INQUIRY-BASED LABORATORY ACTIVITIES: EFFECT ON STUDENTS' INQUIRY SKILLS, CONCEPTUAL UNDERSTANDING AND ATTITUDE TOWARD GENETICS

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The dissertation attached hereto entitled **INQUIRY-BASED LABORATORY ACTIVITIES: EFFECT ON STUDENTS' INQUIRY SKILLS, CONCEPTUAL UNDERSTANDING AND ATTITUDE TOWARD GENETICS** in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education (major in Biology Education), is hereby accepted.

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ABSTRACT

The study developed and determined the effects of the inquiry-based laboratory activities on the inquiry skills, conceptual understanding and attitude toward Genetics of undergraduate Biology and Biology major Education students. The quasi-experimental design for quantitative methodology and qualitative data analysis were used to assess the (1) difference in the inquiry skills and conceptual understanding among and between students exposed to inquiry-based laboratory activities and those who are not; (2) change in the attitudes of the students toward Genetics in inquiry-based laboratory activities; (3) correlation among students' inquiry skills, conceptual understanding, and attitude toward Genetics; and (4) impact of inquiry-based laboratory activities in Genetics to students who use it. The students enrolled in Genetics class in a state university in the Visayas for the 2nd Semester Academic Year 2014-2015 served as subjects of this study. The students were randomly assigned to two groups - the control and the experimental groups. The control group consisted of one section of Bachelor of Science in Biology (Premed and Biotechnology Track) students taught using the traditional cookbook method in Genetics while the experimental groups consisted of two separate sections of Bachelor of Science in Biology (Microbiology Track) and Bachelor in Secondary Education (major in Biology) students utilized the researcher-made inquiry-based laboratory activities in Genetics. Qualitative analysis was done using focus group interview to obtain an in-depth analysis of the perceptions on the strategy and implementation of inquiry-based laboratory activities. This was further triangulated through students' laboratory reports, inquiry skills, conceptual understanding results, attitude questionnaire responses and observation checklists. The quantitative data on conceptual understanding, inquiry skills and attitude toward Genetics were assessed in a pretest-posttest implementation of the strategy used. In the laboratory period, the control group used the conventional laboratory method, the "cook book" method while the inquiry-based laboratory method was employed in the experimental group. Statistical analyses of the study employed both descriptive and inferential statistics.

Results showed that the pretest mean scores of the control (Inquiry Skills, M=12.20; Conceptual Understanding, M= 11.58; Genetics Attitude, M=2.39) group and experimental group (Inquiry Skills, M=12.42; Conceptual Understanding, M=10.78, Genetics Attitude, M=2.39) were comparable and showed no significant difference (Inquiry Skills, p=0.807; Conceptual Understanding, p=0.231; Genetics Attitude, p= 0.921) prior to the intervention. Independent samples t-test on inquiry skills and conceptual understanding showed that the experimental group had a significantly higher (inquiry skills, p = 0.043 and conceptual understanding, p = 0.002) posttest mean scores than the control group after using the inquiry-based laboratory activities in Genetics, respectively. The experimental group inquiry skills (M=24.67) is two percent higher than the control group (M=22.76) suggesting that the inquiry learning strategy helped students to construct and conceptualize the knowledge on Genetics laboratory from basic principles to applications. Furthermore, the experimental group conceptual understanding (M=22.73) which is four percent higher than the control group (M=18.80) revealed that the approach has effectively improved the conceptual understanding of the students. With better understanding of the concepts, students would be able to perform better in their courses. The posttest mean scores in the attitude toward Genetics of the experimental group (M=2.430) and the control group (M=2.433) were almost equal after the intervention. However, the independent samples t-test result showed no significant change on the attitude mean scores toward Genetics of the control (p=0.278) and experimental (p=0.104) groups exposed to inquiry-based laboratory activities and those who are not, respectively. Attitude toward Genetics did not

significantly vary in the two groups probably because they were all science majors and initially they had a good attitude toward Genetics. Hence, inquiry-based learning (IBL) did not cause a significant change in the students' Genetics attitudes.

The correlation tests indicate that there is a significant relationship between students' conceptual understanding and inquiry skills in the control (r=0.451, p=0.002) and experimental (r=0.492, p=0.001) groups while attitude did not show any significant relationship with them after the intervention. The non-significant negative correlation between conceptual understanding and attitude of students in the experimental group could be attributed to factors that had contributed to the high level of resistance to inquiry in this study. The impacts of inquiry-based laboratory activities in Genetics were better retention of information, expertise in inquiry skills, enhanced critical thinking skills, facilitated problem solving, drawing of conclusion and prediction of possible outcomes, and lesson mastery.

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CHAPTER 1

INTRODUCTION

This chapter presents the background of the study, statement of the problem, significance of the study, and scope and delimitation of the study.

Background of the Study

The competence of Filipinos is believed to be anchored on their educational attainment. Quality of education is reflected through academic achievement which is a function of good attitude towards learning, positive self-concept and favorable interaction of the learners with adults in the society (Bacus, 2014). One of the indicators of quality education is the performance of students in international comparison tests. One of the few standards for international comparison of students' performances is the Trends and International Mathematics and Science Study (TIMSS 2003) which is jointly implemented by the Department of Science and Technology (DOST), through the Science Education Institute (SEI), and the Department of Education (DepEd). It is noted that Filipinos ranked second to the lowest in Grade IV Science and Mathematics among 25 countries, 43rd out of 46 and 34th out of 38 countries in high school Science and Mathematics (TIMMS 2003, 2008).

A study on "National Achievement Test Results Fourth Year (2005-2006)" (Benito, 2013) revealed that in the Total Test, almost 2/3 of the high school graduating students showed performance within the Low Mastery Level (65.63%); slightly 1/3 had manifested Near Mastery (33.24%); more than 1/10 exhibited Mastery of learning competencies (1.13%); and seldom that 1 out of 5 students showed Mastery in Science. To help students succeed in international assessments and address students' weaknesses, the national research coordinator for TIMSS in the Philippines suggested that necessary intervention techniques should be used to teach beyond memorization and expose students to tasks that require understanding and analysis (Understanding the Trends in Math and Science Study (TIMSS): A Closer Look at Filipino Student Functional Literacy in Math and Science, n.d., para. 1-3).

Inquiry-based learning is a dynamic and emergent process that builds on students' natural curiosity about the world in which they live. Teaching science through science inquiry is considered the cornerstone of good teaching. Unfortunately, although inquiry-based science is popular, many curriculum materials, textbooks, laboratory guides and other materials are still prepared using traditional approaches. The inquiry-based approach to teaching science is not the norm in schools as many teachers are still striving to build a shared understanding of what science as inquiry means.

The idea of teaching science by inquiry methods is not a new one. In Dewey's Democracy and Education (1916), he states that it is not advisable to present the learner with just the conclusions from scientific experimentation. Instead he proposed that students be allowed / encouraged to explore and experiment to come up with their own conclusions about science concepts, as well as the process and nature of science. Dewey's philosophy on education was widely accepted, and was used as an integral concept during the curricular reform in the 60's and 70's. Inquiry-based learning installed by Dewey is a type of problem-solving approach and based on the students' research and analysis.

For the last several years, there has again been a call for curricular reform in science classes and laboratories in particular. The National Science Foundation (NSF) has put out a call for instructors to educate students in the ability to formulate usable questions, plans, appropriate experiments, conduct observations, interpret, and analyze data, draw conclusions, communicate their results, as well as coordinate and implement a full investigation (NRC, 2000; Thomas, 2005). Thus, it has been widely recommended that the learning approach should be changed from a teacher-centered to a student-centered approach with a balanced knowledge, skills and attitudes. These educational reforms recommend incorporating inquiry to classroom. In the Philippines, the instruction on the new K to 12 science programs shifts from traditional methods of teaching to a more innovative exploration that emphasizes the enhancement of the students' critical thinking and scientific skills. The new curriculum utilizes learner-centered approach such as the inquiry based learning pedagogy.

The interest in using inquiry-based teaching strategies has increased in recent years as science teachers have become more critical about the efficacy of cookbook-type laboratory activities and the purposes, practices, and learning outcomes of laboratory in general. It is gradually being recognized that whereas cookbook labs can teach some laboratory techniques and skills (Wu & Hsieh, 2006) or serve as visual aids for concepts already studied, they are largely ineffective as a tool for teaching science concepts.

The science laboratory is important to science teaching and it offers an environment different from the traditional classroom (Henderson & Fisher, 1998). Laboratories offer a unique environment for immersion and participation in the scientific community of practice. The laboratory work has the potential to engage students in authentic investigation in which they can identify the problem to investigate, design procedures and draw conclusions. In a review study on the role of laboratory instruction, Hofstein and Lunetta (1982) emphasize the tremendous potential of laboratory instruction but they find prior research on the role of laboratory instruction on student learning and growth to be inconclusive. In another review study, Nakleh, Polles and Malina (2002) indicate a lack of evidence coming directly from students about their understanding based on laboratory experiences. They suggest further investigation of laboratory's potential to contribute to the development of metacognitive skills of students involved in the processes of problem solving, creative thinking, and scientific thinking. The review also places an emphasis on conducting research studies that have a blend of both qualitative and quantitative methods to further establish the relevance of laboratory instruction. However, although interest in inquiry is on the rise, there are still relatively few contemporary studies or learning from inquiry-based laboratories.

It has been suggested that laboratory activities be redesigned to center more on the process of inquiry and open-ended discovery. By giving students control of their own learning and opportunities to investigate problems in an open-ended way, they engage in the same kinds of scientific procedures and reasoning that scientists use in their research, and can develop a deeper and more lasting understanding of content (Bransford, Brown & Cocking, 1999).

The researcher believes that it is only through research that a teacher could really understand, evaluate and find possible solutions that work for educational problems. Addressing educational concerns especially those that are associated to student achievement, attitude, and science process skills should start from the classroom. Therefore, it is in the hand of the teacher to innovate or find effective solutions by exploring on teaching strategies to deal with such issue. Thus, the study was conducted to determine the relationships between inquiry-based learning approach and inquiry skills, conceptual understanding and attitude of undergraduate Biology and Biology major Education students in order to build more evidence on the implications of laboratory instruction for the learning of Genetic concepts in particular.

Statement of the Problem

One of the major challenges in teaching any college level Genetics course including a laboratory component is having the students actively understand the research part of an experiment as well as to develop the necessary skills. Most laboratory exercises published for undergraduate biology courses fall under the traditional cookbook approach and do not provide the students with the opportunity to design their own experiments.

Also, little progress has been made with respect to the inquiry process at the tertiary level. College professors especially at the undergraduate level place less importance on knowledge construction and inquiry skills than the school teachers (Australia Capital Territory Parliamentary Counsel, 2004). Thus the obstacles to the incorporation of inquiry laboratories may in part be due to science instructors' lack of preparedness for inquiry and other constraints.

Studies on inquiry-based instruction mentioned in the literature review suggested that this approach to laboratory work had a positive effect on students' knowledge and attitudes toward Science. Despite its important role in shaping students' mind and behavior, there exists a paucity of information on this subject matter especially in developing countries such as the Philippines. Few institutions are also adopting the strategy mainly because of its low promotion by the scientific and educational communities. This is critical for students in Genetics because it is one of the most difficult subjects in the biology curricula at all educational levels (Chatopadhyay, 2005). Its understanding and appreciation require the use of inquiry skills. Studies in other countries have shown that understanding and its various aspects are poor among students of various levels and among the population in general.

Hence, the study was conducted to contribute to the existing conversation about the approach and add more empirical evidences on the role of inquiry-based approach in teaching a laboratory course in Genetics. The study aimed to analyze the effects of inquiry-based laboratory activities on students' inquiry skills, conceptual understanding and attitude toward Genetics. To facilitate the implementation of the approach, an inquiry-based laboratory manual was developed.

Objectives of the Study

The study aimed to develop and determine the effects of the inquiry-based laboratory activities on the inquiry skills, conceptual understanding and attitude toward Genetics of undergraduate Biology and Biology major Education students.

Specifically, it aims to answer the following questions:

1. Is there a significant difference in the inquiry skills among and between students exposed to inquiry-based laboratory activities and those who are not?

2. Is there a significant difference in conceptual understanding among and between students exposed to inquiry-based laboratory activities and those who are not?

3. Can inquiry-based laboratory activities in Genetics change the attitudes of the students towards Genetics?

4. Is there a correlation among students' inquiry skills, conceptual understanding, and attitude toward Genetics?

5. What is the impact of inquiry-based laboratory activities in Genetics to students who use it?

Significance of the Study

This study contributes to the understanding of the educational theories of constructivism, inquiry-based approach, and laboratory work as an active form of learning. A teaching strategy based on constructivism focuses on providing students with physical experiences that induce cognitive conflict and encourage students to develop new knowledge schemes while inquiry-based learning is a pedagogical strategy that uses the general processes of scientific inquiry as its teaching and learning methodology.

For students. Inquiry at the undergraduate level is of importance because once they graduate and serve in their respective professions, they will need to apply their knowledge and their understanding. Unfortunately, most undergraduate instructions including laboratory experiments are based on structured inquiry despite obvious benefits of more open inquiry instructions (Buck et al., 2008; Roth et al., 1998). Inquiry teaching and learning methods affect student performances in problem solving, reflecting on their work, drawing conclusions and generating predictions. These qualities are necessary for a high-achieving graduate.

For teachers and curriculum designers and developers. The research findings could guide teachers and/or curriculum designers and developers in preparing inquiry-based laboratory for various Biology courses that will enhance the students' conceptual understanding, inquiry skills and attitude toward Genetics.

For researchers, education specialist and administrators. It will also provide additional information on inquiry-based laboratory for researchers which would direct the education specialists and administrators in the improvement of student learning.

Scope and Delimitation of the Study

The study involved three intact classes of undergraduate Biology and Biology major Education students enrolled in Genetics class in a state university in the Visayas for the 2nd Semester Academic Year 2014-2015. The study was limited to determining the effects of inquiry-based laboratory activities on students' inquiry skills, conceptual understanding and attitude toward Genetics.

The inquiry-based laboratory instruction material that was used in the study was developed by the researcher, herself, though it was validated by three science professors in Genetics. It was developed in the context of the current study's participants. Thus, any attempt to use the material in another classroom setting should consider this context. The researcher conducted the study through the Genetics professor of the said university who implemented the material in his classes.

The quasi-experimental method of investigation using pretest-posttest non-equivalent control group design was used in the study. Thus, any secondary analysis of the data gathered in the study should consider this. Since three intact classes were used, participants were randomly assigned to groups as control and experimental group. For comparability of the two groups, students with more or less same pretest scores were involved in the study.

A researcher-made pretest-posttest in Genetics was used to assess the effect of inquiry-based laboratory on the students' conceptual understanding, whilst modified and adopted questionnaires were developed to evaluate students' inquiry skills and attitude in Genetics. These instruments were validated and underwent reliability testing using Cronbach alpha. To evaluate students' observation and feedback, an observation checklist for laboratory instruction and inquiry instruction material and feedback questionnaire for interview were used. These instruments underwent face-content validation but not reliability testing due to limited timing.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND THEORETICAL FRAMEWORK

This section presents the related literature and studies to support the study, the theoretical framework, conceptual framework, statement of the hypotheses and definition of terms.

Review of Related Literature and Studies

Educators around the world are seeking ways to prepare students for living and working in the changing information environment of the 21st century. Inquiry is a way of learning new skills and knowledge for understanding and creating in the midst of rapid technological change.

Inquiry-based learning (IBL) is student-directed and can be linked to John Dewey's philosophy that education begins with the curiosity of the learner. E. Lee May, Salisbury State University, defines IBL as "*a method of instruction that places the student, the subject, and their interaction at the center of the learning experience. At the same time, it transforms the role of the teacher from that of dispensing knowledge to one of facilitating learning. It repositions him or her, physically, from the front and center of the classroom to someplace in the middle or back of it, as it subtly yet significantly increases his or her involvement in the thought-processes of the students*" (The Academy of Inquiry Based Learning, 2013).

Inquiry-based learning provides students the opportunity to construct the understanding necessary to produce deeper learning. Such understanding greatly increases the chances that students will be able to apply the concept in new situations. This increases the likelihood that it will be remembered. Inquiry-based learning strategies serve as a stimulus for learning, thinking and questioning. In inquiry-based learning, students are presented with a challenge (such as a question to be answered, an observation or data set to be interpreted, or a hypothesis to be tested) and accomplish the desired learning in the process of responding to that challenge.

Inquiry has frequently been found to be more effective than traditional science instruction at improving academic achievement and the development of thinking, problem-solving, and laboratory skills (Haury, 1993; McCreary, Golde, & Koeske, 2006; Shymansky, Hedges, & Woodworth, 1990; Oliver-Hoyo & Allen, 2005). Colburn (2006) recommends focusing inquiry-based activities around questions that call for experimental investigation, involve materials and situations somewhat familiar to students, and pose a sufficient level of challenge to promote skill development.

Inquiry-based methods have been used in many different disciplines, including physics (Fencl & Scheel, 2005; Thacker et al., 1994; Heflich, Dixon, & Davis, 2001), biology (Londraville et al., 2002), and chemistry (Jalil, 2006; Lewis & Lewis, 2005; Oliver-Hoyo, Allen, & Anderson, 2004; Oliver-Hoyo & Allen, 2005).

Since late in the 19th century, science educators have believed that the laboratory is an important means of instruction in Science. Laboratories play a significant role in effective Biology education. Laboratory classes are supplementary to Biology education and make up a crucial part of Biology courses. Laboratories are very important to comprehend abstract concepts (Demirtaş, 2006) in Biology like Genetics.

Laboratory instruction was considered essential because it provided training in observation, supplied detailed information, and aroused pupils' interest. Often though, labs are presented as mere recipes in which students follow precise instructions to arrive at a conclusion and the importance of which is not clear. Typically, students work their way through a list of step-by-step instructions, trying to reproduce expected results and wondering how to get the right answer. .

Interest in using inquiry-based teaching strategies has increased in recent years as science teachers have become more critical about the efficacy of cookbook-type laboratory activities and indeed the purposes, practices, and learning outcomes of laboratory in general. It is gradually being recognized that whereas cookbook labs can teach some laboratory techniques and skills (Wu & Hsieh, 2006) or serve as visual aids for concepts already studied, they are largely ineffective as a tool for teaching science concepts. As stated by one teacher-researcher, "In the same way as any scientist, students will see what their prior theories lead them to expect. More significantly, they will not make the meaning that we as teachers expect them to make of experimental evidence until they have already grasped the theoretical framework that allows them to 'see' the evidence" (Wu & Hsieh, 2006).

