

Genome Island: a virtual science environment in Second Life

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Article originally published in "Innovate – Journal of Online Education", V. 5 (2009), n. 6 <http://innovateonline.info/?view=article&id=562&action=synopsis>
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ABSTRACT. Second Life's virtual environment has particular implications for science education as it fosters a sense of play in the virtual laboratory. Genome Island is a laboratory environment of genetics built in the virtual world of Second Life supported by the Biology Department of Texas Wesleyan University and by a Sam Taylor Fellowship awarded by the Division of Higher Education, United Methodist General Board of Higher Education and Ministry.

Genome Island is a didactic area in the virtual world of Second Life where students can perform a lot of genetic simulation experiments. The four activities described below (Bacterial Transformation; Monohybrid Pea Cross; X-Linked Inheritance in Cats; Message in a Bottle) illustrate some of the data that can be collected on Genome Island and the learning objectives addressed by each experiment. Virtual worlds offer a learning environment that combines active engagement with the convenience of online access. Students analysed came from two classes of Texas Wesleyan University. Student performance on Second Life learning objectives was assessed as part of the final laboratory exam, which included material covered in Second Life activities. Actually is available for public access.

KEYWORDS: *Biology simulation, Experimental research, Science education, Second Life laboratories, Virtual environments*

An increasing market for online courses (Allen, Seaman, 2007) has created a need for online laboratory experience, and Second Life, a multiuser virtual environment (MUVE) developed by Linden Lab, offers a new dimension for science education. Virtual environments can be visited as "field sites" for face-to-face or online courses, developed for stand-alone courses given entirely within the virtual world, or used as resources for informal learning. Virtual experiments performed in Second Life laboratories offer students activities that are both hands-on and minds-on, making it possible for students to replicate classic experiments or perform laboratory

activities that might be too dangerous, too expensive, or too time-consuming in the real world. As an added benefit, the social environment invites conversation outside of formal class hours, and the game-like environment of Second Life encourages exploration. This article describes the development and preliminary testing of Genome Island, a virtual laboratory environment for teaching undergraduate genetics in Second Life.

Second Life, science, and recess

Through the interest and inventiveness of its educational community, Second Life is rapidly developing into a course management venue (Kemp, Livingstone, 2006). This is due to the innate characteristics of the Second Life environment, including the possibilities for creating interactive objects, the potential for multimedia presentation, the flexibility of the environment, and the immersiveness of the experience. The gamelike nature of Second Life's virtual environment has particular implications for science education as it fosters a sense of play in the virtual laboratory. Norval Kneten, chemist and former dean of science and humanities at Texas Wesleyan University where I teach, used to say that "Science is the next best thing to recess"! As Laszlo (2004) points out, "Playing with ideas is, after all, what science is about" (400). Laszlo identifies aspects of play in both the intellectual and procedural components of doing science: Scientists play "guessing games" with the natural world and employ a number of "toys", such as instruments and other laboratory tools, in evaluating their guesses.

Second Life also facilitates social learning. Robbins (2007) has noted that when social interactions in Second Life are mediated by avatars rather than via message boards or chat rooms, students have a more vivid sense of being part of a community. The avatar puts a face, a body, and a physical location on each community member, all of which contribute to a sense of "thereness". As Annetta, Klesath, Holmes (2008) have pointed out, the feeling of social presence conferred by an avatar contributes to the perception of the virtual environment as a real place. As an additional advantage, in contrast to other kinds of simulated experiments, the immersive graphic environment of Second Life supports learning with visual memory. For example, a student inferring the parent plant's genetic makeup

by counting red and white flowers among the progeny has seen the flowers in the garden as well as recorded their numbers in a table. The visual image may make it easier for the student to recall the relationships between parent and progeny later.

Science educators have begun to see the value of the virtual world as a laboratory environment; a number of simulations are now available online, in Second Life and elsewhere (Exhibit 1)¹. The quantitative aspects of genetics are particularly suitable for simulated laboratory experiments; Second Life's scripting tools allow variable and realistic data sets to be generated by programming each object in a data population to select its features according to established probabilities.

Genome Island

Genome Island began, almost literally, with a light bulb. One of the most common Second Life building and scripting tutorials is for making a light that switches on and off. A modification of this basic script now animates many of the experiments on Genome Island. Late in 2004, I began to experiment with building and scripting in Second Life using tutorials available both in-world and elsewhere online; I constructed some of the genetics objects that are now found on the island as part of this exploration. Initially, I worked entirely "after hours", but early in 2007, with funding from a fellowship and the encouragement and generosity of Texas Wesleyan's biology department, I moved the project from its small plot on the Second Life mainland to a private island and began to develop Genome Island as a teaching venue. A critical event was the installation of laboratory computers capable of running the Second Life program at Texas Wesleyan, which meant students could access Genome Island from campus. By the end of the spring semester in 2007, Genome Island was ready for student trials.

Since Second Life's main grid is restricted to people over the age of 18, the conceptual material at Genome Island is pitched at a level appropriate for a university undergraduate. Selected areas of the island are suitable for more advanced students. The materials on the island are not intended to correspond to any particular textbook or curriculum but constitute a series of encounters with genetic objects. These interactive objects behave according to established genetic principles.

Activities are organized into four main areas (Figure 1). The Abbey and Gardens contain experiments illustrating the principles of Mendelian inheritance. More complex inheritance patterns and genetic interactions are represented in the Terrace. The Tower houses demonstrations of molecular genetics, bacterial genetics, and *Drosophila* genetics. The Gene Pool demonstrates principles of population genetics and includes the Atelier where students or other guest builders who want to contribute activities to the island can work. Visitors can follow walkways or stepping stones, fly from place to place, or use the teleport panels found at the entry points to the island and in each of the main areas. Teleports also connect related experiments.

