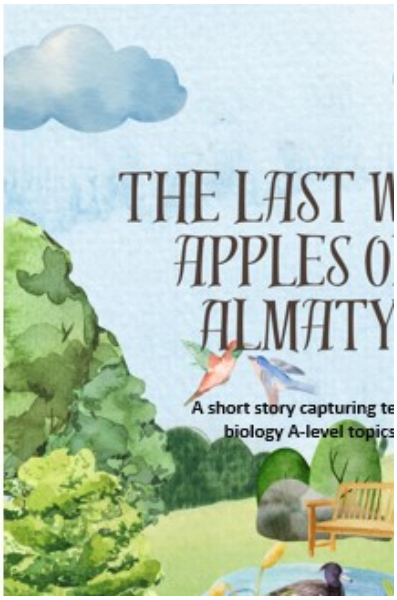


Figure 33. Cover page of the short story "The last wild apples of Almaty"

Chapter 1

Day 1: Our threatened heritage

The day finally arrived! Aigerim, the girl with a personality as wonderful as the full moon she was named after, and Baizhan, the boy with a rich soul, are among a group of grade 12 biology students embarking on a 3-day horseback hike into the famous northern Tien-Shan Mountains near Almaty. Their teacher, miss Ayakoz Kairatkyzy, with the beautiful eyes that lights up like the clear, bright blue sky on a typical spring day in Almaty, has prepared this trip for them as it would be their final few days together before the dreaded Cambridge A-level exams start. High up in the mountains is a last remaining population of wild apples, *Malus sieversii,* the ancestors of the present-day varieties of apples. The students are carrying with them various biology equipment, including **1m x 1m quadrats**, wooden frames which they will use to **randomly sample** the plant **community** to establish what makes this **habitat** so uniquely suitable for this rare and precious **endemic** plant **species**, that only grows in Kazakhstan. Each group of four students will be using different statistical methods to test the **hypotheses** which they have come up with as to why this habitat within this vast 2.725 million km^2 country is so unique. Baizhan and his group will use a **t-test** to see if there is a significant difference in size between the wild apples in the mountains vs the apples found in Almaty city. Aigerim's group will use a **χ^2-test** to see if wild apples taste significantly different to apples sold in the city. The third group is using **Simpsons' diversity index** to study the **biodiversity** of the community where the wild apples grow compared to where there are no wild apples. In this way they can comment on the **species richness** and **species evenness** of the area and add to data used by the managers of the Ile-Alatau National Park. Miss Ayakoz hopes that this trip will encourage, Gulbatira to pursue a career in **nature conservation** as she has a passion for the mountains; maybe it has something to do with her name, which was given to her by her wise grandmother, who still lives in a village in the mountains where the **air quality** is much better than in the city.

Figure 33 b. Excerpt from chapter 1 in the short story "The last wild apples of Almaty"

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