Recent publications from the National Academy of Sciences have encouraged the need to introduce research-driven exploration in lieu of "cookbook" exercises (National Academy of Sciences, 2010). The term "cookbook" refers to experimental procedures in which students follow a step-by-step method reminiscent of a cooking recipe. The expected end result of the experiment is often provided to the students before they even initiate the experiment. Evaluation of student performance is often based on how well they follow the protocol. Because the laboratory exercise was validated with repeated data output, any discrepancy in the results was attributed to student's inability to follow the protocol. Failure to obtain satisfactory results is a common occurrence of the scientific research process and is acceptable. What is unacceptable however is the inability to troubleshoot and explain the possible errors or circumstances that yielded unexpected results. The students that do obtain the pre-determined results often lack the conceptual understanding and significance of individual steps of the experiment. For many students this leads to frustration and often, for non-science majors from pursuing their education within the natural sciences. Student perceptions and attitudes towards Science have been shown to improve if laboratory instruction is taught with a connection to the real world and students are provided an opportunity to participate in the experimental design (Mathews, 2010).

Unfortunately, an inquiry-based approach to teaching Science is not the norm in schools as many teachers are still striving to build a shared understanding of what Science as inquiry means. By including inquiry-based activities in the lab, the assumption is that students will increase their scientific literacy and build creative problem-solving abilities through a more challenging curriculum than is offered through traditional cookbook activities. However, there has been little assessment to determine whether inquiry-based labs achieve these goals with greater success than traditional labs. There is no clear consensus on the function and purpose of laboratory instruction within an academic curriculum (Russell, 2008). Leading purposes include: bridging the gap between theory and practice, illustrating material taught in lecture, increasing enthusiasm and fostering scientific attitudes, and develop skills of observation, reasoning and critical thinking (Waters, 2012).

Traditional versus Inquiry-based Laboratory

In a traditional science classroom, the teacher uses a textbook to transmit knowledge and explain conceptual relationships to students. Students listen to their teachers and are later responsible for memorizing the information to restate on a test. In this type of classroom, the teacher and the textbook are the source of authority and students are passive receivers of information. Students in these classes all complete the same teacher prescribed activities (Anderson, 2002).

An inquiry-based science classroom looks very different from a traditional science classroom. Teacher and student roles change, as well as the work students complete. Teachers in inquiry classrooms take on the role of a coach and model the learning process for students. Students are responsible for naming the scientific question under investigation, designing investigations to research their question, and interpreting findings from investigations. In this classroom, students may be working on different research questions, or may be at different phases in the research cycle. Students in inquiry classrooms are self-directed learners and there is not one official authority of knowledge in the classroom.

There has been a recent and strong advocacy to introduce inquiry-based laboratory instruction into biological science courses. It is believed that developing laboratory exercises that have a research-oriented focus will not only teach science, but will develop students who think like a scientist. In the traditional approach to laboratory work, students' activities are focused mostly in verifying information previously communicated in class by the teacher or in the provided instructional material. Literature has encouraged the inquiry-based approach to laboratory work over the traditional approach. A number of studies show that inquiry-based laboratories generate more positive results than traditional laboratories.

Inquiry-based laboratories are inductive in nature and are used to explore, invent or introduce, and apply concepts. In this laboratory format, students start with making observations and collecting data to generate concept. Compared to traditional format, students in inquiry-based labs are involved, receive less direction from instructor, and bear more responsibility for designing procedure to answer questions they formulate. In inquiry labs, students' activities are focusing on collecting, processing and analyzing data to discover new concepts, principles, or laws in much the same way and with similar tools as real scientists and practitioners conduct investigations. This means that students are given more control of their own learning and consequently it is accepted when things go wrong or not as expected, as long as students learn from mistakes and missteps through reflection and self-assessment; time and opportunity is provided to students to make and recover from mistakes and/or dead-end explorations. Going through activities in the laboratory may influence their attitudes about scientific enterprise (Chiappetta & Koballa, 2006).

One study (Brownell et al., 2012) provides empirical evidence supporting the recommendations for incorporating more authentic research components in laboratory courses. The study found that students in the research-based lab had a) more positive attitudes toward authentic research; b) higher self-confidence in lab-related tasks; and, c) increased interest in pursuing future research compared with students in the cookbook laboratory course. This study had twenty (20) students in the research-based lab matched with 20 students in the cookbook lab on the basis of five demographic characteristics. The research-based lab course had several hallmarks of authentic research: a single longitudinal research focus, research questions with currently unknown answers, student-determined experimental designs, and collaboration among lab peers.

In addition, Gormally et al. (2009) research on the effects of inquiry-based learning on students' science literacy skills and confidence demonstrated greater improvements in students' science literacy and research skills using inquiry lab instruction. Inquiry lab students also valued more authentic science exposure but acknowledged that experiencing the complexity and frustrations faced by practicing scientists was challenging. On the other hand, gains in self-confidence were true for students from both inquiry and traditional labs but traditional students' gain was greater.

Another study (Rissing & Cogan, 2009) measured student performances on a series of objective and subjective questions on two different laboratory exercises on enzyme activity. The first measurement was taken before and after completion of the inquiry-based, hands-on laboratory exercise while the other measurement was taken before and after completion of an existing, standard, "direct" laboratory exercise over the same topics. Results showed that student performance on these questions increased significantly after completion of the inquiry exercise, while student performance did not increase after completion of the control, standard exercise.

Results of another study (Hasan, 2012) revealed that implementing the guided inquiry instruction in teaching the environmental biology subject has significant effect in improving tenth grade students' academic achievement. However, results also suggested that the guided inquiry instruction alone seems insufficient in developing the nature of science (NOS) conceptions in the students. Differences in the total average scores between pre- and post-NOS scale are not statically significant for both the experimental and control groups. It is possible that more explicit instructional approaches are needed to be investigated for their effectiveness in achieving NOS understandings in students' minds.

Hasan's study investigated two things: a) Students' views of the nature of science (NOS) based on the newly implemented science curriculum, the Hartcourt International; and, b) Impact of guided-inquiry instruction in teaching the environmental biology subject and the NOS aspects with students. Seventy-six (76) tenth-grade students in UAE public schools, distributed amongst four mutual exclusive classes, served as subjects of the study. The respective classes were randomly divided into two intact groups: experimental and control groups. The experimental group was taught using the guided inquiry instruction during theoretical classes and laboratory activities were based on grappling with guided-inquiry questions and practicing science as process skills. The control group was taught using the traditional strategies, without incorporating the guided inquiry instruction and the science process skills.

Waters (2012) evaluated the advantages and disadvantages of utilizing 'cookbook and 'inquiry-based' laboratory within the life science curriculum as summarized in Table 2.1.

Table 2.1 Advantages and Disadvantages of Utilizing 'Cookbook' and 'Inquiry-based' Laboratory within the life science curriculum (Waters, 2012)

Laboratory Type	Advantages	Disadvantages
Cookbook	1. Laboratory exercises are easily designed to fit into restricted student schedules 2. The results of the exercise are predetermined allowing assessment of the students performance 3. Conducive and manageable for courses with large student enrollment 4. Can cover multiple biological concepts within a course 5. Laboratory exercises can be created into modular exercise that correspond with classroom lecture	1. Students easily lose enthusiasm for science education and an interest in ongoing and future scientific achievements 2. Students quickly learn what steps of the procedure can be ignored or fail to thoroughly read the protocol for complete understanding 3. Critical thinking skills are not developed 4. There are little opportunities to apply problem-solving strategies 5. Students feel disconnected from the exercise and lack "ownership" of the collected data 6. Collaboration among peers is discouraged 7. Students do not plan the experiments and results are not properly interpreted 8. Scientific concepts are "verified" rather than "discovered"
Inquiry-based	1. Students take "ownership" of the laboratory exercise 2. Students experience the scientific method and acquire an appreciation and understanding for scientific achievement 3. Students become interested in ongoing and future scientific achievements as it relates to current events 4. Students experience the successes and failures of scientific research 5. Students are encouraged to collaborate to	1. Difficult to manage in courses with large student enrollment 2. Requires significant amount of time that students must be in the laboratory 3. Students can become easily frustrated

	obtain successful results 6. Students learn critical thinking and problem solving skills 7. Students retain the learned concepts

It is clear that "cookbook" laboratory exercises persist mainly due to a logistic advantage. The bottom line is that they are easier to manage and set-up. With limited budgets and laboratory support personnel, these types of laboratory instructions are favored. They tend to be advantageous to the instructor but place the student at a disadvantage for enhanced learning. The major strength of "cookbook" exercise is that numerous biological concepts can be taught by using independent modules that can be interchanged and aligned with classroom lectures. In this regard students are solely validating concepts learned from the lecture. Critical thinking and reasoning skills are not developed and students easily lose enthusiasm for the process of scientific investigation.

According to Waters (2012), students who are given the opportunity to design experiments and execute them, regardless of whether or not the proper results are obtained, are more likely to become "self-educators" and maintain curiosity and enthusiasm for scientific achievement. These students are likely to pursue advance science degrees and become the next generation of scientists.

Inquiry Skills

Inquiry has been viewed as an approach to learning science that involves a process of exploring the natural or material world (Tamir, 1983; NRC, 1996). Inquiry is congruent with constructivist teaching ideology which emphasizes students' prior knowledge as the foundation of further learning (Llewellyn, 2002). This calls for a type of scaffolding, in the Vygotskyan (1978) sense, that involves taking students from where they are and, with just the right amount of support from the teacher, guiding them to become more autonomous learners (McNary, Glasgow, & Hicks 2005). In science education, it is students' experience with the natural world that is viewed as forming the basis of their active engagement in attaining this understanding (Llewellyn 2002). Students address teachers' and students' questions about natural phenomena or events by conducting scientific investigations in which the collaboratively develop plans, collect and explain evidence, connect the explanations to existing scientific knowledge, and communicate and justify the explanations (Anderson, 2002).

The National Science Education Standards (NSES, p. 23) defines scientific inquiry as *"the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."*

Scientific inquiry is a powerful way of understanding science content. Students learn how to ask questions and use evidence to answer them. In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions.

Following NRC (2000) and Krajcik et al. (1998), there are seven phases in an inquiry process: (1) asking and deciding questions, (2) searching for information, (3) designing investigations (4) carrying out investigations, (5) analyzing data and making conclusions, (6) creating artifacts, and (7) sharing and communicating findings. These phases are not steps to take in a linear fashion and students can go through the phases in complex ways. For example, students can reframe their research question and redesign their investigation after recognizing that their data cannot answer their questions. Additionally, due to the nature of inquiry, some scientific investigations do not involve all seven phases. For example, analyzing data from a weather database and constructing explanations of phenomena such as global warming and climate change could be an interesting project for inquiry although students do not collect empirical data by themselves, nor do they carry out hands-on experiments.

NRC (2000) indicates five essential features of classroom inquiry that emphasize questions, evidence, and explanations within a learning context. The features include asking scientifically-oriented questions, using evidence to formulate and evaluate explanations that address the questions, considering and evaluating alternative explanations, and communicating and sharing explanations. In classroom inquiry, one of the major knowledge productions created through inquiry learning is explanations that address scientifically oriented questions and are supported by empirical evidence. Students not only learn science from explanations provided by teachers and textbooks but they also participate in explanatory activities that involve formulating, evaluating, and communicating explanations.

However, students' difficulties in constructing explanations are well documented. Part of students' difficulties stem from their lack of inquiry skills. Many students generate incoherent explanation from personal ideas and are not able to make logical relationships between evidence and explanations. Students tend to use linear causal reasoning and attribute the cause of a phenomenon to the existence of an agent (Andersson, 1986). According to Abrams, Southerland and Cummins (2001), a majority of students were not able to provide a causal explanation to a why question about biological changes and could not make a distinction between explanations that involve causal relationships in the changes and explanations that address the rationales of the changes. Additionally, many students in the middle grades confuse explanatory claims with evidence and have difficulty making logical inferences (Kuhn, 1989).

When students engage in explanatory activities and inquiry learning, they are believed to develop a set of intellectual skills that enable them to construct understandings about science (Windschitl, 2000). If students lack these essential skills, inquiry learning may not be productive and lead students to frustration, and students may generate conclusions that are not empirically proved. Kuhn (1989) argued that these skills are the "most central, essential, and general skills that define scientific thinking" (p. 674).

One factor that could affect students' development of inquiry skills is teachers' instruction (Eick & Reed, 2002; Rop, 2002). When using an inquiry approach to science teaching, teachers are expected to support students' exploration of phenomena and to engage them in constructing meaningful scientific understandings (Hogan & Berkowitz, 2000). Teachers need to shift the emphasis from textbooks to exploring questions and topics that are student-centered (Keys & Kennedy, 1999). They also need to facilitate students building on their current knowledge and revising their understanding (Eick & Reed, 2002; NRC, 1996). Thus, teachers play varied roles in supporting students' development of inquiry skills which include modeler, guide, diagnostician, facilitator, mentor, and collaborator that indicate varied amount of structure and scaffolding teachers build into an activity (Crawford, 2000; Osborne & Freyberg, 1985).

Conceptual Understanding

For generations, science teaching has relied on methods that train students to follow directions with little connection to doing real science. Students have become accustomed to this method of learning, but most do not form a deep conceptual understanding of science (National Center for Education Statistics, 2001). As quoted by Grant Wiggins and Jay McTighe (1998), *"Knowing the facts and doing well on tests of knowledge do not mean that we understand"* and associate the term *knowing* with facts, memorization, and superficial knowledge, whereas the term *understanding* signifies a more complex, multidimensional integration of information into a learner's own conceptual framework.

Concepts are like mental representation which, in their simplest forms, can be expressed by a single word, such as "plant" or "animal", "alive" or "dead", "table" or "chair", "apple" or "orange" (Carey, 2000). Concepts may also represent a set of ideas that can be described with a few words. Whereas the term "deep understanding" in the cognitive sciences generally refers to how concepts are "represented" in the student's mind, and most importantly, how these concepts are "connected" with each other (Grotzer, 1999). To demonstrate understanding, students must not only possess rudimentary knowledge, but must also be able to explain, interpret and apply that knowledge, as well as have perspective on the information, possess self-knowledge of their own understanding, and empathize with the understandings held by others.

Conceptual understanding, which permits one to transfer an explanation of a phenomenon to different variants of a situation that have been previously analyzed, is clearly a goal to be recruited under the label "learning science", at any level. National science standards (National Research Council, 1996) urge the use of inquiry teaching to help students develop deeper conceptual understanding in science.

Striving for student understanding as a result of instruction, above and beyond memorizing or knowing, requires that instructors take into account students' prior knowledge and support students in integrating new knowledge with their existing ideas. An explicit confrontation between preknowledge and new knowledge is the critical element in teaching toward understanding put forward by Posner and colleagues' theory of conceptual change. Posner et al., (1982) define conceptual change as a learning process in which an existing conception (idea or belief about how the world works) held by a student is shifted and restructured, often away from an alternative or misconception and toward the dominant conception held by experts in a field.

Thus, in teaching toward understanding of major concepts in biology and achieving conceptual change for students, it is necessary to understand students' prior knowledge, examine it, identify confusions, and then provide opportunities for old and new ideas to collide. Inquiry-based science teaching is seen as one strategy for teaching toward conceptual change, in that inquiry engages students in the exact same questioning of one's preconceptions and challenging of one's own knowledge that is characteristic of both conceptual change and scientific habits of mind (Tanner & Allen, 2005).

In a study by Simsek and Kabapinas (2010) on students' conceptual understanding of matter in a 5th grade science class using a teaching intervention designed on the basis of IBL principles, findings indicated that IBL had a positive impact. Similar study by Ali Abdi (2014) investigated the effect of IBL on academic achievement in the science lessons of 40 fifth grade students and showed that students who were instructed through IBL achieved higher score than those who were instructed through the traditional method.

Another study (Mc Neal et al., 2008) on the use of IBL and multiple representations to support introductory students' conceptual model development of the complex and dynamic Earth process, eutrophication, through the evaluation of student drawings and written reports has a positive impact on students' conceptual model development of eutrophication. A case study in IBL by Power and Steel (2003) found out that students who completed the IBL task demonstrated a better knowledge of anatomical topography and anatomical detail in their end-of-semester assessment. They appeared to have acquired the ability to problem solve by providing a detailed prognosis for the holistic effect of injuries. Through their IBL task, they showed an understanding of the consequences on the environment for anatomical structures and physiological processes—for example, the reasons for the increase in the proportion of juxtamedullary nephrons in animals in an arid environment.

Attitude toward Genetics

Regardless of one's major or profession, science plays an enormous role in everyone's life. From discovering cures for diseases, to creating innovative technologies, to teaching how to think critically, science has become an indispensable feature of modern society. Biology in particular has generated its share of controversies, including evolution, cloning and genetic engineering, global warming, premature species extinction, animal rights and animal suffering, human overpopulation, and the right to determine the timing and means of one's own death, to name a few (Leonard, 2010). Science teaches people how to think critically about not just scientific subjects, but all subjects.

Due to scarcity of specific studies about effects of inquiry-based approach on students' attitude toward Genetics, this literature review on effects of inquiry-based approach on students' attitude toward Science is considered relevant to Genetics as a branch of Science.

Ajzen (1988) defined attitude as a disposition to respond favorably or unfavorably to an object, person, institution, or event (p. 4). The research on students" attitudes toward science is important for several reasons. First, science is often seen as being unpopular among students, with negative attitudes developing as early as primary school level (Greenfield, 1996). Second, attitudes toward science are believed to influence behaviors, such as selecting courses and supporting scientific inquiry (Koballa & Crawley, 1985). **Third**, there is a strong relationship between attitudes and achievement. For example, Bloom (1976) and Bandura (1986) highlight the impact of learners" attitudes on their concept of discipline-related self-efficacy and achievement. According to Bloom (1976), how students feel toward what they are studying, their school environment, and their concept of self-account for 25% of the variance in school achievement.

The investigation of students' attitudes towards studying science has been a substantive feature of the work of the science education research community for the past 30–40 years (Osborne et al, 2003). The decline of interest in science remains a serious matter of concern for any society attempting to raise its standards of scientific literacy. Whitfield (1980) argued that the rejection of science was accounted for by the perception that it was a difficult subject but his findings, based on data collected in the 1970s, now lack significance because of the considerable changes that have occurred in the science curriculum (in particular, the move to balanced or integrated science) since his study was conducted.

Studies report that the general public (that is, non-science majors) does not generally have positive feelings toward science and scientists (Rogers & Ford, 1997). These findings are unfortunate because such attitudes may have negative effects on the entire society. Since non-science majors are potential lawyers, presidents and managers of companies, politicians, and civic leaders, they will influence how research and development funds are spent, how scientific discoveries and technological innovations are implemented, and how scientific evidence is used in courts and other social organizations.

Several reasons have been suggested for these negative attitudes including students' undesirable experiences in previous science courses and with instructors, lack of needed skills to learn and apply scientific concepts, lack of motivation to work hard in science classes, home backgrounds, school and classroom environments, biases of peer groups, the media's portrayal of scientists, and students' perceptions of rewards associated with learning, to name a few (Rogers & Ford 1997). The way science is taught, both at the high school and college level, also plays a major role in shaping students' attitudes toward science. According to a study by Cherif and Wideen (1992), which addresses the question of whether a problem exists for science students moving from high school to the university, students are being presented with selected aspects of scientific dogma at the high school and university levels rather than being taught the innovative and visionary character of science and the value that such knowledge has to the educational process. Some of the students in this study reported that they were confused because the information they learned in college contradicted the information they gained in their high school science classes. As the study concluded, this dogmatic approach to teaching science, coupled with the drastic cultural changes that students undergo as they transition from high school to college, affect students' attitudes toward and performance in college-level science courses.