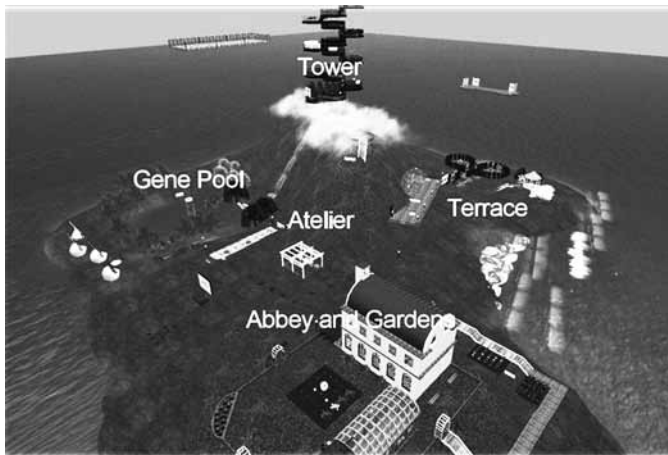


Figure 1.
Aerial view of Genome Island

There are now about 50 different activities available at Genome Island. For each one, a note card or slide show provides background information, suggests a hypothesis to be tested or a principle to be applied, and gives instructions for using one or more interactive objects to generate a data set. Some data is recorded in the chat record from which it can be copied and pasted into spreadsheets for further analysis (Exhibit 2)². Other data is not automatically recorded but has to be processed as it is collected. For example, bacterial colonies have to be counted, rabbit coat colors identified, pedigree patterns figured out, or DNA sequences matched. Methods of analysis are suggested for each activity.

Representative activities

Genome Island experiments occupy a niche somewhere between a written problem set in which all data are immediately accessible and identical for all students and a real-life laboratory experiment in which data collection might take hours or even weeks to complete and might vary from student to student. At Genome Island, students can perform an experiment quickly, usually within a few minutes, but each data set, within the probabilities governing the experiment, can be different. The four activities described below illustrate some of the data that can be collected on Genome Island and the learning objectives addressed by each experiment. The Bacterial Transformation and Message in a Bottle experiments are found in the Tower, the Monohybrid Cross comes from the Abbey Greenhouse, and the X-linked Inheritance experiment is part of the Cattery on the Terrace.

Bacterial transformation

3. Appendix

The Bacterial Transformation experiment (Exhibit 3)³ is a reproduction of the 1928 experiment by Frederick Griffith that yielded the first indication that there was a chemical basis for inheritance. The learning objective of the activity is for students to be able to explain the results of injecting each of four mice with a different bacterial culture. This experiment could not be reproduced in most university laboratory settings, both because of the danger of handling pathogenic bacteria and because of serious ethical objections with regard to animal rights. To explain the data that the activity generates, students must understand how each of the four bacterial cultures is different from the others and why two of the four cultures can result in the death of the mice. Students must also understand that while the test organism is the mouse, the genetic change occurs only in the bacteria injected into the mouse.

Monohybrid pea cross

4. Appendix

The Monohybrid Cross experiment (Exhibit 4)⁴ is a reproduction of one of Gregor Mendel's experiments with garden peas. The traits represented in this activity are two seed colours governed by a single pair of genes: yellow vs. green. The cross represents three generations of progeny from two pure-breeding parents with different traits. The appearance of each pea in the second and third

generations is determined independently, based on the probabilities of inheriting each possible trait. The learning objective for this experiment is for students to be able to apply Mendelian principles to explain the types and ratios of progeny that appear. In just a few minutes, students can generate representative data like that Mendel collected over several growing seasons.

X-Linked inheritance in cats

The Cattery is my Second Life homage to Judith Kinnear's CatLab; the activity here studies sex linkage, the inheritance of traits carried on the sex-determining chromosomes (Exhibit 5)⁵. The learning objective is for students to recognize the features of X-linked inheritance and to be able to identify the presence or absence of the dominant orange gene in each parent and kitten. Clicking on one of four cat houses in the exhibit produces a set of parents. Clicking on the parents then results in kittens. Although this experiment could be performed with real cats, the two-month wait for progeny, as well as an inconvenient number of kittens, would render it impractical.

Message in a bottle

The Message in a Bottle experiment (Exhibit 6)⁶ is part of a Tower unit on genetic coding. Many genes encode the structure of proteins with specific groups of nucleotides in DNA corresponding to specific amino acids in proteins. Students often confuse DNA and proteins; this exercise is designed to help clarify the relationship between the two. After examining the introductory information on this relationship, the student clicks on the bottle to get a note card containing the DNA coding sequence for a specific human protein. In-world links to an external DNA translation utility (EBI) and a protein sequence comparison program (NCBI) allow the student to identify the protein encoded by the DNA sequence. The learning objective here is for the student to understand the differences between DNA and protein sequences, to understand the informational relationship between the two, and to acquire experience using genetics databases. This activity illustrates how external data resources accessed from within Second Life can be applied to specific tasks.

5. Appendix

6. Appendix

Teaching on Genome Island

The best use of the materials on Genome Island will vary with class size, class level, students' level of access to and experience with computers, students' science background, and the instructor's teaching style. The same activity can be used for multiple purposes and can be revisited as students develop more sophisticated understanding of a given topic. Instructors might wish to assign specific activities as independent investigations or run a given experiment as an in-class demonstration with a large group of observers. Students might be given a list of experiments to complete or allowed to blaze their own trail around the island. Experiments might be followed with a synchronous group discussion in one of the conference areas on the island, by asynchronous online reflections, or by written reports. Self-assessment games are also offered in several areas.