Though the development of desirable attitudes toward science is not the primary goal of introductory science courses, such as biology, chemistry, and earth science, the instructors usually recognize that attitude formation is one of the important aspects of instruction (Cherif & Wideen, 1992; Garcia & McFeeley, 1978). Most instructors focus primarily on increasing the students' knowledge of the subject rather than increasing their favorable attitudes toward it. Many instructors assume that students will naturally acquire positive attitudes toward science as they learn more about it. However, a study by Garcia and McFeeley (1978) found that the positive attitudes of students toward biology in 18 introductory biology courses at East Texas State University decreased by the end of the term. This necessarily raises the questions of how to improve students' attitudes toward science, and whether the way one teachers science plays a significant role in this challenge. In short, it is not only what the teacher teaches but also how he/she teacher that are important considerations in how to improve student success (Moore, 1989).

There is growing evidence that students who possess positive attitudes toward science will perform better academically. Russell and Hollander (1975), who created the Biology Attitude Scale - a tool designed specifically to measure students' attitudes toward biology - support this claim. "The tool was developed on the assumption that an important consequence of instruction is a positive change in the student's attitude toward the subject, and the authors argue the importance of focusing on attitudes by stating that there usually exists a positive correlation between attitudes and achievement" (Russell & Hollander, 1975).

A positive attitude toward science may improve students' academic performance in not only science classes, but in other classes as well because science is a way of knowing and understanding through the exercise of reason, a construction of the mind based on actual observation to explain natural phenomena. It is therefore in the interests of society, and the responsibility of educators, to improve students' attitudes toward science, and to prepare students to live in a highly scientific and technological society. The future of society will be determined by citizens who are able to understand and help shape the complex influences of science and technology on the world (Ungar, 2010).

In other words, the most successful students are usually the most highly motivated; they are most likely to come to class, do extra-credit work, and attend help sessions (Moore, 2006). A highly motivated student is usually one with a positive attitude toward the subject s/he is learning. Therefore, in order to improve students' attitudes toward science, faculty must motivate students, which they can do through their teaching styles and by showing them the relevance of the learning topics to their everyday lives. In addition, they must create the learning environment that helps motivate students not only to come to classes but also want to learn and enjoy learning.

Studies have shown that students who use an inquiry approach have improved attitudes towards both science and school while other studies show more negative attitudes resulting from traditional methods (Gibson, 1998a, 1998b; Jaus, 1977; Selim & Shrigley, 1983; Shrigley, 1990).

A study by Gibson and Chase (2002) on the long-term impact of the Summer Science Exploration Program (SSEP), a two-week inquiry-based science camp from 1992 to 1994, suggested that students maintained a more positive attitude towards science and a higher interest in science careers than students who applied to the program but were not selected.

Some short-term studies have also shown that students who use an inquiry approach have improved attitudes towards science. These same studies show negative attitudes resulting from traditional methods. For example, Selim and Shrigley (1983) compared two instructional modes, discovery and expository, for teaching science knowledge to fifth grade students. The treatment period was 21 days. After the treatment period, they found that students taught by teachers using the discovery approach (an inquiry approach) had a more positive science attitude than the control group who were taught by teachers using the traditional lecture approach.

A significant change occurred in the attitude towards physics in the experimental group compared to the control group (Amadalo et al., 2012). This group was able to determine for themselves the touted experiences. They were able to control the pace at which the practical progressed. They found out that they could negotiate meanings and all of a sudden the subject was comprehensible. This experience was repeated many times in the various experiments they went through. Lack of continued exposure to these experiments by the control group left them still wondering what the subject was all about.

Findings of Arthur (1989) on the effect on inquiry-based instruction on students' participation attitude in a third grade science classroom showed that inquiry-based science experiences positively affected students' attitudes in science and their participation. In addition, students worked collaboratively, made connections to other experiences, and demonstrated confidence in their ability to ask and answer their own questions through inquiry-based experiences.

Results of Ergul et al. (2011) study on the effects of inquiry-based science teaching on Turkish elementary school students' science process skills and science attitudes showed that the use of inquiry-based teaching methods significantly enhances students' science process skills and attitudes.

Hofstein and Lunetta (2004) add to this list by emphasizing the central role played by the science laboratory in contributing to students' perception of science and attitudes by stimulating interest and enjoyment, and motivating students to learn science. There is indication that students' attitudes towards science are improved after having been involved in Inquiry-Based Learning (IBL) environments (Gibson & Chase, 2002).

On the other hand, findings of a study by Simsek and Kabapinar (2010) indicated that IBL had a positive impact on students' conceptual understanding and scientific process skills, but did not make any difference on their attitudes towards science. This finding is also parallel to the results of the previous studies as research on attitudes indicates that attitude towards science does not change over a short period of time (Neiderhauser, 1994; Ünal & Ergin, 2006).

Effects of Inquiry-based Laboratory Activities on Students

Two studies by Cheung examined teachers' perceptions regarding the implementation of inquiry-based laboratory work. The first study (Cheung, 2008) found that chemistry teachers in

Hong Kong secondary schools are having difficulty implementing inquiry-based laboratory activities due to lack of class time, shortage of effective instructional materials, and large classes. This study developed strategies, which include the use of guided inquiry rather than open inquiry, development of ten examples of authentic inquiry, and inclusion of student oral presentations as a key component of the inquiry process, to aid teachers in addressing the enumerated concerns. Trials done in schools indicated that these strategies are useful.

The other study (Cheung, 2011) measured teachers' beliefs about implementing guided-inquiry labs in secondary schools using a researcher-developed guided-inquiry scale (GIS). Results indicate that both users and nonusers of guided-inquiry labs of the 200 Hong Kong chemistry teachers who served as subjects of this study valued guided-inquiry lab work and recognized the limitations of cookbook-style labs. However, nonusers tended to believe that students dislike guided-inquiry and that it is not feasible for students to design experiments. The length of chemistry teaching experience and the level of student ability did not influence teachers' beliefs about implementing guided-inquiry labs. Construction of the guided-inquiry scale was based on a model with three dimensions: the value of guided-inquiry labs, limitations of cookbook-style labs, and implementation issues with guided-inquiry labs. The subjects responded to the GIS items using a seven-point Likert scale. The GIS data were of adequate reliability and confirmatory factor analysis indicated that a good fit exists between the hypothesized model and data.

A separate study dealt with students' perceptions regarding inquiry-based science programs. This qualitative study (Kazempour, Amirshokoohi & Harwood, 2012) which was part of an ongoing research investigating experiences of undergraduate students who enrolled in an integrated inquiry-based biology program during their freshman year found that students had positive perceptions regarding inquiry and considered it as a more effective way to learn science and an excellent preparation for future science endeavors. These students who embarked on inquiry projects were found to have greater understanding of the process of science and the type of work done by scientists.

A related study by Alba (2002) determined the 36 General Botany students' laboratory performance using inquiry-oriented laboratory activities and traditional laboratory activities in terms of acquired laboratory skills and scientific attitudes. The study shows that inquiry-oriented laboratory activities can be performed successfully even in a not-so well equipped laboratory room. It also shows that students using the inquiry-oriented laboratory activities do not only acquire much needed laboratory skills but also scientific attitudes which are helpful in coping with the cognitive demands of other science subjects.

In another study, Petilos (2002) compared the effects of the constructivist and traditional models of teaching problem-solving strategies on the students' problem-solving and critical thinking skills. The students exposed to the constructivist model of teaching problem-solving strategies posted higher but not significant posttest mean scores on the problem-solving test than those exposed to the traditional model. Within the framework of the limitations of the study, the constructivist model for teaching problem-solving strategies has a positive impact on the overall critical thinking skills of the students. Although it did not differentiate the problem solving performance between the experimental and control groups, the trend in the results was still in favor of the experimental group and that it benefitted the low-ability students more than the high-ability students in terms of problem-solving performance.

On the other hand, Torre (2002) study's attempted to determine the effectiveness of practicals in enhancing conceptual understanding about cellular respiration in relation to the functioning of six body systems, and enhancing inquiry skills. Findings show that students who performed the practicals were able to learn more scientific concepts than those taught using the traditional lecture method. However, the difference was not statistically significant. On the other hand, students in the experimental group also performed better in the use of inquiry skills than the control group. The difference in their mean scores was significant. They improved greatly in their performance in the use of inquiry skills from pre- to posttests, specifically, in identifying the problem, formulating hypothesis and seeing patterns or relationships in the data. The difference was statistically significant for identifying the problem and seeing patterns or relationships in the date, and nearly so for formulating hypothesis. The study provided evidence that practicals are effective in enhancing students' inquiry skills. It also identified tenacious alternative conceptions on cellular respiration in relation to the functioning of six body systems that urgently need to be addressed using conceptual change strategies. Lastly, it produced instructional materials (the practicals) which teachers' can utilize in their natural science classes or use as a guide for developing their own practicals.

Theoretical Framework of the Study

This study is primarily based on the concept of human curiosity where it stipulates that once stimulated, it would lead to positive learning outcomes; thus, students should be encouraged to use their curiosity in learning. In 1954, Daniel Berlyne made a theoretical distinction between *'perceptual curiosity'* involved when a stimulus has some property such as novelty and attracts attention and *'epistemic curiosity'*. The latter is a term used only for human behavior, and describes a desire for knowledge, which Berlyne described as "*why certain pieces of knowledge are more ardently sought and more readily retained than others*". Clearly, epistemic curiosity has a particular relevance to learning in an academic setting. Loewenstein (1994) elaborated on the concept of epistemic curiosity and has theorized that 'information gaps' in an individual's knowledge of a topic are of central importance. A prime example in the classroom would be when a student knows the basic structure of a theory or concept, but lacks specific details. Loewenstein's theory suggests that the student would then be curious about the missing information and be motivated to fill the information gaps Although traditionally associated with the psychology of perception and illusions, it merges well with the information gap theory of curiosity. It is further hypothesized that curiosity about a topic will not be invoked when either there are no information gaps identified or if the individual feels that they already know the information. In addition, it is suggested that curiosity becomes stronger, the closer the individual feels that they are to achieving the knowledge, and that there is a pleasant feeling of satisfaction when information gaps are resolved.

Zion and Sadeh (2007) described the role of curiosity as a motivating factor is probably a key component of the success of inquiry-based learning, and there is evidence that it is a driving force of dynamic inquiry in student learning. In a study about stimulating curiosity to enhance learning, Pluck and Johnson (2011) have concluded that inquiry-based learning approaches such as problem-based learning appear to be consistent with theories and evidence regarding the effective stimulation of students' curiosity. Even without switching paradigms, simple techniques such as providing regular feedback and assessments of students' current state of knowledge may aid teachers in enhancing learning via increased curiosity.

Furthermore, this study is also rooted on constructivism which is based on "the conception that we learn by relating new experiences to our prior knowledge; we construct new understandings based on what we already know" (Sherman & Kurshan, 2005). Involvement in learning implies possessing skills and attitudes that permit students to seek resolutions to questions and issues while constructing new knowledge. Hanauer et al. (2006) stated that when students engage in inquiry and learn to integrate their ideas, they are prepared to apply what they learn in science classes to contexts beyond the classroom. Students gain interest and have a better understanding when they use the skills and knowledge they have learned in the classroom and apply it to activities or experiments. "Classrooms that are active, interesting, learner centered, focused on real life, are social and provide time to learn, allow frequent and facilitative feedback, and support both learning to be good learners as well as learning content have consistently been shown to be more effective with all learners," (Sherman & Kurshan, 2005).

Inquiry learning broadly includes science process skills and higher-order thinking skills, as well as abilities in questioning, predicting, explaining, and communicating findings (NRC 2000). Inquiry-based instruction allows students to engage in open-ended, student-centered, hands-on activities (Colburn, 2003). National Research Council (2000) defines scientific inquiry as "the activities through which students develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world." Educators think that they can either stress inquiry learning, using lots of hands-on experiences, or stress content knowledge, decreasing hands-on learning and proportionately increasing direct instruction (Robertson, 2007).

Student perceptions and attitudes towards science have been shown to improve if laboratory instruction is taught with a connection to the real world and students are provided an opportunity to participate in the experimental design (Mathews et al., 2010).

Conceptual Framework of the Study

Hofstein and Naaman (2007) reviewed and reported several studies conducted in various countries about laboratory applications. In their evaluation, they stated that laboratory applications aimed to enhance students' science process and problem-solving skills and their interest in and attitudes toward scientific approaches in accordance with the objectives of basic science education.

Garnett and Hackling (1995) argued that laboratories will contribute to improve students' conceptual understanding, application skills and techniques, and ability to analyze inter-variable relationships and biological analyses-syntheses. The authors highlighted the need to use student-active laboratory approaches so as to enhance students' research skills including problem analysis, research plans, research management, data recording, and interpretation of the findings. Besides offering scientific knowledge, laboratory classes also contribute to improve student skills including, scientific thinking, observation, creative thinking, interpretation of events, data collection and analysis, and problem solving (Ausubel, 1968).

It is undeniable that scientific skill, or more specifically science process skills such as observing, hypothesizing, conducting experiments and so on are among the ingredients to produce scientific society (Chiappetta & Koballa, 2006). Scientists do not use a specific, step-by-step method in their research but through several ways to approach a problem (Martin et al., 2009). The compilation of all these skills is what we call "science process skills" which are always associated with scientific inquiry (Chiappetta & Koballa, 2006). Different researchers provide different sets of skills that are to be included in science process skills. Friedl and Koontz (2005) suggested six process skills – observing, inferring, communicating, classifying, measuring and experimenting. However, the more common definition of science process skills contains two levels of skills – the basic skills and the integrated skills (Abruscato, 2004; Chiappetta & Koballa, 2006; Curriculum Development Centre, 2002; Martin et al., 2009).

This study is guided by the assumptions underlying the conceptual framework as shown in Figure 2.1.

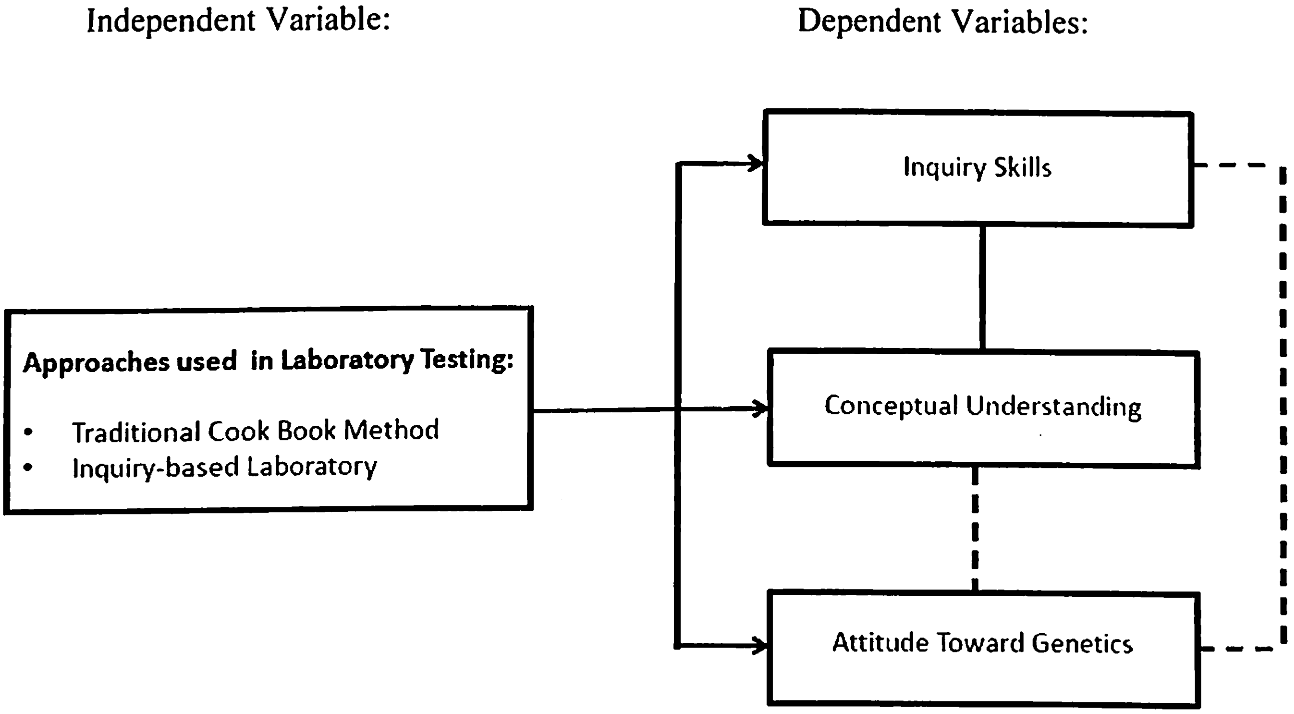

Figure 2.1 Conceptual Framework of the Study

The designed laboratory activities in Genetics incorporate the constructivist features such as learning by doing, use of relevant concepts that provide student background knowledge for them to actively construct meaning by themselves and give the opportunity to relate concepts and let students work independent research. Inquiry skills instruction is carried out to enhance integrated science process skills.

Based on the aforementioned features of the lab manual, it aims to improve the conceptual understanding, science inquiry skills, and positive scientific attitudes toward

Genetics. The antecedent variables such as pre-conceptual understanding, pre-attitudes, and pre-science skills could possibly influence the effect of Genetics lab manual for its implementation. Thus, an effective laboratory environment requires the following conditions: teachers should be prepared and must have planned for classes and have previous experience for the experiment to be carried out in the class; students should have conceptual pre-knowledge about the experiment; students should be provided an environment to use and reinforce such knowledge; basic and higher-level science process skills should be used; links should be established between the subjects taught in classroom and laboratory and their daily lives; and the laboratory environment should introduce innovations. Furthermore, laboratory safety should be effectively maintained and safety awareness should be raised among students.

Statement of the Hypotheses

Hofstein and Lunetta (2003) suggested that students work like technicians in "cookbook" laboratory activities which focus on improving low-level skills and are still commonly used in laboratories. Students are provided with very few opportunities to have experimental discussions, to construct and test hypotheses or to design an experiment that is, to conduct an authentic experiment (Lunetta & Tamir, 1979). Researchers reported that most laboratories at universities still employ the traditional "cookbook" approach (Tümay, 2001).

This study hypothesized that:

1. There is a significant difference in the inquiry skills among students who used inquiry-based laboratory activities (IBLA) and those who use traditional cookbook method (TCBM).

2. Inquiry-based laboratory activities in Genetics significantly increase the science inquiry skills of students who used IBLA over those who use TBCM.

3. There is a significant difference in the conceptual understanding of Genetics among students who used IBLA and those who use TCBM.

4. Inquiry-based laboratory activities in Genetics significantly increase the conceptual understanding of students who used IBLA over who use TBCM.

5. There is a significant difference in attitude toward science among students in the traditional laboratory and inquiry-based laboratory.