I brought students from two of my classes into Genome Island in 2007 and early 2008 for initial testing of the site. A group of 5 advanced genetics students in Fall 2007 was followed by a larger group of 23 freshmen in Spring 2008. None of the students in either group had previous experience with Second Life. The students were assisted with setting up Second Life accounts and given a brief, supervised orientation session. After they completed a self-paced scavenger hunt designed to provide navigational practice and to familiarize them with the island, the students were assigned a small set of Genome Island's available activities. Since students were familiar with Wesleyan's WebCT course management system, I used the WebCT assignment page, accessible from within Second Life, to provide information about tasks for the week and to collect students' task reports (Figure 2).

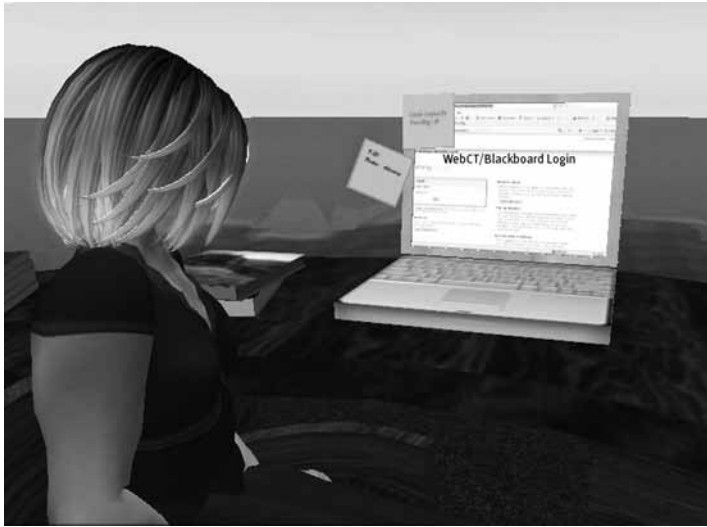


Figure 2.
Blackboard link from Genome
Island

I observed and informally debriefed the advanced students as we explored the new learning environment together. Observing this group of first users helped me to understand more clearly the special character of the Second Life environment, which is different both from a classroom setting and from a typical Web-based course (Exhibit 7)⁷. In a live, synchronous class, the instructor is available to establish context, demonstrate procedures, clarify instructions, and answer questions. Web sites can use a navigation menu to lead students through sequential activities. In Second Life, on the other hand, the instructor may be off-world, students frequently work asynchronously, and the virtual territory to be navigated is the size of a small campus. The Genome Island activities are accompanied by general operational instructions and basic background information; in addition, related activities are grouped together. However, most activities can be used in different conceptual frameworks, and the intended conceptual focus, the specific navigational pathway, informational resources, and data collection procedures must all be included in each assignment (Exhibit 8)⁸.

The freshmen students in the second class were asked to complete a questionnaire about their experience in Second Life (Exhibit 9)⁹. The survey asked about access to and ease of operation of the Second Life software, assignment routines, specific Second Life features and Genome Island activities, and the student's general evaluation of Second Life as a learning venue. Student responses

7. Appendix

8. Appendix

9. Appendix

to Second Life were about evenly distributed between positive and negative (Table 1); a significant factor in determining students' overall satisfaction was the ability to run Second Life from their personal computers. Being confined to campus labs understandably vitiates the benefits of the online environment. In addition, the pilot group may not have been in-world long enough to overcome the stresses of working in an unfamiliar environment. Favored activities were those that presented puzzles to be solved by the application of principles learned in preparatory experiments performed in Second Life.

Table 1.
Freshmen students responses
to Second Life

General questionnaire items		
Access and operational ease	Positive: 42	Negative: 45
Orientation experience	Positive: 20	Negative: 3
Orientation preference	Instructor: 17	Other: 6
Satisfaction with assignment routines	Yes: 55	No: 14
Ease of assignment completion	Easy: 45	Hard: 42
Better than problem sets/regular labs	Yes: 15	No: 14
Second Life appropriate for class use	Yes: 37	No: 9
Would repeat or recommend SL	Yes: 27	No: 19
Activity-specific items		
Most difficult in-world activity	Finding assigned activities	
Most interesting activity	Guess the parents, Mating game	
Most educational activity	Guess the parents, Mating game, Blood types	
Contributed most to positive experience	Genome Island interesting, Self-pacing, Creating avatar	
Contributed most to negative experience	Computer crashes, Program stalling	

The questionnaire on the Second Life experience was given to 23 freshmen students. Responses to related questions are combined into a single category; for example, responses regarding the ease of getting accounts, the ability to download and run the program on personal computers, and experience with laboratory computers are all included under the category "Access and operational ease". Student performance on Second Life learning objectives was assessed as part of the final laboratory exam, which included material covered in Second Life activities (Table 2). The mean student score on items drawn from Second Life activities was higher than mean

performance on items related to other lab activities although the wide variation in individual student performance makes the difference between means barely significant.

	Average %	STD DEV
Second Life Activities	79.1	13.6
Other Lab Activities	60.5	15.9

Table 2.
Student performance on
Second Life learning activities

Since time on task is an important factor in learning, general visitor data was collected from proximity sensors distributed at various locations around the island (Table 3). The sensors count unique visitors and total time spent in range of the sensors. A student who leaves an area and then returns during a specified time period is not counted as a new visitor, but the time spent during repeat visits does contribute to total time. The sensors do not distinguish between my students and other visitors to the island and cannot distinguish visitors actively engaged with experiments from passive observers who may just be passing through. Of the 111 visitors to the Greenhouse in May 2008, no more than 23 could have been students from my freshman class. Sensors located in low-activity sections of the Tower give average monthly visit durations of about 3 minutes, so the average visit duration of 14 minutes for the Greenhouse indicates active engagement from at least some visitors.