6. Inquiry-based laboratory activities in Genetics significantly change the attitude toward Genetics of students who used IBLA and those who use TBCM.

7. There is a correlation among the conceptual understanding of the students, science inquiry skills and attitude in the traditional laboratory and inquiry-based laboratory.

The null hypotheses of the study were:

1. There is no significant difference in the inquiry skills among students who used inquiry-based laboratory activities (IBLA) and those who use traditional cookbook method (TCBM).

2. Inquiry-based laboratory activities in Genetics do not significantly increase the science inquiry skills of students who used IBLA over those who use TBCM.

3. There is no significant difference in the conceptual understanding of Genetics among students who used IBLA and those who use TCBM.

4. Inquiry-based laboratory activities in Genetics do not significantly increase the conceptual understanding of students who used IBLA over who use TBCM.

5. There is no significant difference in attitude toward science among students in the traditional laboratory and inquiry-based laboratory.

6. Inquiry-based laboratory activities in Genetics significantly do not change the attitude toward Genetics of students who used IBLA and those who use TBCM.

7. There is no correlation among the conceptual understanding of the students, science inquiry skills and attitude in the traditional laboratory and inquiry-based laboratory.

Definition of Terms

The following terms are conceptually defined and operationally used in this study:

1. Attitude – It represents a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable (Ajzen, 2001).

In this study, this refers to students' responses in the science attitude questionnaire obtained in the pre- and post-survey which is composed of positive attitudes and negative attitudes and responses in the interview conducted after the intervention specifically in the experimental group.

2. Conceptual Understanding – It means that students understand which ideas are keys (by being helped to draw inferences about those ideas) and that they grasp the heuristic value of those ideas. Thus, they are able to use them strategically to solve problems – especially non-routine problems – and avoid common misunderstandings as well as inflexible knowledge and skill (Wiggins, 2014).

In this study, this refers to students mean scores obtained in the pretest and posttest administered in the control and experimental groups in Genetics laboratory of the Second

Semester of the Academic Year 2014-2015. Both descriptive and experimental statistics were employed to describe students' conceptual understanding.

3. Cookbook-type Laboratory Activities – Sundberg and Moncada (1994) describe several alternatives to traditional, didactic, "cookbook" type laboratories where students are told what to do and learn.

In this study, this refers to the laboratory instruction in the control group that uses the traditional lab instruction such as reading the procedures, doing the lab activities as instructed, and answering the guide questions.

4. Genetics - the scientific discipline dealing with the study of inheritance and variation of biological traits (King, Stansfield, & Mulligan, 2006).

In this study, this refers to one of the major Biology subjects BIO 207C: Genetics in third year BS Biology with majors or tracks in Microbiology and Biology Education program offered during the second semester at the University.

5. Inquiry-based Laboratory Activities – According to the National Research Council (1996) refers to the activities of students and how they develop understanding of scientific ideas and how scientists study the natural world.

In this study, this refers to the laboratory instruction in the experimental group that uses the integrated science process skills such as formulating hypothesis, identifying variables, defining variables operationally, describing relationship of variables, designing investigations, organizing data in tables and graphs, and analyzing investigations and their data in completing the activity in each lesson.

6. Laboratory Manual – It contains all the information needed for the laboratory course. Included is an overview of how the lab course is structured, lab scripts for all the introductory sessions and most of the experiments to be done Handy guides on keeping a good laboratory notebook and how to write a lab report are also included (Imperial London College, 2014).

In this study, this refers to the researcher-made laboratory activities in Genetics. It is characterized as student-centered, provides opportunities for the students to be an active and creative investigator, develops critical thinking by doing independent research, and develops lab skills and scientific attitudes as measured using the conceptual understanding, science inquiry skills and attitudes towards research instruments.

7. Skills – Different researchers provide different sets of skills that are to be included in science process skills. Friedl & Koontz (2005) suggested six process skills – observing, inferring, communicating, classifying, measuring and experimenting. However, the more common definition of science process skills contains two levels of skills – the basic skills and the integrated skills (Abruscato, 2004; Chiappetta & Koballa, 2006; Curriculum Development Centre, 2002; Martin et al., 2009).

In this study, this refers to the Genetic inquiry skills which are formulating hypothesis, identifying variables, defining variable operationally, describing relationship of variables, designing investigations, organizing data in tables and graphs, and analyzing investigations as described in science inquiry skills which were employed before and after the intervention.

CHAPTER 3

METHODOLOGY

This chapter describes the research design, sample, instruments, data collection, and data analysis procedures used in the study.

Research Design

The study employed both quantitative and qualitative research design methodologies. For quantitative part, this study utilized three intact classes of block sections based on students chosen track or major. The group design was quasi-experimental design as shown in Figure 3.1.

Experimental Group	$O_1\ O_2\ O_3$	X	$O_4\ O_5\ O_6$
Control Group	$O_1\ O_2\ O_3$		$O_4\ O_5\ O_6$

Figure 3.1 Pretest-Posttest Non-equivalent Control Group Design

where

O_1 = Pretest on Conceptual Understanding;

O_4 = Posttest on Conceptual Understanding;

O_2= Pretest on Science Inquiry Skills;

O_5= Posttest on Science Inquiry Skills;

$O_{3=}$ Pretest on Genetics Attitude;

O_6 = Posttest on Genetics Attitude

The three intact classes were randomly assigned to either control or experimental groups. The control group consisted of one section of BS Biology (Premed and Biotechnology Track) students while the experimental groups consisted of two separate sections of BS Biology (Microbiology Track) and B in Secondary Education (major in Biology) students. From the three intact classes, students from the control group were match paired with the students in the two experimental groups.

Students from the control and experimental groups with more or less comparable scores in the conceptual understanding test along with their inquiry skills test and attitude questionnaires were match paired based on the result of the pretest scores. There were about forty-five students who match paired from their pretest scores in the pre-conceptual understanding test, pre-inquiry skills test and pre-attitude questionnaire. These students were used as the respondents of the study.

For the qualitative part, focus group interview in the experimental group was done to obtain in-depth analysis of their perceptions on the strategy and implementation of the manual used. This was further validated through triangulating students' laboratory reports, inquiry skills, conceptual understanding results, attitude questionnaire responses and observation checklists with in-depth probing interview.

The summary of the research procedure is shown in Table 3.1.

Table 3.1 Summary of the Research Procedure

	Research Question	Instrument Used	Data Gathered	Data Analysis Used
1.	Is there a significant difference in the inquiry skills among and between students exposed to inquiry-based laboratory activities and those who are not?	Genetic Inquiry Skills Questionnaire consisted of 40 items and a reliability value of Cronbach alpha = 0.8382	Pretest scores of the control and experimental groups Date: November 20-21, 2014 Posttest scores of the control and experimental groups Date: March 12-13, 2015	Mean, standard deviation, Paired sample t test for pre-posttest within groups; Independent sample t-test between groups for pretest and posttest of two groups
2.	Is there a significant difference on conceptual understanding among and between students exposed to inquiry-based laboratory activities and those who are not?	Conceptual Understanding Questionnaire consisted of 40 items and a reliability value of Cronbach alpha= 0.875	Pretest scores of the control and experimental groups Date: November 20-21, 2014 Posttest scores of the control and experimental groups Date: March 12-13, 2015	Mean, standard deviation, Paired sample t test for pre-posttest; Independent sample t-test between groups for pretest and posttest of two groups
3.	Can inquiry-based laboratory activities in Genetics change the attitudes of the students towards Science or Genetics?	Attitude Questionnaire Consisted of 20 items and a reliability value of Cronbach alpha =0.9652	Pretest scores of the control and experimental groups Date: November 20-21, 2014 Posttest scores of the control and experimental groups Date: March 12-13, 2015	Mean, standard deviation, Paired sample t test for pre-posttest; Independent sample t-test between groups for pretest and posttest of two groups
4.	Is there a correlation among students' inquiry skills, conceptual understanding, and attitude towards Science or Genetics?	Genetic Inquiry Skill Questionnaire, Conceptual Understanding Questionnaire, and Attitude Questionnaire	Posttest scores of the control and experimental groups Date: March 12-13, 2015	Pearson r correlation coefficient
5.	What is the impact of inquiry-based laboratory activities in Genetics to students who use it?	Interview Questionnaire	Student's transcripts from the interview of the control and experimental groups Date: March 5-6, 2015	Qualitative data analysis

Sample/Respondents

The Biology major students enrolled in Genetics class in a state university in the Visayas region for the 2nd Semester Academic Year 2014-2015 served as subjects of this study. The letter requesting to conduct the request permission addressed to the Vice President for Academic Affairs of the University is attached as Appendix A.

The control group consisted of 45 students from BS Biology (Premed and Biotech Track) with 12 males and 33 females. The experimental group consisted of forty-five students from BS Biology (Microbiology) and B in Secondary Education (major in Biology) with 11 males and 32 females. The sample size of the 2 groups was determined based on the result of the pretests on conceptual understanding, inquiry skills, and attitude questionnaires through match pairing of the individual students of the two groups with more or less equal scores. The assigning of the 2 classes to either control or experimental group was done through fish bowl method. The equivalence of two groups in terms of pretests mean scores on conceptual understanding, inquiry skills and attitude toward Genetics was tested using the paired sample t-test for equality of means.

The Genetics Laboratory Course Outline, Sample Laboratory Lesson Plan and the Laboratory Schedule of Intervention are attached as Appendix B.

Table 3.2 summarizes the results of the paired sample t-test and shows no significant difference among the scores of the students. The paired samples t-test on Pretest Scores of Inquiry Skills, Conceptual Understanding, and Attitude are attached as Appendix C.

Table 3.2. Paired samples t-test results for the conceptual understanding, inquiry skills and attitude toward Genetics

Test	Group	Mean	N	SD	t	df	Sig. (2-tailed)
Pre-Conceptual Understanding	Control	11.5778	45	3.04876	1.216	44	0.231
	Experimental	10.7778	45	3.12533			
Pre-Inquiry Skills	Control	12.2000	45	4.04295	-0.245	44	0.807
	Experimental	12.4222	45	4.81234			
Pre-attitude	Control	2.3956	45	0.17672	1.00	44	0.921
	Experimental	2.3922	45	0.14808			

The Instruments

The major instruments used to assess the students' inquiry skills, conceptual understanding and attitude toward Genetics are Inquiry-based Laboratory Manual, Genetics' Inquiry Skills Test, Conceptual Understanding Test and Attitude Questionnaire. The validators used the scoring rubrics in validating the learning materials used, the observers used the observation checklists to assess laboratory activities, and the instructor used the scoring rubrics to evaluate students output and performance. The next sections provided the description for each instrument used.

1. Inquiry-based Laboratory Manual. It is composed of 10 inquiry-oriented activities developed by the researcher (Appendix D). It utilized student-centered approach that allows students to create and perform an independent research. With the approach, it is expected that they would be able to develop their skills on critical thinking and laboratory, and gain positive

attitudes towards the subject matter. Since the instructional material is the intervention, it contains the essential features of an inquiry-based material.

Table 3.3 shows the comparison of the laboratory activities content of the traditional and inquiry-based activities. Both traditional and inquiry-based manuals provided introduction of the concepts. In addition, the inquiry-based manual introduces the problem in each activity. The identified problem in Introduction is supported in the procedure part wherein students design their experiment to confirm a given genetic mechanism or phenomenon. Thus, the manual is a confirmatory type of inquiry-based approach because the students confirm a principle through activities in which the results are known (Bell, Smetana & Binns, 2005; Herron, 1971).

Table 3.3 Comparison of Laboratory Activities Content

Part	Traditional Manual	Inquiry-based Manual
Introduction	Concepts/ Introduction	Concepts Problem Introduced
Objectives	Present	Present
Materials	Present	Present
Procedure	Present based on the manual provided (Group activity)	Designing investigation and presentations (Group activity)
Results	Data to be completed in tables (Group Activity)	Data analysis, formulating hypothesis, identifying variables and relationships; graphical data presentation (Group Activity) Individual Activity: Conceptual Understanding (Student's Learning Progression Profile); Elaboration (Concept Mapping)
Discussions	Present: Guide questions	Present: Guide questions
Conclusions	Present	Present

The result section of the manual is divided into two parts. The first part involves group activity dealing with inquiry skills whilst the second part involves individual activity dealing with student's conceptual understanding through concept mapping. The controlled group followed the traditional manual used by the school. The students simply follow the procedure on the things to do to complete the task, complete the data needed to arrive at a conclusion. In the result part, it provides a space to complete the data and answer the guide questions. In general, the inquiry-based manual provides with a research question, formulates protocol, and identify what data to collect and analyze from an authentic inquiry where students choose the research question, variables, procedures, and must explain their results in light of other studies and theories.

Three experts who are teaching biology in a state university evaluated and validated the instructional material for its content and accuracy using Validation of the Written Content Questionnaire Form, researcher-made improvised scoring Rubric for Instructional Material and Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials adapted and modified from Council of State Science Supervisors (2001). Sample laboratory activities from the traditional manual and inquiry-based laboratory manual are attached as Appendix D.

A researcher-made Validation of Written Content Questionnaire (Appendix E) was used to evaluate the researcher's formulated manual with seven criteria or indicators used. A four-point scale ranged from "Excellent= 4 points" through "Poor=1 point" was used in the evaluation. Three education experts reviewed and critiqued the instrument. Their comments and suggestions were used in the revisions of the instrument. Appendix E also presents the sample validation of written content questionnaire on inquiry-based manual.

A researcher-made improvised scoring rubric (Appendix F) was used to evaluate for the developed instructional material in the laboratory. It consists of seven criteria with four-point rating scale ranged from "Excellent= 4 points" through "Needs Improvement =1 point." Three education experts reviewed and critiqued the instrument. Their comments and suggestions were used in the revisions of the instrument. A sample of completed Scoring Rubric is also attached as Appendix F.

An adapted and modified scoring rubric (Appendix G) for Evaluating Essential Features of Classroom Inquiry in Instructional Materials was also used to evaluate the inquiry-based instructional material. It contains thirteen criteria with four-point rating scale ranged from "Excellent= 4 points" through "Needs Improvement =1 point." A sample of completed Scoring Rubric is also attached as Appendix G.

The students' laboratory report at the end of every laboratory experiment/activity was individually assessed using a researcher-made scoring Rubric for Laboratory Report (Appendix H). It is composed of four major parts such as the clearly identified hypothesis, written procedure, and obtained materials. For full credit, the report contains the hypothesis, procedure (with materials list), observations/data made during experiment, and conclusion. A sample of completed scoring rubric is also attached as Appendix H.

In assessing student's conceptual understanding based on what they have written on their connecting ideas, a researcher-made improvised Rubric for Conceptual Understanding (Appendix I) with three criteria or indicators was used. A four-point scale ranged from "Excellent= 4 points" through "Poor=1 point" was used in the evaluation. Three education experts reviewed and critiqued the instrument. Their comments and suggestions were used in the revisions of the instrument. A sample of completed questionnaire for control and experimental group are also attached as Appendix I.

Lastly, a Rubric for Concept Mapping (Appendix J) from Tantiado (2014) was used to evaluate students' concept map in every after each laboratory activity. It consists of three criteria with four-point rating scale ranged from "Excellent= 4 points" through "Poor=1 point." A sample of completed questionnaire for control and experimental group are also attached as Appendix J.

2. Genetics' Inquiry Skills Test. This is a researcher-made questionnaire test that measures students' pre- and post- implementation of genetic inquiry skills in the laboratory course (Appendix K). The test was administered to both control and experimental groups. It is a 40-item multiple-choice type of test with four plausible choices and one correct answer. The questionnaire is composed of the following integrated science process skills: formulating hypothesis, identifying of variables, defining variable operationally, describing relationship of variables, designing investigations, organizing data in tables and graphs, interpreting data, and analyzing investigations and their data.

Three experts who are teaching Biology in a state university validated the test for its content and accuracy using the same Validation of the Written Content Questionnaire Form (Appendix E). Appendix E presents the sample validation of written content questionnaire on Genetics' Inquiry Skills Test. The result of the evaluation as well as the comments and notes made by the evaluators was considered in the revision of the test questions. Items that were considered unsuitable were revised to preserve their distribution in the table of specifications of the course syllabus. After the face and content validation, a trial run was conducted, which involved 120 fourth year BS Biology students who have already taken the course to determine the reliability (Appendix L) value of the test. Table 3.4 shows the table of specifications for inquiry skills.

Table 3.4 Table of Specifications for Inquiry Skills

Integrated Science Process Skill	Item Number	f	%
1. Formulating Hypothesis	16,17,21,22,24,25,27,30,31,38	10	25.00
2. Identifying of variables	40	1	2.50
3. Describing relationship of variables	23,28, 33,36	4	10.00
4. Designing investigations	7,15,26,29,32,34,35,37	8	20.00
5. Interpreting data	1,2,3,6,18,19,20	7	17.50
6. Organizing data in tables and graphs	12,13,14	3	7.50
7. Analyzing investigations and their data	4,5,8,9,10,11	6	15.00
Total		40	100

3. Conceptual Understanding Test. This is a researcher-made test that measured students' pre- and post- intervention achievement in the course. The test was administered to both control and experimental groups (Appendix M). It is a multiple-choice type of test with five plausible choices and one correct answer. Three experts teaching Biology in a state university validated the test for its content and accuracy using the same Validation of the Written Content Questionnaire Form (Appendix E). Appendix E presents the sample validation of written content questionnaire on Conceptual Understanding Test. The result of the evaluation as well as the comments and notes made by the evaluators was considered in the revision of the test questions. Items that were considered unsuitable were revised to preserve their distribution in the table of specifications. After the face and content validation, a trial run was conducted, which involved 120 fourth year BS Biology students who have already taken the course to determine the reliability (Appendix N) value of the test. Table 3.5 shows the Table of Specifications for the Conceptual Understanding Test.

Table 3.5 Conceptual Understanding Table of Specifications

Topic	Item Number			f	%
	Knowledge/ Comprehension	Application/ Analysis	Synthesis/ Evaluation		
1. Variations	19			1	2.5
2. Genetic concepts	28,31,34	15,18	29, 33	7	17.5
3. Cytology	5,32	27	26	4	10.0
4. Chromosomes	7	19,30	6,9	5	12.5
5. Cell Cycle, Mitosis, and Meiosis	8,11	1,4	2,3	6	15.0
6. Chromosomal Aberrations	25	10, 22	23,24	5	12.5
7. Mendelian Genetics	12,14	17,21,39	13,16	7	17.5
8. Multiple Alleles	36	35,38,40	37	5	12.5
Total	13	15	12	40	100

4. Genetics Attitude Questionnaire. This is a 20-item researcher-modified questionnaire (Appendix O) with four options adopted and modified from Test of Science Related-Attitude by Fraser (1978). The questionnaire consisted of two parts, 10 positive and 10 negative attitudes towards Genetics and scored in a Likert scale from 1 to 4. The rating ranges from one, with a qualitative definition of "Strongly Disagree" to four "Strongly Agree." The modified questionnaire was used to identify the students' pre- and post-attitudes toward inquiry-based instruction in the Genetics laboratory. The modified instrument was reviewed and critiqued by three science instructors in a state university using the same Validation of the Written Content Questionnaire Form (Appendix E). Appendix E presents the sample validation of written content questionnaire on Genetics Attitude Questionnaire. The instrument was revised according to their comments and suggestions. The instrument was pilot tested to 120 fourth year BS Biology students to determine the language suitability of the items, and ease in following directions by

the students and to determine the Cronbach alpha test of reliability value (Appendix P). Table 3.6 shows the Table of Specifications for the Genetics Attitude Questionnaire.