Table 3.
Visitor records for selected
activities on Genome Island

Activity	February 2008		May 2008	
	Number	Time (m)	Number	Time (m)
Abbey	186	9	181	8
Greenhouse	111	5	111	14
South Garden	147	8	146	7
North Garden	137	6	122	5
Cattery	351	8	246	9
Tower: Genes and DNA	143	14	184	13
Tower: Chromosome Gallery	138	17	150	13
Tower: Drosophila Lab	85	17	83	9

Data were collected from non-overlapping sensors located at 8 of the 15 different activity areas on Genome Island. Sensors were supplied by Maya Realities. Sensors record unique visitors over the time period selected and total visitor time spent in the sensor range. Time listed here is average time in minutes spent by each visitor to the area. Sensors do not track individual visitor progress from area to area.

Conclusion

These initial trials indicate that virtual worlds offer a learning environment that combines active engagement with the convenience of online access. Encouraged by the results of my preliminary trials, I taught a fully in-world course for nonmajors in the fall of 2008, and I am now trying Second Life “light” (virtual laboratory experiences offered as in-class instructor demonstrations) with the current group of freshmen. When the current class is completed, I will be able to compare student responses to these two instructional modes with those from the “field trip” approach used with the pilot classes.

Genome Island is available for public access, and I welcome testing of the activities by students from other institutions. A guide to Genome Island for instructors is in preparation.

[Author’s Note: Genome Island is supported by the Biology Department of Texas Wesleyan University and by a Sam Taylor Fellowship awarded by the Division of Higher Education, United Methodist General Board of Higher Education and Ministry.]

Appendix

EXHIBIT 1:

VIRTUAL SIMULATIONS IN THE LIFE SCIENCES

A number of biology simulations have been developed by individuals and teams at various universities. Some of these are now associated with and marketed through textbook companies, like Virtual Biology Laboratory, marketed through Cengage Learning, and Biology Labs Online, marketed through Benjamin Cummings. Both of these programs offer simulated experiments in various areas of biology, including genetics.

Other virtual labs are available as free activities. The Biology Project at the University of Arizona (UA) offers a mixture of simulated biology laboratories, tutorials, and problem sets. Students can simulate several protein and DNA analysis procedures at the Biotechniques Virtual Laboratory at the University of Utah, part of the online Genetics Science Learning Center. In the bioinformatics project Origin Unknown at the Southwest Biotechnology and Informatics Center (SWBIC), students compare unknown DNA sequences with those in public genetics databases. Various problems in bioinformatics are also the focus of Biology Workbench, hosted at San Diego Supercomputer Center (SDSC). The Virtual Genetics Lab, developed by graduate students at the University of Massachusetts Boston (UMB), is a simulation that allows students to explore various types of inheritance patterns using imaginary organisms. The Virtual Fly Lab at Western Kentucky University (WKU) simulates first- and second-generation crosses between normal and mutant fruit flies. The genetics simulations in the Enlivening Genetics Education project, created by MathResources, Inc. for the Education Development Center (EDC), are both dynamically and graphically rich.

A number of life science projects are under development in Second Life. At A Biologist's Retreat, Paul Decelles (Johnson County Community College, Overland Park, Kansas, Second Life Avatar Simone Gateaux) is creating activities related to bioenergetics. At Biome, Carolyn Lowe (Northern Michigan University, Second Life Avatar Clowey Greenwood) is building activities centered around ecology and biodiversity. Biomedicine-related projects include

the Second Health Research Organization, the National Library of Medicine's Tox Town, and the multi-island medical complex of the Imperial College of London.

Such simulations are useful adjuncts to course textbooks, instructor explanations, and laboratory experiments for promoting student understanding of biological principles and phenomena. In addition, simulations can expand the working range of activities that students experience. What virtual worlds add to the mix is the elements of immersiveness and social interaction. Avatars in a virtual environment can meet and converse during the process of data collection as they could in a real-world laboratory.

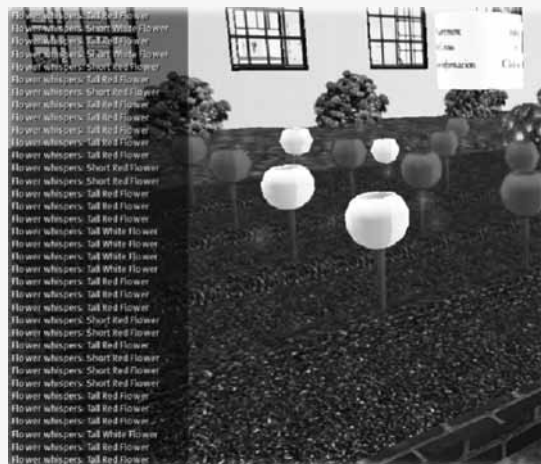
How virtual laboratories compare with other types of simulation in fostering student learning is an open area for testing. Most simulations (including Genome Island) represent selected content areas. However, specific concepts that are addressed across different modes - textbooks, simulations, and virtual laboratories - could be used as foci for student testing.

EXHIBIT 2:

DATA RECORD AND SPREADSHEET

Data from experiments are recorded in the chat record from which the data can be pasted into a spreadsheet for sorting, summary, and analysis. The inset in the image below (Figure 2-1) shows information reported by several progeny sets recorded in the chat record.

Figure 2-1.
Chat record for data collected
in the Garden

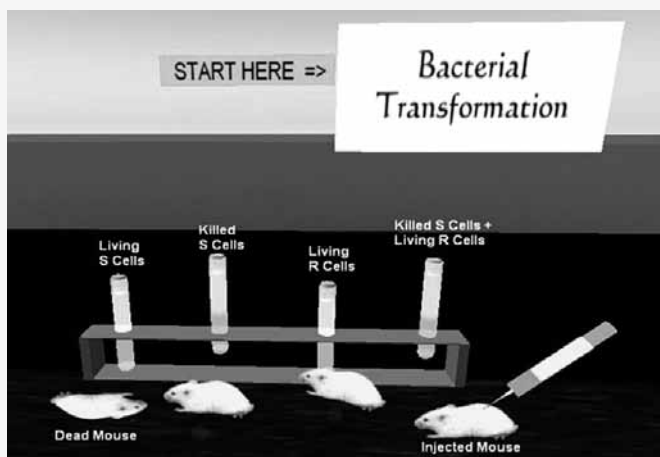


In the spreadsheet (Figure 2-2), a table summarizes data from several sets of progeny. Below the table is the section into which chat data was pasted.