Table 3.6 Genetics Attitude Questionnaire Table of Specifications

Statement Description	Item Number	f	%
1. Positive Statements	1,2,5,6,9,10,13,14,17,18	10	50
2. Negative Statements	3,4,7,8,11,12,15,16,19,20	10	50
Total		20	100

A researcher-made Teacher Observation Checklist Questionnaire was used to evaluate the teacher's behavior in handling the class as to either control or experimental for the given laboratory period (Appendix Q). A two-point scale (i.e., yes or no) was used in the evaluation. An observer was requested to conduct the evaluation using the questionnaire. Three education experts reviewed and critiqued the instrument. Their comments and suggestions were used in the revisions of the instrument. A sample of completed questionnaire for control and experimental group are also attached as Appendix Q.

A researcher-made Students Observation Checklist Questionnaire was used to evaluate students' learning activities and behavior in the classroom during the laboratory period (Appendix R). A two-point scale (i.e., yes or no) was used in the evaluation. An observer was requested to conduct the evaluation using the questionnaire. Three education experts reviewed and critiqued the instrument. Their comments and suggestions were used in the revision of the instrument. A sample of completed questionnaire for control and experimental group is also attached as Appendix R.

A researcher-made personal Genetics Interview Questionnaire for students' reaction in the control and experimental groups (Appendix S). The questions include the instructional strategies that they like and dislike most and attitude towards each activity during the lab session. Three experts in a state university reviewed and critiqued the face value and content of the questionnaire. A sample of completed questionnaire for control and experimental group are also attached as Appendix S.

Data Collection Procedure

The questionnaires or checklists used to assess students' pre-inquiry skills were rubric for laboratory report and Genetics inquiry skills questionnaire; for pre-conceptual understanding were rubric for conceptual understanding, rubric for concept mapping, and conceptual understanding test; and for pre-attitude in Genetics were interview questionnaire, student' observation checklist, teacher observation checklist questionnaire, and Science attitude questionnaire on the first week class of the second Semester Academic Year 2014-2015. During the intervention, the teacher's and student's inquiry observation checklists were used to identify and guide the teacher's strategy and students' activities that conform to the implementation of the strategy for the control and experimental groups. An alternate schedule for teacher and student observation for the control and experimental groups was made for the entire intervention by the two members of the validators of the questionnaires.

Implementation of Strategies. Similar method of instruction was used in the lecture part of the control and the experimental groups, since they were handled by the same instructor. The lecture utilized various teaching aids to enhance students' learning. However in the laboratory period, the conventional laboratory method, i.e. the "cook book" method was used in the control group. The inquiry-based laboratory method was employed in the experimental group. The conduct of classes for the experimental and control groups is summarized in Table 3.7.

Table 3.7. Summary of Laboratory Intervention

Phase	Time (Minutes)	Control Group	Experimental Group
Prelab Instruction	30	Attendance, Materials checking, preparation; Overview of the topic	Attendance, Materials checking, preparation; Overview of the topic
Activity Proper	60	Traditional Activities (Following procedure in manual by group)	Inquiry-based activities (experimentation by group) Group Activity: Discussion about experiment results (identifying variables, hypotheses, data analyses and guide questions)
Postlab	45	Gathering results within the group; Answering lab guide questions	• Providing Students with Learning Progression (LP) Profile Form • Answering the LP Profile Form The instructor collects the form before the allotted time in this period ends.
Phase	Time (Minutes)	Control Group	Experimental Group
Assessment	30	Class discussion and manual checking	Individual Activity: • Providing Students with Concept Mapping Form • Answering the Concept Mapping form by listing the learned concepts in the lab, then each student constructs his/her own concept map based on the activity. The instructor collects the form before the allotted time in this period ends.
Assignment	15	Request of materials for the next lab	Request of materials for the next lab
Total Time	180 minutes		

The control and experimental groups have similar phases of laboratory activity. In the experimental group pre-laboratory instruction, the students were taught how to make concept maps as part of the intervention. This was further followed up in the assessment phase of the laboratory period. In the assessment phase, the experimental group did concept mapping as part of the student's individual learning activity. The students were provided with individual learning profile sheet to assess their conceptual understanding on the laboratory activity for the day.

The student's individual activity sheet is composed of student's connecting ideas and concept mapping form. The students' connecting ideas identifies students' learning or conceptual understanding on a specific topic. It reflects the Genetic concepts in a specified Genetics laboratory activity, e.g. topic on Genetic Variations. In one of the columns of the profile sheet, connecting ideas, the students filled out the column based on their knowledge and conceptual understanding of the said topic. The students interconnect the concept learned based on the approaches or branches of Genetics which include the Classical or Mendelian Genetics, Cytogenetics and Molecular Genetics. Students make scientific connections of the genetic mechanisms underlying in each laboratory topic. To further enhance student's conceptual understanding, the students listed some concepts learned from the activity performed within the laboratory period. The students connect the concepts based on what they have learned from the activity. To assess students' conceptual understanding of the topic, a scoring rubric was used to evaluate their conceptual understanding and concept map. Students' outputs serve as the sources of acquisition/performance of inquiry skills as cited in the sample laboratory output of the experiment done in Activities 1, 4, and 5. Appendix T presents sample of students' completed inquiry-based laboratory activities 1 to 10. Students were provided with the "backbone" of what to be included in the write-ups. They were free to choose or further modify their setups of their experiments to gather data in order to explain or confirm an existing genetic mechanism or phenomenon.

One week before the semester ended, the students' post-inquiry skills, post-conceptual understanding and post-attitude in Genetics were assessed. This was followed with focus group interview for an in-depth analysis of the intervention used in the laboratory. Appendix U presents the photodocumentation on the conduct of the study.

Data Analysis Procedure

Data were analyzed by using both descriptive and inferential statistical tests. The descriptive statistics used were mean and standard deviation. The inferential statistics include: (1) t-test for independent samples; (2) t-test for dependent samples; and (3) Pearson r correlation coefficient to measure the degree of significance of the difference of the variables between groups and the relationships among variables, respectively. Inferential statistical tools were also used to determine significant difference of the conceptual understanding, inquiry skills, and attitude toward Genetics mean scores between the stage of implementation (i.e., pre-post implementation) and between groups, respectively.

All statistical tests were computed through the aid of Statistical Package for Social Sciences (SPSS) v11.5. The statistical level of significance was set at 0.05 alpha level.

The qualitative data were analyzed by using the coded responses of the focus group interviews of the control and experimental groups. Coded responses were analyzed to identify themes and patterns. A focus group interview was made for six respondents in the experimental group to probe the themes used for qualitative data. Interpretation and analysis were done by comparing themes and identifying interrelationships. Validity was enhanced through triangulation of the interview responses with students' narratives or reflections, actual observations, and laboratory outputs. Furthermore, pseudonyms were used for students. The summary of the data analysis procedure is shown in Table 3.1.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the results of quantitative and qualitative data analyses of the study, and findings which answer the research questions.

Students' Inquiry Skills

Table 4.1 summarizes pretest mean scores on inquiry skills of the control and experimental groups before the intervention.

Table 4.1. Independent samples t-test of the pretest mean scores on inquiry skills between the control and experimental groups.

Test	Group	Mean	N	SD	t	df	Sig. (2-tailed)
Pretest	Experimental	12.4222	45	4.81234	-0.245	44	0.807
	Control	12.2000	45	4.04295			

Results showed that there is no significant difference on the pretest mean scores of the control and experimental groups prior to the intervention. This means that the two groups are more or less equal. This is expected as the students do not have the necessary knowledge and skills that the test is measuring during pre-test. However, both groups' inquiry skills significantly improved after the intervention. The experimental group is two percent higher than the control group suggesting that the inquiry learning strategy helped students to construct and conceptualize the knowledge on Genetics laboratory from basic principles to applications. The results are further supported by the research on inquiry-based ecology laboratory courses by

Beck and Blumer (2012), which showed that students exhibited a significant increase in overall confidence and scientific reasoning skills. Interestingly, their study showed that students in the lowest quartile at the beginning of the semester for each construct exhibited a significantly greater gain in comparison to students in the highest quartile for the same construct. The pretest-posttest scores of control and experimental group are detailed in Appendix V.

Table 4.2 shows the t-test results on the difference in pretest-posttest mean scores on inquiry skills within the control and experimental groups.

Table 4.2. t-test results on the difference in pretest-posttest mean scores on inquiry skills within the control and experimental groups.

Test	**Group**	**Mean**	**N**	**SD**	**t**	**df**	**Sig. (1-tailed)**
Control	Pretest score	12.20	45	4.04	-11.61	44	0.000*
	Posttest score	22.76	45	4.60			
Experimental	Pretest score	12.42	45	4.81	-12.62	44	0.000*
	Posttest score	24.67	45	4.21			

The result shows a significant difference (p = 0.000) between the pretest and posttest mean scores of the control and experimental groups after the intervention. This is expected since students do not have the necessary knowledge that is being measured during the pretest. Table 4.3 shows the t-test results on the difference in posttest mean scores on inquiry skills between the control and experimental groups. As indicated in Table 4-3, the experimental group (M=24.67) showed a significantly higher (p = 0.043) posttest mean score than the control group (M=22.76) after the intervention. Appendix W presents the results of independent samples t-test on inquiry skills.

Table 4.3. t-test results on the difference in posttest mean scores on inquiry skills between the control and experimental groups.

Test	Group	N	Mean	SD	t	df	Sig. (1-tailed)
Posttest	Experimental	45	24.67	4.22	-2.054	88	.043*
	Control	45	22.76	4.60			

Rissing and Cogan (2009) reported similar results where they found significant gains in student performance and attitudes in an inquiry enzyme laboratory. Brickman, Gormally, Armstrong & Hallar, (2009) also reported a significant improvement in science literacy skills and process skills of students working in an inquiry based laboratory for an entire semester. The improvement was found to be consistent with the manner in which an average citizen would use them.

The higher inquiry skills mean score of the experimental group after the intervention indicates that the experimental instructional technique has a positive influence on the students' direct understanding of the items in the Genetics Inquiry Skills test. The students' were able to develop a focus on the tasks required in the activity after the instruction. Though laboratory investigations allow learners to reach their own conclusions (Tifi et al., 2006), inquiry-based laboratory approach helps students gain process skills that are necessary to perform learning activities. As these activities were done in groups, they give the students the opportunity to allow their gained process skills develop their social skills of collaboration, sharing, debating and extending ideas in the group. The benefits of collaboration were also reflected by the student responses on the survey given at the end of the semester. Most students reported that they felt that their group members were well prepared for laboratory and that they were able to collaborate well. Most students also agreed that when they did not understand a laboratory procedure their group members explained it. However, most of them did not agree with the statement that they did not need to prepare individually because their group members already did the laboratory procedures. The data from this research suggest that in these laboratories, the students collaborate their efforts to compensate for individual weaknesses. Working in groups provides the opportunity for cooperative learning. Travis and Thomas (2004) demonstrated that group interaction increased the level of student involvement in the laboratory. They showed that students working in groups were able to recall and apply the information learned in laboratory better than students that did not participate in a group.

Collaborative group interactions encourage a commitment to working as a group, valuing each other's participation, being mindful and caring of others, and showing appreciation for team members (Preskill & Torres, 1999). Students work together in groups had the opportunity to take different roles, sharing responsibility, active listening, developing consensus, and reflecting on one's own and the group's work (Johnson & Johnson, 1991).Unfortunately, this opportunity is absent in the control group, and may have limited the development of their process skills. As indicated by Waters (2012), the traditional cookbook type laboratory could make students easily lose enthusiasm or quickly learn what steps of the procedure can be ignored or fail when they thoroughly read the protocol for complete understanding. Consequently, their critical thinking skills are not developed or they had little opportunities to apply problem-solving strategies. They also feel disconnected from the exercise or lack "ownership" of the collected data. Collaboration among peers is discouraged and they do not plan the experiments and results are not properly interpreted (Waters, 2012). Recent studies have indicated that students believe that "cookbook" laboratory formats are trivial and are executed for unknown reasons (Luckie, Maleszewski, Loznak & Krha, 2004). Students want to be challenged in the laboratory and therefore "cookbook" laboratory exercises fail both the student and the intent of a scientific education.

On the other hand, the inquiry-based approach in the experimental group helped the students demonstrate superior practical performance skills. This is attributed to the fact that the experimental group did more of the equipment setting than their control group counterparts. According to Dillon (2008), good quality practical work helps develop pupils' understanding of scientific processes and concepts. There is strong evidence that: *'When well-planned and effectively implemented, science education laboratory and simulation experiences situate students' learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other science education experiences'* (Lunetta, Hofstein & Clough, 2007, p. 405). Moreover, White and Gunstone's (1992) study indicates that *'students must manipulate ideas as well as materials in the school laboratory'* (Lunetta, Hofstein & Clough, 2007). Furthermore Dillon (2008) added that there is a growing body of research that shows the effectiveness of 'hands-on' and 'brains-on' activities in school science inside and outside the laboratory. It reveals that practical work can increase students' sense of ownership of their learning and can increase their motivation.

Results from the study of Ketpichainarong, Panijpan, and Ruenwongsa (2009), inquiry-based laboratory showed enhancement of students' knowledge as reflected in tests for understanding. They also indicate students' improvement in scientific skills, including hypothesizing, data handling and analysis. The inquiry-based approach boosted the development of critical thinking and problems solving skills in students. Furthermore, inquiry-based exercise promotes scientific curiosity (Haury, 1993). Curiosity is the foundation of the scientific method

(Waters, 2012). As part of the experimental intervention in the study, students were allowed to make their own inquiry questions, observations, and formulate their own hypotheses. Students, who were given these opportunities, regardless of whether or not the proper results were obtained, are more likely to become "self-educators" and maintain curiosity and enthusiasm for scientific achievement (Waters, 2012).

In addition, students in the experimental group were given the opportunity to reflect more on their work, drew conclusion, and even came up with some predictions. According to Colley et al (2012), reflection is an important driver for the development of critical thinking. As emphasized, they considered "reflective writing focuses learners' attention on their thinking by asking them to delve into their thoughts about specific topics as well as their individual learning methods." Allowing the students to reflect on their work, it is possible that the inquiry approach has enhanced their understanding and develops their critical thinking skills. As indicated by Brown et al. (2006) and Howard and Miskowski (2005), inquiry-approach seemed to enhance students understanding on the topic and to develop their critical thinking and problem solving skills. The current study was able to receive the following unedited responses of the students under the experimental group:

> *It **enhanced my ability in thinking skills** in comprehensive and understanding and also in problem solving. - Ginina*
>
> *Yes. Because lab activities **widens our knowledge and practice our learned lessons** in the lecture area and being able to do it personally or apply our skills and knowledge on hands-on activities.- Vhanilyn*
>
> *It enables me to **learn and appreciate science** experiments. - Joy*
>
> *I **gain deeper insights and understanding** about Genetics. - Pauline*

> *It **boosts my critical thinking skill** especially in answering the questions and problems. - Paulo*

> *I learned to **think more critically** because the cases in genetics are not easily deciphered that it must be analyzed very well in order to understand the questions. I also learned to think beyond what is normal because in Genetics there are a lot of things you thought not possible but it does exist and that every gene, cell, chromosome present in your body matters. And lastly, it taught me to follow instructions, steps because if I did otherwise I would never come up with an accurate result. - Vincent*

> *Yes. I learned to **think in a step by step process** to ensure that I am doing right. By using the right methods, I can make sure that I can work safely in the laboratory and that I am not missing something that can affect negatively on my work. -Claire*

> *Makes me **appreciate science more** and understand why I am and who I am. - Job*

As indicated in their responses, students learn to think critically, develop an understanding of the concepts, gain deeper insights of the topic, and apply their learning in the lecture. Thus, these observations supports the results of the studies conducted by Pandey et al. (2011) and Akpulluku and Gunay (2011) that inquiry training model have statistically significant effect over conventional teaching method on academic achievement of students.

Students' Conceptual Understanding

Table 4.4 shows the pretest means scores on conceptual understanding of the control and experimental groups before the intervention.

Table 4.4. Independent samples t-test of the pretest mean scores on conceptual understanding between the control and experimental groups.

Test	**Group**	**Mean**	**N**	**SD**	**t**	**df**	**Sig. (2-tailed)**
Pretest	Experimental	11.5778	45	3.04876	1.216	44	0.231
	Control	10.7778	45	3.12533			

Results showed that there is no significant difference on the pretest mean scores on conceptual understanding of the control and experimental groups prior to the intervention. This means that the two groups are comparable. This is expected as the students do not have the necessary knowledge that the test is measuring during pre-test. However, both groups' inquiry skills significantly improved after the intervention.

Table 4.5 shows the mean scores of the pretest-posttest of the students in the control and experimental groups on conceptual understanding. As indicated in Table 4.5, post test scores are higher than the pretest scores for both groups. This difference is significant at 0.05 level.

Table 4.5. t-test results on the difference in pretest-posttest mean scores on conceptual understanding within the control and experimental groups.

Test	Group	Mean	N	SD	t	df	Sig. (1-tailed)
Control	Pretest score	11.58	45	3.04	-9.38	44	0.000*
	Posttest score	18.80	45	5.57			
Experimental	Pretest score	10.78	45	3.12	-11.63	44	0.000*
	Posttest score	22.73	45	5,85			

In addition, the mean score of the experimental group after the intervention is higher than the mean score of the control group. As Table 4.6 indicates, the difference in the posttest mean scores on conceptual understanding between the control and experimental groups is highly significant (p = 0.002). Appendix X presents the results of independent samples t-test on conceptual understanding.

Table 4.6. t-test results on the difference in posttest mean scores on conceptual understanding between the control and experimental groups

Test	**Group**	**N**	**Mean**	**SD**	**t**	**df**	**Sig. (1-tailed)**
Posttest	Control	45	18.80	5.57	-3.265	88	0.002*
	Experimental	45	22.73	5.85			

The results indicate that inquiry approach has effectively improved the conceptual understanding of the students. With better understanding of the concepts, students would be able to perform better in their courses. Several studies (Basaga, Geban, & Tekkaya, 1994; Hall & McCurdy, 1990; Luckie, et al., 2004; Sundberg & Moncada, 1994) have demonstrated better performance of students under inquiry laboratory classrooms. The impact of inquiry-based instruction encourages students to adopt different approaches in the service of developing a better understanding of the subject, helps students familiarize themselves with on-going experiments and areas of inquiry, and enables them to obtain better scores on examinations (Wang et al,, 2013). The learning activities involved in scientific exploration may benefit students by helping them develop critical thinking skills and individual knowledge structures

(Schneider et al., 2002). Thus, inquiry-based instruction may help students understand how to identify problems, seek answers independently, and develop and verify solutions through collaborations. Students had become active learners where they answer research questions via data analysis (Bell et al., 2005). This is also consistent with the study by Sesen and Tarhan (2013) revealing that instruction based on inquiry-based laboratory activities caused a significantly better acquisition of scientific concepts related to electrochemistry and laboratory.