EXHIBIT 3:

BACTERIAL TRANSFORMATION EXPERIMENT

This experiment utilizes four culture tubes of bacterial cells and four mice (Figure 3-1). Virulent strains of the bacteria cause a fatal pneumonia in mice; nonvirulent strains do not kill the mice. Clicking on one of the tubes produces a notecard describing the contents of the culture and injects a mouse with the contents of that tube. Subsequently clicking on the mouse results in either a mouse that falls over dead or a mouse that survives and runs around. A notecard also summarizes the mouse's behaviour. Students must inject each of the tubes into a mouse and infer the reason for their results.



Two types of bacterial cells of the species that causes bacterial pneumonia are represented: virulent S cells, which cause pneumonia and kill the mouse, and mutant R cells, which the immune system of the mouse can overcome. Killing the S cells renders them harmless. The critical experiment is the combination of killed S cells with living R cells. Although neither cell type alone harms the mouse, the combination causes pneumonia and kills the mouse. Examination of the dead mouse shows that the harmless

Figure 3-1.
Bacterial transformation
experiment

living R cells were transformed into living virulent S cells by some component of the killed S-cell culture.

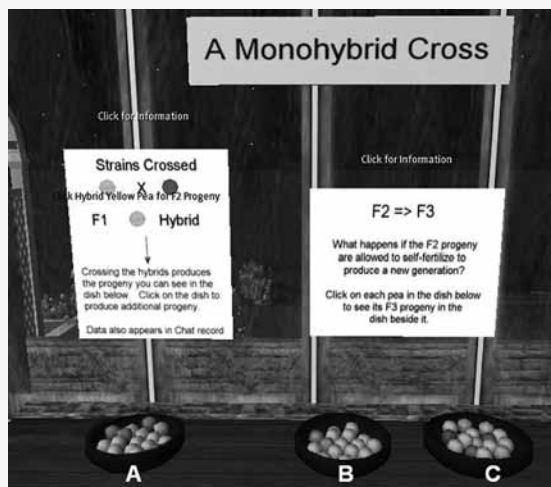
Later experiments by Oswald Avery indicated that the transferable component was DNA. Identification of DNA as the genetic material was verified by Hershey and Chase whose experiment students can study in a follow-up activity on Genome Island.

EXHIBIT 4:

MONOHYBRID CROSS EXPERIMENT

The two posters and three dishes in this activity represent three progeny generations of a monohybrid cross, that is, a mating between individuals differing in a single trait (Figure 4-1). Students are presented a notecard with background information and instructions for making the cross. Each pea has two genes for colour. One of the two genes - the yellow one - is expressed preferentially and is called the dominant (although strictly speaking dominance is a feature of the trait, not of the gene). Peas with two yellow genes are yellow, peas with two green genes are green and hybrid peas with one yellow and one green gene are yellow.

Figure 4-1.
Monohybrid cross experiment



The poster on the left gives the results of crossing pure yellow with pure green parents. All members of the first progeny generation (F1) are yellow and all have the same parental combination of genes. The yellow colour of the F1 peas identifies this colour as

the dominant trait. Clicking on the F1 yellow pea produces the next generation of peas (F2), which appears in dish A.

In the F2 generation, both yellow and green peas appear, with a yellow to green ratio of about 3:1. Dish B also contains a typical F2 population, and a different set of F2 peas will appear each time the dish is clicked. In dish B, each individual pea can be clicked to see third generation progeny (F3) of that pea, which appears in dish C. Each of the F2 peas in dish B triggers a different F3 sample in dish C. Three F3 results are possible: all yellow, all green, or a mixed yellow and green.

The F1, F2, and F3 progeny represent the experiments that led Mendel to formulate the rules of inheritance that later became known as the Mendelian laws of inheritance. While all of the yellow peas in the F1 generation are genetically identical, there are two possible gene combinations for yellow peas in the F2: yellow/yellow or yellow/green. Which combination is present in each pea is revealed by the composition of the F3 progeny.

Spreadsheets are provided for collecting and summarizing the F2 and F3 progeny data. In addition to the visual data, a description of each pea is recorded in the chat record from which it can be copied into the student's lab record. Instructors can also give students a list of leading questions to be answered, like what genes might be present in peas of each colour in each generation. This is a simple set of experiments that demonstrates both qualitative and quantitative output from the different matings possible.

EXHIBIT 5:

X-LINKED INHERITANCE ACTIVITY AT THE CATTERY

In this experiment, students are introduced to X-linked genes. Background information is provided by a notecard and a short slideshow. There are four sets of cat parents, which appear when one of the four cat houses is clicked. One set of parents is shown here: a tortie (orange and black) mom and an orange dad (Figure 5-1). Clicking on the female produces all four types of kittens possible from the mating of the parents shown.

Figure 5-1.
The Cattery



Different combinations of colours can be seen in males and females. The dominant gene for orange coat colour in cats is located on the X chromosome. Cats with no orange gene express other coat colours, usually black. Since females have two X chromosomes, their fur can be either all orange (two orange genes), all black (two non-orange genes), or tortie, with some orange and some black patches of fur. The patches are due to random inactivation of one of the two X chromosomes in different tissues. Since males have only one X chromosome, they are either orange or black, but they cannot be both.

As the kittens appear, the chat record displays the sex and colours for the kittens. The data for kittens of different parents can be copied and summarized in a spreadsheet provided with this experiment.

EXHIBIT 6:

MESSAGE IN A BOTTLE ACTIVITY

In this experiment, students click on the green bottle to get one of a selection of genetic messages delivered in a note card (Figure 6-1). Each message includes the DNA coding sequence for a human protein. To identify the encoded protein, students must translate the message. An external link to a DNA translation utility from the European Bioinformatics Institute (EBI) is provided. The student copies the DNA message from the note card and pastes it into the query box of the translation program. This program will deliver the amino acid sequence encoded by the DNA.

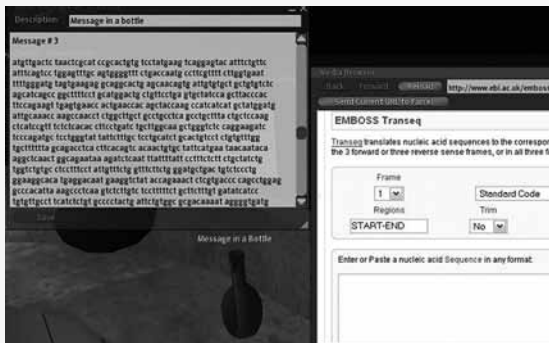


Figure 6-1.
Message in a Bottle activity
with translation program
activated

After the translation is run, the protein corresponding to the DNA coding sequence can be identified by using protein BLAST software from the National Center for Biotechnology Information (NCBI). The BLAST program allows the comparison of the mystery protein sequence with those in a large protein database. This experiment reinforces the student's understanding of the coding function of genes and the difference between DNA and protein sequences. It also introduces students to bioinformatics tools and public genetics databases. More advanced students can also use the translation program to examine the effect of introducing various types of mutations in the DNA sequence, such as changes in the reading frame or single nucleotide substitutions.

EXHIBIT 7:

LESSONS LEARNED FROM FIRST USERS



Figure 7-1.
Second Life "group portrait"
of the initial class of users

Informal debriefing with Genome Island's first users, a class of 5 advanced students (Figure 7-1), suggested a number of principles that would make the use of Second Life in science classes more successful:

1. Students should be instructed to get their Second Life accounts before the laboratory period in which Second Life activities are introduced. Accounts can take anywhere from minutes to days to be confirmed and usable.
2. The "default" orientation activities are not suitable for educational uses. Instructors should create their own orientations or use one of the education-specific orientation sites, such as the SciLands Orientation Walkway.
3. Unlike a Web site, Second Life has no navigation bar. Include prominent landmarks or location coordinates in assignment instructions.
4. Every assignment must include a reminder for students to read the instructions associated with an activity.
5. Each activity has a single data source; too many students at an activity at the same time results in data collection interference. In general, Second Life activities are best done by individuals or pairs of students working asynchronously.
6. Although voice is available and can enhance social conversations, communicating via text has several advantages: even shy students can get a word in, writing seems to help students clarify their thoughts, and the chat record of individual conversations or group discussions can be saved and made available for students to consult later.
7. The Second Life browser exerts serious demands on classroom computers and frequent crashes frustrate students. Simultaneous use should probably be limited to the training period.

EXHIBIT 8:

SAMPLE ASSIGNMENT

The assignment below was given to freshmen students working on the Monohybrid Cross. "Guess the Parents" and "The Mating Game" are in-world assessment activities that required students to collect and analyze data (Supplement 8-1).

ASSIGNMENT

Maximum grade: 25

Due date: March 7, 2008

Instructions:

Go to Genome Island. You may work with one or two friends in doing the experiment, but each of you should collect and analyze your own data set. Later we will compare data across the class.

In the Greenhouse behind the Abbey are several experiments with yellow and green peas in the area marked "The Monohybrid Cross". One shows the F1 and F2 of the cross; another shows the F3 progeny of the F2 individuals. There are two additional activities: **Guess the Parents** and **The Mating Game**. **Guess the Parents** asks you to predict whether your parents were two heterozygotes ($Aa \times Aa$) or one heterozygote x and a homozygous recessive ($Aa \times aa$). **The Mating Game** asks you to identify which of the six possible crosses of individuals homozygous or heterozygous for one pair of alleles is represented by each cross.

Task 1: Read the information in the sign that represents the green x yellow cross. Access and save the spreadsheet supplied with this experiment. The sign illustrates the F1 progeny. Click on the F1 pea in the sign to produce the F2. The F2 will appear in the dish below the sign. The dish contains 16 peas. How many are green? How many are yellow? (Hint: Count the green peas and subtract to get the number of yellow peas.) Click on the dish four more times to get four additional sets of progeny. The phenotypes for these progeny will be recorded in the SL chat record. Copy your data from the chat record and paste it into the spreadsheet provided for this experiment. Summarize the number of green and yellow peas in EACH progeny set of 16 peas. How close to the predicted 3:1 ratio did you get?

Task 2: Do the $F2 \Rightarrow F3$ experiment. Read the instructions in the sign. Access and save the spreadsheet linked to the experiment. Click on the dish to produce a new F2 population. Count the number of yellow and green peas in this population. Click on EACH pea in the dish to classify it as homozygous yellow, homozygous green, or heterozygous. Record your data on the spreadsheet provided with this experiment. You need not count the yellow

and green progeny of the F₂; just note whether the progeny are all yellow, all green, or mixed. What were the apparent genotypes of the F₂ peas?

Task 3: Do the **Guess the Parents** experiment. Read the instructions in the sign. Download and save the spreadsheet provided with the experiment. Generate a set of progeny by clicking on the red dish. Then click on the dish again to generate four sets of data that will appear in the chat record. Copy and paste your raw progeny data into the spreadsheet provided and then record the number of progeny in each class. Count the green and yellow peas for each separate set of progeny since each is derived from a different set of parents. What progeny numbers would you expect from an Aa x Aa cross? What progeny numbers would you expect from an Aa x aa cross? Do four sets of progeny and decide which of the two models each data set fits. Do NOT do the Chi Square Analysis at this time.