The higher mean score of students under the experimental group could also probably be due to their newfound or gained ability to apply their learned concept to real-life situation. As indicated in their responses, students in the inquiry laboratories repeatedly mentioned their newfound abilities as learners and their ability to apply the material to the real-world. They also commented on how the collaborative aspects of struggling together were both rewarding and frustrating. Some of the unedited responses of students on the topics that improve their conceptual understanding at the end of the intervention are as follows.

> *It is clear to me now how the possibility to predict possible outcome of the offsprings. I also know that **blood types of a child is based** on what blood types the parents have.-Charina*

> ***Karyotyping**, it helps us to predict what possible diseases and syndromes that can emerge in just a mutation of a chromosome. - Faith*

> *The concept of **Mendelian Genetics and inheritance**. I can now cross and predict the genotypes of the offspring given the genotype of the parents.- Heaven*

> ***Multiple Alleles** . Because it teaches you how to trace something on your family especially genes that you could acquire. And also that of your blood type. - Leigh*

> *How the **gene or traits passed**. - Joy*

The use of a variety of inquiry-based activities in Genetics laboratory was observed to be more helpful in understanding Genetics concept. Students reported that allowing them to discover things on their own and using real-life materials in the activities have helped them understand genetic processes. They were also able to conceptualize genetics concepts through the use of such activities as concept mapping and pedigree analysis. Some of the students' unedited responses on this are shown below:

> *In Chromosome morphology. I never seen a real chromosome before. In this activity, I had the chance to* ***observe the different stages of mitosis*** *in onion root tips. I am quite* ***amazed and truly understand*** *how things are going inside the cell of an onion during mitosis.- Neil*
>
> *Students can* ***picture out*** *the real scenario.- Bea*
>
> *It is when you did on your own to experience the feeling of discovering something that you do not know somehow. With* ***learning by doing.*** *I can apply my skills in performing such activities. - Xianne*
>
> *The* ***concept mapping helps me in understanding*** *Genetics more because it breaks down complex ideas into simple ones which enables us to understand the topic more. - Shane*
>
> *For me,* ***pedigree*** *is what I like the most, for it can be* ***illustrated*** *well and just by having a legend you can apply it on your own family tree and you will be amazed. - Catherine*
>
> *Activities which allow us to* ***apply it in real life*** *such as* ***pedigree analysis.*** *-Griggy*

In addition, the various activities in the inquiry laboratory helped students gained comfort and confidence in learning Genetics concepts. These are indicated in the following unedited responses:

> *This course only* ***gives us enough knowledge that fits to the capacity of our intellect and skills.*** *By this we are not pressured and can handle well the activities in set schedule. - James*

It is because the ***activities are not difficult to work and I easily understand*** *the concepts and principles underlying on it. - Zoie*

I was able to ***gain knowledge and worthwhile experiences*** *out of the activities. - Zendi*

The ***required work is on the right track of our course*** *and it is really needed for our subject. - Zarah*

It is quite ***manageable and tackles topics needed to learn in Genetics.*** *With probably other matters, the research proposal for Drosophila and Onion are satisfying. - Ella*

I can ***handle the activities very well*** *and also we* ***can work without any stress or pressures.*** *And this level of required work, students could really learn on their best. - Cherry*

It is ***challenging and exciting.*** *It can solve mysteries that I can't understand about genetics.- Ann*

Yes because they have ***stated clearly the procedures*** *as well as our professor explains or discusses it further. - Yehlene*

It ***challenged me*** *on how to solve things when book cannot provide ample information. It made* ***me use my time properly*** *and made me realize how every steps of the activities are important. - Faye*

It helps me to be ***more critical thinker and understanding things.*** *- Cherry*

It ***enhances our cognitive skills and those knowledge-based concepts*** *can be put into action by doing our lab activities. - Ann*

Yes. Because ***enhanced thinking and accuracy*** *which are displayed in genetic activities are all needed in order to master the level of required work for this course. - Marinelle*

Yes, because it is very ***satisfactory.*** *Not to busy, not to happy go lucky. - Allysa*

Yes. This course is a bit ***challenging*** *but I like the thought that it gives as more than enough knowledge we should have been acquiring. - Joyce*

> *Some of the laboratory works are in **need of higher thinking.** - Alec*
>
> *Yes. It **challenges one's mind** to understand stuff in science because laboratory activities are not that easy. - Gen*

In a dissertation study on the effects of the inquiry-based learning (IBL) on college students' concept of proof, Dhaler (2008) found that IBL had a positive effect on student's conceptualization of mathematical proof, as well as on self-confidence in their abilities, their appreciation of the relevance of proof, and their ability to be independent thinkers. The study supports the claim that inquiry laboratory students demonstrated small but significant gains in science literacy and science process skills compared to students enrolled in the traditional cookbook laboratory. Brickman, Gormally, Armstrong, and Hallar (2009) documented significant improvement in students' confidence to use science literacy skills after participation in the inquiry labs. The inquiry lab students were required to write numerous reports describing their findings that they had higher gains in confidence in writing or critiquing a lab report.

Students' Attitudes toward Genetics

Most students enjoyed working in groups and agreed that their group members explained laboratory procedures if they did not understand them. Other studies have also found that students enjoy working in groups in the laboratory (Pratt, 2003, Travis & Lord, 2004). One student eloquently wrote that he/she enjoyed this aspect of the course because "it (working in groups) helped when there were many minds over just one." Thus, this shows that inquiry-based laboratory activities motivate students to work joyfully and ignite their interests.

Table 4.7 shows the pretest means scores on attitude of the control and experimental groups before the intervention.

Table 4.7. Independent samples t-test of the pretest mean scores on attitude toward Genetics between the control and experimental groups.

Test	**Group**	**Mean**	**N**	**SD**	**t**	**df**	**Sig. (2-tailed)**
Pretest	Experimental	2.3956	45	0.17672	1.00	44	0.921
	Control	2.3922	45	0.14808			

Results showed that there is no significant difference on the pretest mean scores on attitude of the control and experimental groups prior to the intervention. This means that the two groups are comparable. This is expected as the students do not have the necessary knowledge that the test is measuring during pre-test.

Table 4.8 shows t-test results on the difference in pretest-posttest mean scores on attitudes toward Science within the control and experimental groups.

Table 4.8. t-test results on the difference in pretest-posttest mean scores on attitudes toward Genetics within the control and experimental groups.

Test	**Group**	**Mean**	**N**	**SD**	**t**	**df**	**Sig. (1-tailed)**
Control	Pretest score	2.395	45	0.184	1.099	44	0.278
	Posttest score	2.433	45	0.176			
Experimental	Pretest score	2.392	45	0.160	1.660	44	0.104
	Posttest score	2.430	45	0.148			

However, the result shows no significant difference on attitude mean scores toward Science between the pre- and post-test of the control and experimental groups (p=0.278) and (p=0.104), respectively. Despite the motivation there is no significant change in the attitude of the students within or without inquiry approach. Student responses were almost equal towards feeling they should be rewarded for completing science work. A study on the use of inquiry-based instruction, the majority of student responses indicated they were motivated by the variety of activities and a few specifically mentioned a topic they studied. Many students indicated mini-lectures and note taking were least motivating items but they learned a great deal while the need to do well for college is most crucial.

Furthermore, Table 4.9 shows no significant difference of the t-test (p=0.927) on the difference in post-attitude mean scores toward Science between the control and experimental groups. Appendix Y presents the results of independent samples t-test on attitude toward Genetics.

Table 4.9. t-test results on the difference in posttest mean scores on attitude toward Genetics between the control and experimental groups.

Test	**Group**	**N**	**Mean**	**SD**	**t**	**df**	**Sig. (1-tailed)**
Posttest	Control	45	2.433	0.184	0.091	88	0.927
	Experimental	45	2.430	0.160			

Attitude towards science did not significantly vary in the two groups probably because they were all science majors and they already have a good attitude towards it. Hence, inquiry-based learning (IBL) did not cause a significant change in the students' science attitudes. If this is the case then this finding both contradicts with Gibson and Chase (2002), who reported that

IBL could change students' attitude towards science and a higher interest in science careers. On the other hand, it is also possible that teaching time was not enough in changing students' attitudes towards science. This finding is also parallel to the results of the studies of Neiderhauser (1994) and Ünal and Ergin (2006) that showed no significant change in students' attitude towards science over a given period of time. However, the higher value of standard deviation (Table 4-7) observed in the control group indicated persistence of variegated thinking due to teacher-centered instruction (Musasia, Abacha, & Biyoyo, 2012). For every concern, the experimental group had more respondents scoring “High” compared to the control group. This implies that the experimental group had a more positive view concerning a particular attitude though they were not significantly different from those in the control group. Furthermore, a positive change in attitude towards science is drawn from the unedited positive responses of the experimental group during the class interview.

> *I became more enjoyable in doing science experiments, wanted to know everything by doing experiment by myself, and by lab activities, it really answers the question that was formed in my mind by the help of doing of activities. - Conni*

> *It makes me experience how interesting, challenging, and my mind opening towards science. - Kaneesha*

> *Yes and these are like you should research of find out more about something that you have a doubt to confirm its authenticity. You should be more open-minded to others opinions in order to generate better ideas. – Mary Ann*

> *Yes, because when you are under the lab activities, you may able to manipulate things and while you are doing that you are learning already. So when you are applying what you have learned, it also enhances your skills. - John*

> *I know how to become careful in handling things, keeping my work neat and clean, observant, and following procedures.-Mikee*

It made more ***become interested*** *in science world. - Johhny*

Yes. Being more studious and critical thinker. - Cristel

Now, I'm ***more responsible*** *in doing my assignments and lab works. - Pam*

Yes, because I'm a lazy person and I don't want to wait because of it, we all know that science experiments requires patience so I ***became patient*** *enough now and I enjoy the activities and experiments we right now that I thought before it will be boring and I got a wrong thinking about it. - Jacin*

By ***becoming organized and systematized*** *in my works, assignments and exam in science related courses.- Ave*

Yes. I become ***more observant, patient, curious and optimistic.*** *– Gracie*

Yes. I am ***more attentive and industrious*** *in lab works because they aren't that boring. –Fely*

Correlation Among Students' Inquiry Skills, Conceptual Understanding, and Attitude toward Genetics

Table 4.10 shows the correlation among students' inquiry skills, conceptual understanding, and attitude towards Science.

Table 4.10. Pearson r Correlation Among students' Inquiry Skills, Conceptual Understanding, and Attitude toward Genetics.

Group	Area	Correlation		Area
Control	Inquiry Skills	Pearson Correlation	0.451	Conceptual Understanding
		Sig. (1-tailed)	0.002*	
		N	45	
	Attitude	Pearson Correlation	-0.225	Skills
		Sig. (2-tailed)	0.137	
		N	45	
	Conceptual Understanding	Pearson Correlation	-0.029	Attitude
		Sig. (2-tailed)	0.852	
		N	45	
Experimental	Conceptual Understanding	Pearson Correlation	-0.109	Attitude
		Sig. (2-tailed)	0.477	
		N	45	
	Inquiry Skills	Pearson Correlation	0.492	Conceptual Understanding
		Sig. (1-tailed)	0.001*	
		N	45	
	Attitude	Pearson Correlation	-0.019	Inquiry Skills
		Sig. (2-tailed)	0.902	
		N	45	

As indicated in Table 4-10, there is not much difference between the control and experimental groups in terms of the relationship between inquiry skills and conceptual understanding. The results showed that inquiry skills of the control and experimental groups significantly correlate with the conceptual understanding, p = 0.002 and p = 0.001, respectively. This is consistent with the result of Uwaifo (2012) which found a statistically significant relationship between theory and practical scores on all science subjects. Lunetta et al (2007) have suggested that engaging in scientific practical work provides simulation experiences which situate students'' learning in states of inquiry that require heightened mental and physical engagement. This engagement leads to better understanding and improved performance. Feyzioglu (2009) has reported a positively significant and linear relationship between science process skills taught to students in laboratory applications and their achievement in a current electricity course. This is observed in both the control and experimental groups.

Below are some unedited responses of the students in the experimental group that relate their skills with their understanding:

> *The* ***skills gave me knowledge*** *to the concept that unclear to my mind. –Daniel*

> *Yes, in doing activities we are* ***applying the concept and learnings that we learned****. By this activities we are experiencing hands-on activities and we can really appreciate the essence of experiment. - Palomaria*

> *The activities stimulate my mind to uncover challenging concepts in the subject matter. - Elihon*

> *I enjoy doing experiments/ activities. For me science is not only focus on the concepts but also on the hands-on activities that* ***promote better understanding of concepts.*** *- Carmi*

> ***Hands-on activities have a long term effect on my memory.*** *- Addy*

> *I clearly* ***understand the concept through learning by doing.*** *It's not easy to forget those learning experiences I once participated in the process of learning. - Joanne*

> ***Lab activities is the time we can apply the concepts or fact that we*** *learned during our lecture. - Vittos*

The result of the correlation implies however that regardless of the approach, whether inquiry or cookbook type, inquiry skills and conceptual understanding work together to allow better performance of the students. However, it should be noted that inquiry-based laboratory activities could lead to a higher student achievement.

The implementation of the inquiry-based laboratory has also improved students' attitude towards Genetics. Rissing and Cogan (2009) observed the same findings among students who participated in an inquiry enzyme laboratory. But the improved attitudes did not show a significantly favorable relationship with conceptual understanding and inquiry skills. Below are sample responses of the students in the experimental group, which show some unfavorable comments regarding the approach:

> *No because I prefer important concepts that are unclear to me and it gave me **lot of works to do.**-Issa*
>
> *We **are not comfortable** with the fact that we don't have an ample amount of time to be with our group to talk about our work because of the other activities we have, but I think it is just a matter of time management.- Faye*
>
> *Not so. Because sometimes I find the **activity too hard** that's why I'm not motivated and I find it **boring.**-Cammile*
>
> *Sometimes no because the **work requires a lot of time and effort to finish**. It contains a lot of question that is not easily understand and left unanswered.- Tommy*
>
> *Sometimes I found it **hard and stressful**. - Hannah*
>
> *No because sometimes they are **tedious and tiring.**-Leny*
>
> *Not really. **I procrastinate** and it is my fault. - Josy*
>
> *Sometimes I am not. There are laboratory activities **find taxing and very time consuming.** - Robby*

As indicated in these responses, there is a need to revise some of the laboratory activities and consider the number of activities and the amount of time that is needed to do them. This is critical because student's perception of the purposes of a laboratory activity affects their decision-making process. According to Campell et al. (2000), students' perceptions of the purpose of a laboratory task and understandings of laboratory procedures greatly influence their decisions on what to report and on how much detail to include in a report. If needed, the teachers should provide students with an environment in which they will feel interested in facts, events and subjects; briefly, an environment in which they may think and discuss like a scientist.

In addition, negative impressions of the inquiry laboratories focused on frustrations, failures, and workload. Students participating in inquiry laboratories often cited experiencing frustration with the process of struggling to "Figure out" what they were doing without directions when they were accustomed to being provided with exact details. They also commented that the inquiry laboratory was "too much work," especially when compared to other laboratory classes they had taken. These issues combined together to create a feeling of inadequacy and insecurity that every student in the interview group mentioned.

Students in the traditional laboratories also expressed feelings of frustrations, but their complaints revealed a lack of enthusiasm (in themselves and a lack of real learning) rather than frustration due to struggling to learn. This was also revealed in their positive comments that focused solely on the brevity, ease, and "cool" scientific materials they found in laboratories, as well as how laboratories helped reinforce the content knowledge they could use for the lecture class rather than what they had learned for their own lives. For example, student attitude toward the "I- labs" curriculum developed by Sundberg and Moncada (1994) was similar to what we observed, reporting pride in their ability, mixed with some frustration and poor self-evaluation. They interpreted students' very strong initial negative reaction to the course as stemming from the increased demand for them to learn in a new and more rigorous way that was ameliorated over time, very similar to the results of the study.

The non-significant negative correlation between conceptual understanding and attitude of students in the experimental groups could be attributed to other factors that may have contributed to the high level of resistance toinquiry in this study. Statistically, negative correlations reveal a very weak correlation between variables being tested. The most commonly mentioned impediments to inquiry implementation are the challenges faced by students (Anderson, 2002; Sundberg, 1992; Sundberg et al., 1992). Students do not like the extra work required to think through problems on their own (Loughran & Derry, 1997) and reveal a preference for memorization and regurgitation of knowledge rather than deep understanding (Hughes & Wood, 2003; Watters & Watters, 2007).

The existence of relationship between students' performances and attitudes has also been confirmed by the research findings of Eslava (2001), Tomelden (1995), Urmatan (1992) and Sherman and Wither (2003). Moreover, DePaolo and McLaren (2006) found out that attitudes do have an impact on performance, although that effect is small compared to the effects of ability. Thus, it can be concluded that improved attitudes are related to increased performance. In order to enhance the science performance of students, teachers should first help students overcome unfavourable attitudes toward the subject. The study presented shows that inquiry-based strategy which advocates social constructivism, the zone of proximal development, where the students can work independently based on his potential or in collaboration with peers through problem solving in particular, when applied in the classroom had a good effect on students' marks in comparison with the traditional teaching strategy. It was found out that inquiry-based teaching strategy in the laboratories can improve students' performance. Therefore, more importance should be given to developing new methods to help students construct their own learning strategies and become more responsible on their own learning than before, both inside and outside the classroom. The results of Pearson r correlation on inquiry skills, conceptual understanding and attitude of control and experimental group are detailed on Appendix Z.

Impact of Inquiry-based Laboratory Activities in Genetics

The impacts of inquiry-based laboratory activities in Genetics based on the modified class group interview of the experimental groups are retaining or remembering information, demonstrating the process, triggering critical thinking skills, solving problem in a convenient way, concluding and predicting possible outcomes, finding the probability, showing relationships and connections and promoting better learning as shown in Table 4.11. These were also revealed based on the unedited responses of the students' focus group interview.