Task 4: Do The **Mating Game**. Read the instructions in the sign. Click on each of the six peas that generate the progeny for the six crosses represented. There are six sets of parents: Yellow A x Yellow B, Yellow A x Yellow C, Yellow D x Yellow E, Yellow D x Green A, Green B x Yellow F, Green B x Green C. Record the progeny for each cross as you do the six crosses. When you think you have figured out which cross is which (e.g., AA x aa, Aa x Aa, etc.), write the genotypes for each of the parents: Yellow A, B, C, D, and E; and Green A, B, and C. All of the genotypes can be figured out from the cross data except one, which must be inferred by exclusion, since you know that all six types of possible crosses are represented. Parents Yellow A, Yellow D, and Green B each have the SAME genotype in each of the two crosses they are in.

EXHIBIT 9:

SECOND LIFE SURVEY

Second Life Survey: Biology 1322, Spring 2008

Please answer the following questions about your experience in the virtual laboratory environment at Genome Island in Second Life.

When I first applied for my Second Life account,

- a. I was able to set it up and have it confirmed in under an hour.
- b. It took more than an hour but less than a full day (24 hours).
- c. It took a full day or more to get my account set up.
- d. I was never successful in setting up my account.

I was able to download the Second Life browser to my personal computer.

- a. yes
- b. no
- c. I did not attempt to download the Second Life browser to my personal computer.

On my personal computer, the Second Life program

- a. ran well most of the time with few program crashes (no more than once in 3 hours).
- b. ran well most of the time but crashed frequently (twice or more in 3 hours).
- c. ran poorly (slowly or with frequent freezing) and also crashed frequently (twice or more in 3 hours).

In the university computer lab, the Second Life program

- a. ran well most of the time with few program crashes (no more than once in 3 hours).
- b. ran well most of the time but crashed frequently (twice or more in 3 hours).
- c. ran poorly (slowly or with frequent freezing) and also crashed frequently (twice or more in 3 hours).

How did you FIRST learn to navigate and interact with objects in Second Life?

- a. I visited one of the public orientation islands.
- b. I visited the SciLands orientation walkway.
- c. I had visited Second Life previously and learned to get around on my own.
- d. I had visited Second Life previously and learned to get around with help from other visitors.
- e. I went directly to Genome Island and learned the basic skills from my instructor or from other students in the class.
- f. I went directly to Genome Island and was able to figure out

what to do without much assistance.

What do you think would have been the BEST way to learn to navigate and interact with objects at on Genome Island?

- a. A structured orientation experience (like the SciLands walkway) to be completed on my own.
- b. A structured orientation experience with assistance from an in-world instructor or a more experienced user.
- c. A structured orientation experience in a classroom setting with an instructor.
- d. A guided tour of the island given by the instructor in class.
- e. A guided tour of the island using a written guidebook.
- f. Unguided exploration of the island on my own.
- g. Other (specify):

Which of the following activities did you find most difficult? (Circle up to 3)

Walking Flying Teleporting Chatting Finding inventory items
Snapshots Sending IMs Writing notecards Changing clothes
Finding assigned activities Copying from Chat Record Other
(specify):

The class was assigned an Orientation Scavenger Hunt.

- a. I completed the scavenger hunt and found it helpful for becoming more familiar with Genome Island.
- b. I completed the scavenger hunt but did not find it helpful for becoming more familiar with Genome Island.
- c. I did not complete the scavenger hunt.

The class was assigned two sets of tasks at Genome Island.

- a. I was able to complete both sets of tasks by the posted due date.
- b. I was able to complete both sets of tasks but needed additional time for one or both of them.
- c. I completed only one of the two sets of tasks.
- d. I did not complete either set of tasks.

The instructions for the two sets of tasks were given on WebCT.

- a. I was able to understand what to do without additional assistance from the instructor.

- b. I was able to understand what to do with minimal assistance from the instructor.
- c. I could not understand most of the tasks without assistance from the instructor.

What would be your preferred location for receiving Second Life assignments?

- a. WebCT is the most appropriate location for Second Life assignment instructions.
- b. WebCT should simply announce Second Life assignments with the instructions all posted within Second Life.
- c. Second Life instructions should be posted as problem sets from a central location within Second Life.
- d. Second Life instructions should be posted at individual activity locations within Second Life.
- e. Other (specify):

How would you rate instructor availability for assisting with you with the Second Life problem sets?

- a. I was usually able to get help from the instructor when I needed it.
- b. I was occasionally able to get help from the instructor when I needed it.
- c. I was rarely able to get help from the instructor when I needed it.

What do you think is the best way for the instructor to assist if you have questions?

- a. I would prefer to work with the instructor nearby either in world or in class.
- b. I would prefer to work on my own or with a partner with the instructor dropping in occasionally to provide assistance.
- c. I would prefer to work on my own or with a partner and consult with the instructor via external e-mail or asynchronous in-world messaging.
- d. I would prefer to work on my own or with a partner and consult with the instructor by telephone or during the next class meeting.
- e. I would prefer to work mostly on my own or with a partner but have a fixed weekly consultation period when the instructor was available in world.

f. Other (specify):

Most Second Life assignments have linked Excel spreadsheets associated with them. Did you find the spreadsheets helpful for summarizing and analyzing your data?

- a. Yes, the linked spreadsheets were very helpful.
- b. Yes, but I'd rather create my own spreadsheets.
- c. I don't like using spreadsheets for data summary and analysis.

What would be your preferred format for completed Second Life assignments?

- a. Report on Microsoft Office documents or spreadsheets submitted to WebCT.
- b. Report on Second Life notecards dropped into an in-world collection box.
- c. Report on Second Life notecards sent to the instructor as an in-world message.
- d. Other (specify):

What would be your preferred schedule for reporting completed Second Life assignments?