Table 4.11. Themes of Students' Responses Based on Qualitative Data Analysis

Theme	f N=45	Percentage (%)
Retaining information	9	10.59
Demonstrating the process	15	17.65
Triggering critical thinking skills	11	12.94
Solving problem in a more convenient way	12	14.12
Concluding and predicting possible outcome.	13	15.29
Finding the probability	11	12.94
Showing relationship and connections	7	8.24
Promoting better learning	7	8.24

> *Yes, I find the lab activities helpful in retain information for the lab. During the final exam especially the concept maps helps me understand some of the questions that are related to the lab activities that we have. Although not all information go into my brain, and yet*

very useful gid ang tana ngas gintudlo mo sir. Maski somehow I feel sleepy(na natuyo ako) but I was able to retrieve information from the lab acts(pero my nahawiran gid ako sa mga activities sir). – Daniel

While doing the activity, you are demonstrating the process if how things happen. In slide preaparations on Activity 4 on alteration of mitotic activity, as you demonstrated sir, they were so amazing to look at. At first, I can't imagine if I can prepare on my own. But there is a need for patience in preparing the slides…gosh (Pero gale Sir kinahanglan gale ang patience mo sa pag prepare sang slides….gosh dapat haba ng patience….) There are times that they were so frustrating but if you will see under the microscope worth effort done, sir (Daw kaulogot man kung ka isa pero pag nakita mo na sa microscope na ikaw gid nag prepare worth it gid ang effort ko sir). Thank you sir sa help. - Pammy

The activities in DNA investigation and multiple alleles on blood types. It triggers my critical thinking skills at solving problems. At first if you were about to read the problem, they are quite confusing. But with the activity that you have given us, sir, I was surprised to know that there are some techniques on how to deal with the problem. You do it in a step by step manner. You don't just simply procrastinate and just wait for others to do it. That won't help solve the problem. You gave au sir problems that are truly challenging that helps my brain to squeeze out informations needed to be analyzed properly. Problems provided in the lab activity truly need some extra effort before you can solve them. It's not just read and write but you need to think critically (indi man gale basta basta sir mag patuga tuga nga abe mo hapos lang gid…dapa manumdum ka gid) - Cresta

In the activities by finding the probabilities of a certain phenomena to happen. Also in finding the blood type of certain people. We could solve the problem in a more convenient way. Prior to the lab activity on "Bloody Mystery" we have that before in Gen. Bio II. However, insufficient information were provided. But after learning this activity …hmmmm….I think that was Activity 9, sir..hehehe…I forgot already (nalipat na ako)…your lab activities really help (nakabulig gid sir nag lab mo)I was able to perform the necessary steps and skills needed to solve problems like that. At first, it was difficult to try even I read in books, But with your help sir, I was able to make it. And also, sir…hmmm… The information about blood types and using fork line *method and Punnett square we can conclude or predict possible outcome. -Nene*

Yes because according to Confucius, what I hear, I forget, that I see, I remembered, what I do, I understand and what I teach I mastered. For example, finding the probability of a certain trait. Genetics is one of the subjects that uses probability aside from the Statistics that we had before. It seems that the subject is the extension of Statistics. Even though it's hard, I don't have the choice (Maski budlay gina kaya ma gihapon kay wala naman ko choice. But to pass the subject sir. Haaaaay.) Anyway, the use of Mendelian Genetics and probability helped solve problems of better chances of the possibilities. Sooner I may apply what I have learned in the lab that I did everytime we have lab with you sir. -Hensa

Concept mapping, it shows us the relationship and connections of ideas. It is very helpful in retaining ideas and concepts because it is easy to understand. Helping me in retaining information is somewhat difficult but because we have been doing concept maps it's easier for me to understand and to master in a certain topic. Yes, because we are able to work out of the problems on our own and the activities stimulates not only cognitive memory but also physical memory thus promoting better learning - Chucky

Yes specifically the tossing of coins for polygenic traits with that I was able to remember that it follows a continuous variation and exhibits bell-curved when graphed and I was also inculcating in my mind that if ever I've seen a child which is different from its parents color does not mean he/she is not a real/true child instead it's a product of polygenic inheritance. - Leslie

Yes because by working hands on, I can remember the lecture and use them in answering the lab questions. I have a photographic memory. Because during the lecture, you can't listen very well since its very noisy. But during the lab activity, information can be gathered and remembered easily since we are hands-on on how to do such analysis. Hands –on help us in retaining information through manipulating things and underscore some impossible events that cannot be seen by the naked eye. We were able to show the mechanisms by applying them in the actual lab activity and based on some research articles. We were *able to connect and prove some theories in the actual setting. - Kim and Jon*

Yes. The pedigree analysis helped me to retain the concepts of sex linked and sex-influenced genes. Through concept mapping I was able to connect concepts on the different types X-linked genes. The part on the concept map of the activity gives me the opportunity to express what I have learned in each of the activity. Even though I got bored in our lecture class, but I was able to practice it on the lab section of our class. The part of the lab sir that we try to enumerate and make concept maps were so useful, that I was able to use during the final exams especially if the exam is a multiple choice type. -Angelyn

Laboratory activities such as genetic mutation allow me to remember things faster and better. Based the activity 1 that we had, though time consuming to wait for the possibilities and if ever mutation will occur, and yet patience and cooperation from the group helps me learn. I was able to see and apply the theories introduced in the lecture. I and my group mates were given the chance to make or design our own experimental set up and the amount of mutagen to be given to our Drosophila. Even though it was so tiring in catching those fruit flies , and yet I still enjoy together with my group mates. I'm fond in segregating the males form the females fruit flies. (Maski makapoy sang dakop sang mga fruit fly, nag enkoy man kami gihapon sang akon groupmates sir. Nasadyahan ko isip sang mga lalaki kag babae na fruit fly). I really understand what has been discussed in the lab as our lecture prior to the actual experiementation - Marry

CHAPTER 5

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of the findings, the conclusions, and recommendations drawn from the findings.

Summary

The study aims to develop and determine the effects of the inquiry-based laboratory activities on the conceptual understanding, skills, and attitude toward Genetics of undergraduate Biology students. The quasi-experimental method of investigation using pretest-posttest non-equivalent control group design was used in the study. The students in the control group utilized the laboratory manual in Genetics of the professors in the university while the students in the experimental group utilized the researcher-made laboratory manual in Genetics that include inquiry-based laboratory activities integrating inquiry skills used in laboratory classes with students' conceptual profile and concept mapping techniques to enhance conceptual understanding.

The study included three intact classes of BS Biology (Premed and Biotech Tracks) as the control group and BS Biology (Microbiology Track) and B Secondary Education (major in Biology) as the experimental groups enrolled in Genetics class in a state university in the Visayas region for the 2nd semester Academic Year 2014-2015.

The study used both quantitative and qualitative methods of data analyses. Data collection included pretest-posttest questionnaire in Genetics to assess students' conceptual understanding; a Genetic inquiry skills questionnaire to evaluate students' science skills; attitude questionnaire towards in science using inquiry-based laboratory; students' and teacher observation checklist questionnaire for laboratory instruction; and feedback questionnaire for interview were used.

Findings

The study revealed the following results vis-à-vis the objectives and hypotheses:

1. There a significant difference in the inquiry skills among and between students who were exposed to inquiry-based laboratory activities than those we were not. The result showed a significant difference between the pretest and posttest mean scores of the control and experimental groups after the intervention. As expected, posttest mean scores were significantly higher than the pretest mean scores of the two groups. After the intervention, the experimental group showed a significantly higher posttest mean score than the control group (p=0.043< 0.05).

2. There is a significant difference on conceptual understanding among and between students who were exposed to inquiry-based laboratory activities than those who were not. The result showed a significant difference on conceptual understanding in the pretest-posttest mean scores of the control and experimental groups exposed to inquiry-based laboratory activities and those who were not (p=0.000 < 0.05). After the intervention, the experimental group showed a significantly higher posttest mean score than the control group (p=0.002< 0.05).

3. The result showed no significant difference and change on attitude mean scores toward Genetics of the control and experimental groups exposed to inquiry-based laboratory activities and those who were not (p=0.278>0.05) and (0.104>0.05), respectively. However, based on qualitative result of the study, the use of inquiry-based laboratory activities changed students to a positive attitude towards Genetics drawn from the responses of the experimental group during the class interview.

4. There is a significant correlation between students' inquiry skills and conceptual understanding of the control and experimental groups (0.002) < 0.005 and p (0.001) < 0.005, respectively. However, inquiry skills did not significantly correlate with attitude towards Science in control and experimental groups, p (0.137) > 0.05 and p (0.902) > 0.05.

5. The impact of inquiry-based laboratory activities in Genetics to students who use it are retaining or remembering information, demonstrating the process, triggering critical thinking skills, solving problem in a convenient way, concluding and predicting possible outcomes, finding the probability, showing relationships and connections, easy understanding and mastery, and hands-on activity. These were also highlighted based on the unedited responses of the students.

Conclusions

1. Inquiry-based laboratory activities in Genetics significantly improved the Genetic inquiry skills of the students in the experimental group.

2. Inquiry-based laboratory activities significantly increased the conceptual understanding of the students.

3. Inquiry-based laboratory activities in Genetics change towards positive attitude of the students towards Science based on students responses.

4. Students' Genetic inquiry skills significantly correlate with conceptual understanding in learning Genetics concepts. However, students' Genetic inquiry skills did not significantly correlate with attitude. Also, conceptual understanding did not significantly correlate with attitude.

5. Inquiry-based laboratory activities in Genetics help in retaining or remembering information, demonstrating the process, triggering critical thinking skills, solving problem in a

convenient way, concluding and predicting possible outcomes, finding the probability, showing relationships and connections and promoting better learning.

Implications

The implication on the use of inquiry-based activities in the K to 12 curriculum provides the students with the opportunity to achieve three inter-related learning objectives. These objectives are to develop general inquiry abilities, acquire specific investigation skills, and to understand science concepts and principles (Edelson, Gordin, & Pea, 1999). The opportunity to develop general inquiry abilities involves the pursuit of open-ended questions and driven by questions generated by learners (Welch et al., 1981; Blumenfeld et al., 1991; Linn, Songer & Eylon, 1996). General inquiry abilities include posing and refining research questions, planning and managing an investigation, and analyzing and communicating results. The opportunity to acquire specific investigation skills include controlled experimentation (Schauble et al., 1995), modeling (Jackson et al., 1996; Penner et al., 1997; Resnick, 1994; Wilensky, 1995), synthesis of primary sources (Linn, Bell, & Hsi, in press; Wallace et al., 1997), and exploration of quantitative data (Hancock, Kaput, & Goldsmith, 1992; Tabak et al. 1996). Each of the form of investigation has its own specific procedures and skills which engages the learners the opportunity to learn these scientific practices. The use of the developed inquiry-based laboratory activities that improved the students' Genetic inquiry skills, increased conceptual understanding and changed students to a positive attitude towards Genetics will provide the opportunity to develop an improved understanding of science concepts which is a meaningful context for learning.

Recommendations

Based on the results of the study, the following recommendations are drawn and presented:

1. For teachers, curriculum designers/ developers. Teachers should use inquiry-based strategies in combination with some traditional methods in teaching Sciences. But first, they need to re-conceptualize their role as facilitators in the development of the students' science constructions rather than the sole source of science knowledge while employing inquiry in the classrooms. Teachers should continue on working for innovative changes especially on the development of intervention materials and strategies and the integration of instructional technology in the Science classroom to help them explore and discover science concepts on their own for better retention and develop higher appreciation and positive attitudes toward Science. As indicated in some of the students' responses, there is a need to revise some of the laboratory activities and consider the number of activities and the amount of time that is needed to do them. This is critical because student's perception of the purposes of a laboratory activity affects their decision-making process.

2. For administrators. Teachers are encouraged to attend seminars and trainings on the use of inquiry-based strategy. Likewise, administrators should support and provide avenues for teacher advancement especially on the use of instructional strategies and software.

3. For researchers and education specialists. The upshots of the inquiry-based strategy can be best understood when studied quantitatively and qualitatively since academic and non-academic achievements could be assessed. Hence, the researcher highly recommends further studies to be undertaken with inquiry-based strategy and its other forms which involve intensive and extensive use of the strategy.

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APPENDICES

Appendix A
Letter of Permission

November 4, 2014

DR. LUIS A. ABIODA
Vice President for Academic Affairs
This University

Through Channels

Dear Dr. Abioda,

Greetings! I am a contractual faculty member of the Biological Science Department of this University. I would like to ask permission from your kind office to be allowed to conduct a research study entitled "Inquiry-based Laboratory Activities: Effects on Students' Conceptual Understanding, Inquiry Skills, an Attitude Toward Science" on the 3rd year BS Biology and BSEd (Biology major) students under my Genetics Laboratory class together with Ms. Nenita delos Santos, my research partner from the University of the Philippines Open University. Rest assured that informed consent will be obtained anc that all the data gathered from the students will be treated with utmost confidentiality.

Your kind and immediate approval regarding this request is greatly appreciated. Thank you very much

Very truly yours,

REY G. TANTIADO, PhD.
Researcher

Recommending Approval:

GERARD L. PENECILLA, EdD.
Department Chair, Biological Sciences

NANCY S. SURMIEDA, PhD.
Dean, College of Arts and Sciences

ALONA M. BELARGA, PhD.
Director of Instruction and Quality Assurance

Appendix B
Genetics Laboratory Course Outline, Sample Laboratory Lesson Plan and Laboratory Schedule of Intervention

WEST VISAYAS STATE UNIVERSITY
COLLEGE OF ARTS AND SCIENCES
Department of Biological Sciences
La Paz, Iloilo City

BIOLOGICAL SCIENCE
Course Outline

I. Course Number: Bio 207C

II. Course Title: Genetics

III. Course Credit: 4 Units (3 Hours Lecture, 3 Hours Laboratory per week)

IV. Course Description: This course in genetics includes the study of genetic structure and composition (Cytogenetics) and the three branches of genetics: Classical or Mendelian Genetics, Molecular Genetics and a portion of Population Genetics. Topics on genetic mutations and their role in evolution are also included

V. Course Objectives:

At the end of the course, the student should be able to:

1. Discuss basic gene structure and composition, mutations and their roles in evolution.
2. Develop skills in solving problems in Mendelian and Population Genetics.
3. Compare and contrast the different modes of heredity.
4. Describe the nature of the genetic material.
5. Discuss the implications of the knowledge of genetics to the welfare of man.

VI. Laboratory Content Outline:

1. Variations
2. Introduction to Some Genetic Concepts
3. Ultrastructure of the Cell
4. Chromosome Morphology
5. Mitosis
6. Meiosis
7. Chromosomal Abberations
8. Mendelian Genetics
9. Non-Mendelian Genetics: Multiple Alleles
10. Non-Mendelian Genetics: Polygenic Inheritance

VII. Course Requirements:

Laboratory: 40%

a. Attendance	15%
b. Lab. Outputs and other lab extensions	20%
c. Group Evaluation	15%
d. Special problem on Drosophila Mutations and *Allium* Test (Proposal: Chapters 1,2,3 for Midterm; Complete Study for Finals)	20%
e. Midterm/ Final Exams	30%
Total	100%

VIII. References

Essentials of Genetics by Klug and Cummings

Genetic Analysis and Principles by Brooker

IX. Prepared by:

REY G. TANTIADO, PhD.

Sample Laboratory Lesson Plan

I. Activity Number: 9

II. Topic: Multiple Alleles

III. Concepts

In classical Mendelian Genetics, each gene has two possible alleles. However, some genes have more than two alleles. In human blood typing (A, B, AB, and O), the gene for the blood type protein has three alleles (A, B, and O). One eye color gene in fruit flies has many alleles.

Human blood types are determined by proteins on the surface of the red blood cells. Alleles A and B, for A type and B-type glycoproteins, are co-dominant; that is, a person who inherits an "A" allele from one parent and a "B" allele from the other parent will have type AB blood. The "o" allele is recessive. The "o" allele produces no glycoproteins. Thus a person with the genotype "Ao" will make some type A glycoproteins, and have type A blood. A person with the genotype "oo" will make neither the A-type nor the B-type glycoproteins, and will have type O blood.

IV. Objectives:
- To perform Punnett Square crosses for blood type, a multiple allele trait.
- To apply this knowledge to mystery scenario.
- To explain what a multiple allele trait is.
- To identify blood type as a multiple allele trait.

V. Laboratory Teaching Strategy:

Phases and Allotted Time	**Control Group: Traditional Lab Instruction**	**Experimental Group: Inquiry-based Lab Instruction**
Pre-lab Instruction (15 minutes)	1. Giving Instruction 2. Checking students individual lab manual	3. Giving Instruction 4. Providing Students Lab sheets
Lab Activity Proper (75 minutes)	• Review on the concept of Multiple Alleles • Do Problem Solving on blood types • Follow the procedure as indicated in the manual such as survey of blood types in a given population and construct a pedigree of one's own blood type.	• Students determine the possible phenotypes and genotypes involved in blood typing. • Students solve Multiple Alleles Punnett Square for blood typing • Students were given a A Bloody Mystery, a mystery scenario in which they apply their knowledge of blood typing and Punnett Squares to solve the mystery.
Post Lab Activity (30 minutes)	• Answer the Guide Questions as indicated in the lab manual • Lecture Discussion on the result of the lab	• Providing Students with Learning Progression (LP) Profile Form • Answering the LP Profile Form • The instructor collects the form before the allotted time in this period ends.

Phases and Allotted Time	Control Group: Traditional Lab Instruction	Experimental Group: Inquiry-based Lab Instruction
Assessment (60 minutes)	• Provide students with problem set on multiple alleles • Answer Practice Exercises on Multiple alleles problem set. • The instructor collects the form before the allotted time in this period ends.	• Providing Students with Concept Mapping Form • Answering the Concept Mapping form by listing the learned concepts in the lab, then each student constructs his/her own concept map based on the activity. • The instructor collects the form before the allotted time in this period ends.

Genetics Laboratory Schedule of Intervention

Groups	**Control Groups**	**Experimental Groups**	
Month	**BS Bio (Premed and Biotech)**	**BS Bio (Micro)**	**BSEd (Biology)**
November, 2014	21- Orientation and Lecture; Pretest Lab	20 – Pretest Lab; Orientation and Lecture	20 - Orientation and Lecture; Pretest Lab
	28-Activity 1	No Class	27- Activity 1
December, 2014	5-Activity 2	4 – Activity 1	4- Activity 2
	12- Activity 3	11- Activity 2 and 3	11- Activity 3
January, 2015	9-Activity 4	8- Activity 4	8- Activity 4
	16-Activity 5	15-Activity 5	15-Activity 5
	23- Activity 6	22-Activity 6	22-Activity 6
	30- Midterm lab	29- Midterm lab	29- Midterm lab
February, 2015	6- Activity 7	5- Activity 7	5- Activity 7
	13- Activity 8	12- Activity 8	12- Activity 8
	20- Activity 9	19- Activity 9	19- Activity 9
	27- Activity 10	26- Activity 10	26- Activity 10
March, 2015	6-Seatwork; Implementation of Post-attitude Questionnaire; Class Interview	5- Seatwork; Implementation of Post-attitude Questionnaire; Class Interview	5- Seatwork; mplementation of Post-attitude Questionnaire; Class Interview
	13- Posttest Lab	12- Posttest Lab Zx	12- Posttest Lab

Appendix C
Paired Samples t-test on Pretest Scores of Inquiry Skills, Conceptual Understanding and Attitude

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre attitude Control	2.3956	45	.17672	.02634
	Pre attitude Experimental	2.3922	45	.14808	.02207
Pair 2	Preskills Control	12.2000	45	4.04295	.60269
	Preskills Experimental	12.4222	45	4.81234	.71738
Pair 3	Preconceptual Control	11.5778	45	3.04876	.45448
	Preconceptual Experimental	10.7778	45	3.12533	.46590

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Pre attitude Control - Pre attitude Experimental	.0033	.22447	.03346	-.0641	.0708	.100	44	.921
Pair 2	Preskills Control - Preskills Experimental	-.2222	6.07487	.90559	-2.0473	1.6029	-.245	44	.807
Pair 3	Preconceptual Control - Preconceptual Experimental	.8000	4.41382	.65797	-.5261	2.1261	1.216	44	.231

Appendix D
Sample Laboratory Activities – Traditional and Inquiry-based

Sample Laboratory Activity from Traditional Manual

ACTIVITY NO. 1

VARIATIONS

INTRODUCTION

OBJECTIVES:

1. To observe and comprehend the concept of variation in plants and in animals.
2. To understand that variations occur not only between different species but also within species of plants and animals.