- a. Send a single report when all assignments of a set are completed.
- b. Send individual reports as each assignment is completed.
- c. Other (specify):

Your class was given a fixed set of 10 Second Life tasks to complete. How would you prefer to have your Second Life assignments selected?

- a. Selected entirely by the instructor for all students to complete.
- b. Selected by the instructor but with different options for some assignments.
- c. Partially selected by the instructor with additional assignments to be selected by the student according to his or her interests.
- d. Entirely selected by the student according to his or her interests.
- e. Other (specify):

Please rate each of the following assigned Second Life activities on the chart below. Check all appropriate responses.

Bunny Epistasis	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->
Blood Types	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->	<!--[if !supportEmptyParas]--><!--[endif]-->

How would you rate your Second Life activities relative to your written problem sets?

- better
- worse
- about the same

How would you rate your Second Life activities relative to your real life laboratories?

- better
- worse
- about the same

Would you enjoy creating a new Second Life activity either by yourself or in a group?

- yes
- no

What do you think is an appropriate role for Second Life experiments in a regular (that is, not online) science class?

- None. Second Life should be used only for online classes.
- Less than 20% of total class activities (lecture + lab)
- About half of total class activities (lecture + lab)
- Other (specify):

Do you think that Second Life science sections should be available as an option for science majors? (circle one) Yes No

If you answered yes to the question above, which classes do you think would be suitable?

- entry level classes
- advanced classes

- c. special topics classes
- d. all of the above

Please identify up to three factors that contributed positively to your experience of Second Life.

- a. My personal computer ran Second Life well.
- b. I enjoyed doing the assignments.
- c. Genome Island is an interesting place to visit.
- d. Second Life is an interesting place to visit.
- e. I enjoyed meeting new people at Second Life.
- f. I enjoyed creating and modifying my avatar.
- g. I enjoyed learning the Second Life Technology.
- h. I enjoyed being able to do experiments at my own convenience.
- i. Other (specify):

Please identify up to three factors that contributed negatively to your experience of Second Life.

- a. I could only access SL on campus
- b. Campus computer crashes interrupted my work or made it necessary to repeat activities.
- c. Creating my avatar took too much time.
- d. The Second Life program didn't run well on my own computer.
- e. I could not get enough assistance from my instructor.
- f. I've barely learned WebCT; Second Life is just too much new technology.
- g. Visitors to Genome Island bothered me or interrupted my work.
- h. Assignment instructions were confusing or difficult to understand.
- i. Other (specify):

I would take a course based in Second Life (circle one): Yes No

I would recommend visiting Second Life to a friend (circle one):
Yes No

I will probably continue to visit Second Life after this class is over (circle one):
Yes No

Please use the back of the survey for any other comments or suggestions you have.

All URLs checked
December 2009

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Sintesi

Second Life, multiuser virtual environment, ha sviluppato potenzialità interessanti per gli ambienti di apprendimento. La ricerca dimostra quanto nel settore della genetica alcuni fattori specifici di questo social network possano contribuire a costruire un percorso didattico efficace nell'ambito della divulgazione scientifica.

Second life offre infatti la possibilità di creare oggetti interattivi, fornisce ottime potenzialità per le presentazioni multimediali, sviluppa la dimensione del social learning, permette di essere completamente coinvolti dall'ambiente virtuale. Queste

caratteristiche applicate in ambiente scientifico costituiscono aspetti non secondari per alcune sperimentazioni didattiche.

Genome Island è un campus, un'isola virtuale di Second Life, in cui si sono sviluppati e sperimentati una serie di ambienti che costituiscono veri e propri laboratori virtuali per insegnare elementi di genetica a gruppi di studenti universitari. I materiali didattici presenti nell'isola non corrispondono ad una particolare monografia o corso di studio ma costituiscono una serie di "incontri" con genetics objects.

Le attività dell'isola sono organizzate in aree distinte: l'Abbazia e i Giardini presentano esperimenti che illustrano i principi di eredità monogenetica mendeliana, mentre i più complessi modelli di eredità genetica sono rappresentati nella Terrazza, infine nelle Torri sono disponibili le dimostrazioni di genetica molecolare, genetica batterica e genetica drosophila. La Gene Pool mostra invece i principi di genetica di popolazione e include un Atelier in cui gli studenti o i visitatori possono contribuire al lavoro con le loro attività. Sono 50 le attività praticabili nell'isola e per ognuna sono disponibili e accessibili informazioni, ipotesi per testare o principi da applicare e istruzioni per utilizzare uno o più interactive object per generare un data set.

All'interno di Genome Island è possibile eseguire dei veri e propri esperimenti scientifici. Alcuni sono stati proposti come elemento di comprensione dell'ambiente: la trasformazione batterica usata per la mappatura genetica che è la riproduzione degli esperimenti di Frederick Griffith, l'incrocio ibrido del pisello di Mendel, l'eredità diagenica nei gatti e l'esperimento del messaggio nella bottiglia.

Gli esperimenti condotti attraverso Second Life dimostrano come le risorse esterne possano essere utilizzate in un contesto virtuale, rendendo meno impraticabili alcuni esperimenti che richiederebbero anche l'utilizzo di animali, e riducendo in tempi brevissimi i risultati di tali esperimenti.

Le analisi di gradimento di tali attività sulla piattaforma virtuale dimostrano che i livelli di apprendimento sono stati assolutamente positivi e che gli studenti, in particolare quelli advanced, hanno molto apprezzato la chiarezza e la natura dell'ambiente virtuale proposto che era differente sia dall'aula in presenza sia dal tipico corso web-based. Molti studenti hanno poi sottolineato positivamente la possibilità di poter usufruire asincronicamente, dei percorsi didattici anche senza il supporto di un insegnante o di un tutor. La possibilità di lavorare in gruppo ha sviluppato inoltre una maggiore autonomia dei partecipanti.