MATERIALS:

10 branches of different plants of the same species
5 male and female specimens of *Drosophila melanogaster*
Digital camera (optional)
Photomicrograph (optional)
Survey of heights and weights of 25 male and female college students

PROCEDURE:

A. Variations in Plants

1. Collect one branch of at least ten plants of the same species.
2. Observe for the following traits: # of leaves, length of leaf stem, leaf color.
3. Draw or take pictures of your specimens and attach the pictures on the space provided.
4. Record your results in the summary table (table 1) in the activity sheet.

*NOTES FOR PROPER DISPOSAL OF WASTE

B. Variations in Animals

B.1. Between sexes of the same species in *Drosophila melanogaster*.

1. Make a stock culture of *Drosophila melanogaster* (see Appendix 1 for procedure).
2. Etherize some flies from the culture and place them on a sheet of white paper.
3. Using a compound microscope (use LPO) or hand lens, distinguish between a male and a female fruitfly (see Appendix 2 for descriptions).
4. Study at least 5 specimens for each sex. Choose 1 representative from each sex and draw and label the important parts (if a digital camera or a photomicrograph is available, pictures may be taken and copies may be attached on the space provided and labeled).
5. Complete table 2.

*NOTES FOR PROPER DISPOSAL OF WASTE (BOX)

B.2. Between sexes of the same species in humans

1. Ask and record in table 1.3, the height and weight of 25 male and female students between 16 to 18 years old.
2. Combine class data and report results of the survey in table 3.

RATING:

NAME: ____________________ COURSE, YR. & SEC. ______________

GROUP NO. ________________ DATE PERFORMED: ______________

ACTIVITY NO. 1

VARIATIONS

DATA:

Table 1. Variations in 5 samples of ________________

Sample Number	Number of leaves in one branch	Length of leaf stem	Leaf color
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Figure 1. Drawings/Pictures of Variations in ______________________

Table 2. Average Characteristics in Male and Female *Drosophila melanogaster*

Characteristics	Male	Female
a. Overall size		
b. Size of abdomen		
c. Banding on abdomen		
d. Sex combs of forelegs		
e. Shape of tip of abdomen		
f. External reproductive organ		

Figure 2. Drawings/Pictures of male & female *Drosophila melanogaster*

Table 3. Raw Data for Variations in Height and Weight of College Students at WVSU

Name of subject	Sex	Age	Height	Weight
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

QUESTIONS:

1. What is the importance of variations?

2. What are the possible causes of genetic variations? Give specific examples.

3. How would you find out if the causes of variations is genetic or environmental?

4. Is it possible for individuals within the same species to naturally have no variations between them? If such individuals exist, what term is used to describe them?

CONCLUSIONS:

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Sample Laboratory Activity from Inquiry-based Manual

ACTIVITY NO. 1

Mutations on Fruit Fly (*Drosophila melanogaster*) as Sources of Variations

CONCEPTS

Variation is a ubiquitous feature of natural populations. All organisms exhibit variation for a significant number of morphological, biochemical, and behavioral characteristics. Genetic variation is essential for the process of natural selection to produce evolutionary change. This is a teaching cliché thought, but anyway-look around the classroom and you will immediately notice a great deal of variation among members of this class. Some of this variation is morphological: hair color, height, eye color, etc. Some is behavioral: preference for certain foods, knowledge of languages, choice of clothing, etc. For centuries, biologists have sought an explanation for the existence of variation. Much of it has a basis in our genes, a fact that is of tremendous evolutionary significance. Other variation is primarily due to environmental influences on our development. For nearly every trait, however, both genes and environment interact to some extent to produce the organism's phenotype

Genetic variation is essential to biodiversity and the stability of a population. Genetic variation is ensured by the formation of gametes and their combination to form a zygote. Opportunities for genetic variation also occur during cell division when chromosomes exchange genetic material causing permanent changes in the DNA sequences of the chromosomes. Random mutations in DNA structure caused by the environment are another source of genetic variation.

Without genetic variation, some of the basic mechanisms of evolutionary change cannot operate.

There are three primary sources of genetic variation, which you will learn more about:

1. Mutations are changes in the DNA. A single mutation can have a large effect, but in many cases, evolutionary change is based on the accumulation of many mutations.

2. Gene flow is any movement of genes from one population to another and is an important source of genetic variation.

3. Sex can introduce new gene combinations into a population. This genetic shuffling (Figure 1) is another important source of genetic variation.

Mutation is a change in DNA, the hereditary material of life. An organism's DNA affects how it looks, how it behaves, and its physiology — all aspects of its life. So a change in an organism's DNA can cause changes in all aspects of its life.

Mutations are random. Mutations can be beneficial, neutral, or harmful for the organism, but mutations do not "try" to supply what the organism "needs." In this respect, mutations are random—whether a particular mutation happens or not is unrelated to how useful that mutation would be.

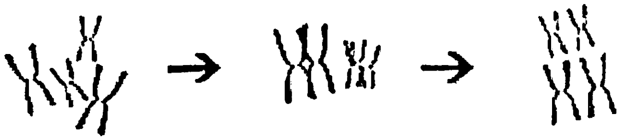


Figure 1: Genetic Recombination

PROBLEM

Design an experiment to examine the effects of exposure to chemical mutagen on the phenotypes of fruit fly.

OBJECTIVES

1. To identify the source of variations in Drosophila melanogaster.
2. To develop a hypothesis to predict the effects of chemical mutagen on the phenotypes of fruit fly.
3. To design an experiment to test this hypothesis.
4. To employ a statistical tool in the data.
5. To draw conclusions from the experiment.

MATERIALS

Fruit flies, 3 pcs. wide mouth bottle, boiled sweet potato (camote), ether, magnifying lens, dissecting microscope

PRELAB ACTIVITY

Students will be oriented on the differences between a male and a female fruit fly as tabulated in Table 1 and shown in Figure 2. They will also be introduced on how to rear and maintain their stock culture until the desired generations will be attained.

Table 1. Differences between male and female fruit fly

Male Fruit fly	Female Fruit fly
The mature male have rounded darker abdomen, and showed dark genitalia	The mature female abdomen is pale in color and relatively smooth
Male flies have a secondary sex characteristic called sex comb, which is a small tuft of about 10 black bristles at the front of the large segment (#) counting from the body which is visible even in immature males	Sex comb is absent
There are 5 segments, 2 dark stripes, more rounded heavily pigmented tip. In immature males, pigmentation may not be developed	There are 7 segments, several dark transverse stripes and is pointed at the tip.
Males are smaller	Females tend to be larger

Students will complete the activity consisting of the following parts:

- Introduction
  - Background of the Study (About the mutation, the mutagen used)
  - Objectives/ Statement of the problem:
  - Significance of the Study
  - Scope and Delimitations
- Review of Related Literature
- Methodology
- Results and Discussion
- Conclusions, Implications, and Recommendations

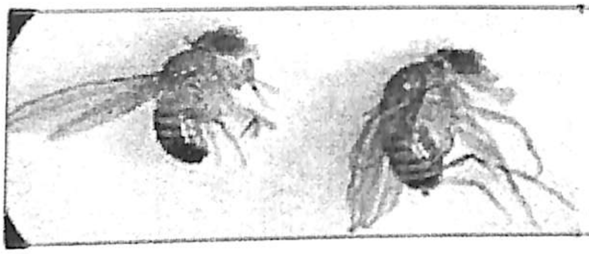


Figure 2. Male (left) and female (right) Fruit fly (Drosophila melanogaster)

PROCEDURE

Culturing the Fruitflies

1. Put the mashed banana or sweet potato in the culture bottle.
2. Carefully brush into the bottle the etherized flies. Deposit them near the mouth of the bottle to avoid their getting stuck to the food.
3. Leave the culture bottle on its side until the flies have revived form ether or chloroform and crawling about actively. Once the flies are awake, the bottles should be stored in an upright position.
4. Label the culture bottles.

Preparation of the Concentration of the Mutagen to be Used

1. Weigh 100g of the mashed sweet potato (camote) or riped banana.
2. Mix a define number of grams of the mutagen to be used. This will determine the final concentration of the mutagen to be used to feed your parent flies.

Etherizing the Flies

1. Transfer the flies to be etherized from the culture to the etherizing bottle to prevent them from getting stuck to the food.
2. Jar the base of the culture bottle on the palm of the hand so that the flies will gather at the bottom of the bottle.
3. Remove the cover of the bottle and quickly replace it with empty etherizing bottle.
4. Reverse the position of the two bottles so that the culture bottle is now the one on top.

5. Hold the bottles firmly together and shake the flies from the culture bottle to the etherizer. Tapping the sides of the culture bottle horizontally will facilitate the transfer of the flies into the etherizing bottle.

6. Remove and replug the culture bottle after the flies have transferred to the etherizing bottle. Simultaneously place the cork with the cotton moistened with ether over the etherizer. Do not saturate the cotton pad, since liquid ether or chloroform coming in contact with flies kills them.

7. Subject the flies to ether for only 10-20 seconds after they have ceased to walk. Do not over etherize the flies. Over-etherized flies with obliquely extended wings and stiffened legs seldom recover.

8. Transfer the flies on a clean sheet of white paper for examination.

Care of Cultures

1. Place the bottles in a pan with water to protect them from ants and to maintain lower temperatue.

2. Be scrupulously clean with your working area and all utensils used in the culturing to prevent the growth of laboratory contaminants.

3. The bottles must be discarded when the molds spread over the entire food surface.

4. One month old cultures must be discarded.

Collecting Virgin Females

1. Discard all adult flies 10 or more days after the start of the culture or when large number of pupa is already produced. This must be done as early as possible in the morning. Be sure no flies remain in the bottle.

2. Within 8 hours from the time the adult flies were released, etherize the newly emerged flies and separate the males from females.

3. Carefully brush the females into a fresh bottle of food, label it, and write the data. Do the same with the males in another culture bottles.

4. All flies not isolated within the maximum 8 hours must be discarded in the morning. Collect again newly emerged flies in the afternoon. Continue collecting until you have what is needed for the crosses assigned to you.

5. For greater accuracy, it is well to keep the virgin flies in the bottle for at least 4 days. The appearance of larvae is a sign that the females are not all virgins and the bottle must be discarded. Start a fresh culture by using the flies from your original culture.

Observing the Progenies (First filial and Second Filial Generations) for Mutations

1. Make a tally count for all the flies that will be obtained in the culture after releasing all the parent flies.
2. Take note of the following mutations based on the eyes, body and wings of the progenies (Figure 3).
3. Make a separate count for the wild type and mutant flies.

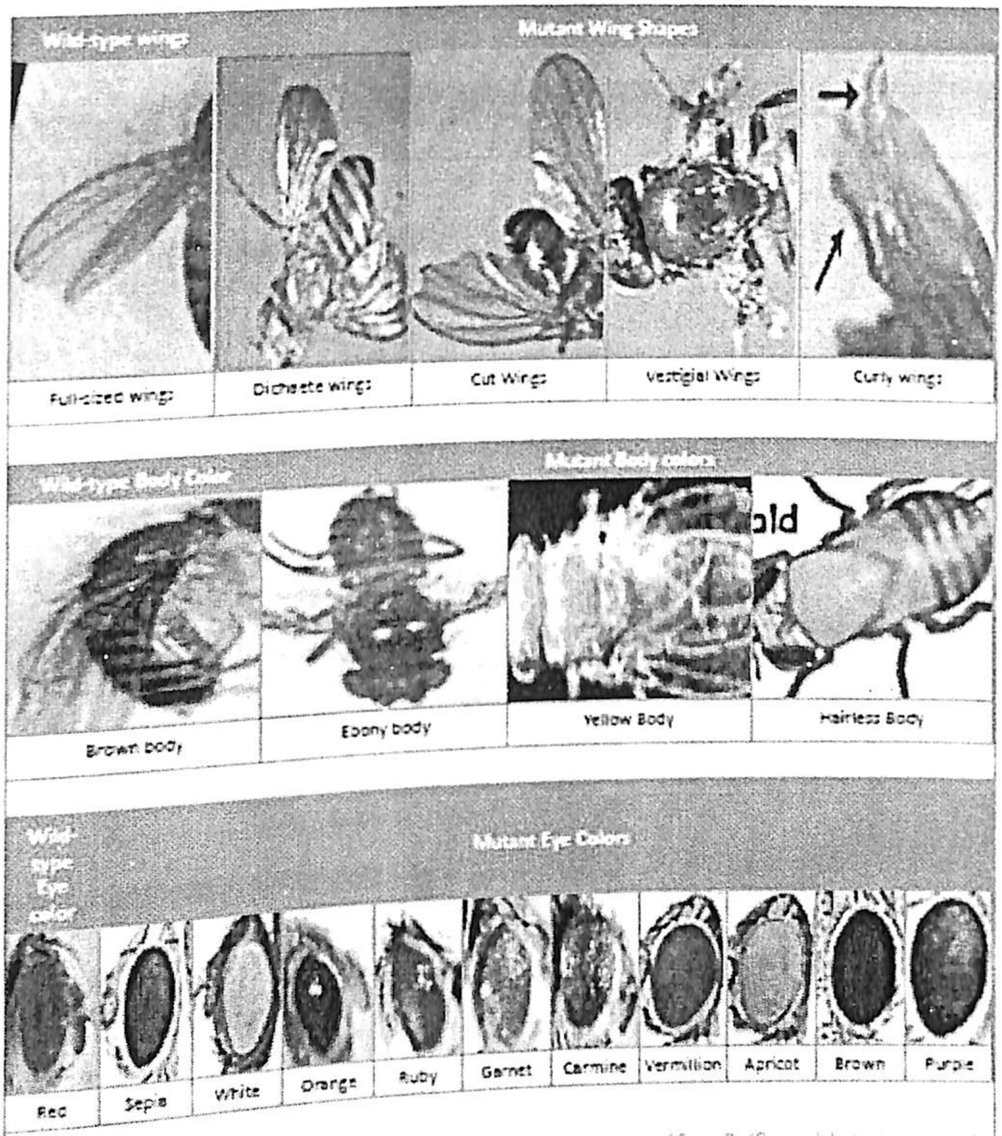


Figure 3. Wildtype and Selected Mutant Phenotypes of Fruit fly (Drosophila melanogaster)

Table 2. Frequency and Percentage for a Number of Mutant and Wild type Flies Obtained

Structure		Frequency (f)	Percentage (%)
Eye	Wild		
	Mutant		
Body	Wild		
	Mutant		
Wings	Wild		
	Mutant		

Table 3. Table of Observed Values (o)

Group	Wild-type	Mutant	Total
Eye	A	B	A+B
Body	C	D	C+D
Wings	E	F	E+F
Total	A+C+E	B+D+F	A+B+C+D+E+F=N

1. Use the total from Table 3 to calculate the expected values (e) from Table 4. Calculate the chi-square value for the data by adding together the numbers in the right column.
2. Compare this value to the critical value in Table 6.

Table 4. Table of Expected Values (e)

Group	Wild-type	Mutant
Eye	(A+B)(A+C+E)/N	(A+B)(B+D+F)/N
Body	(C+D)(A+C+E)/N	(C+D)(B+D+F)/N
Wings	(E+F)(A+C+E)/N	(E+F)(B+D+F)/N

Table 5. Calculation of Chi-square Value

Group	Observed (o)	Expected (e)	(o-e)	(o-e)2	(o-e)2/e
Wild-type eye					
Mutant eye					
Wild-type body					
Mutant body					
Wild-type wings					
Mutant wings					

Table 6. Critical Values of the Chi-Square Distribution

Probability	Degrees of Freedom					
	1	2	3	4	5	6
0.05	3.84	5.99	7.82	9.49	11.1	12.59
0.01	6.64	9.21	11.3	13.2	15.1	16.81

1. The degrees of freedom (df) equals the number of treatment groups minus one multiplied by the number of phase groups minus one. In this case, (c-1)(r-1)= (2-1)(2-1)= 1.

2. The p value is 0.05, and the critical value is 3.84. If the calculated chi-square value is greater than or equal to this critical value, then the null hypothesis is rejected. If the calculated chi-square value is less than this critical value, the null hypothesis is not rejected.

Name: ______________________________ Group No. : ______________

Date Performed: _______________________ Activity No. : ______________

GENETIC INQUIRY SKILLS

1. What are the independent and dependent variables?
2. What is the hypothesis?
3. How will the experiment be done to test your hypothesis?
4. What are the data and statistical tool to be used? What type of graph is used?

GUIDE QUESTIONS

1. What happens in a normal cell in the DNA which has mutations?
2. What would happen if cells with mutated DNA replicate?
3. How do cells monitor integrity?

CONCLUSION/S

FOR INDIVIDUAL ACTIVITY

Conceptual Understanding

Students' Connecting Ideas on Variation

Activity On	Concepts/ Ideas	Connecting Ideas		
Variation	Mutations result to genetic variations. Mutations (changes in an organism's DNA) are the original source of genetic diversity Mutations create different versions of genes called alleles Reshuffling of alleles during sexual reproduction produces genetic variation.	Classical Genetics/ Mendelian Genetics (Explain it at the Organismal level)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)

Concept Mapping

Elaboration.

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping.

Student's Concept Map

Appendix E

Validation of the Written Content Questionnaire Form and Completed Samples

Name of Evaluator: ______________________________

Highest Educational Attainment: ______________________________

Institution: ______________________________

Address of Institution: ______________________________

Position/ Academic Rank: ______________________________

Name of Questionnaire Validated: ______________________________

Description of the Questionnaire:

____

____

____

Guided by the following scale, kindly rate each statement by putting a check (/) mark on the corresponding column.

4 – Strongly Agree
3 – Agree
2 – Disagree
1 – Strongly Disagree

No.	Criteria/ Indicator	1	2	3	4
1	Students will easily comprehend the instructions without much help from the teacher.				
2	Students will have no difficulty with the language used in the questionnaire.				
3	Students will easily comprehend the questions without much help from the teacher.				
4	The statements are appropriate to determine conceptual understanding/ inquiry skills/ attitude of students toward Genetics.				
5	The items represent the coverage of the research adequately. The number of statements per area is representative enough for the questions needed in the research.				
6	The instrument as a whole fulfills the objectives for which it is constructed.				
7	No aspect of the questionnaire suggests bias on the part of the researcher.				

Comments/ Suggestions/Recommendations:

____

____

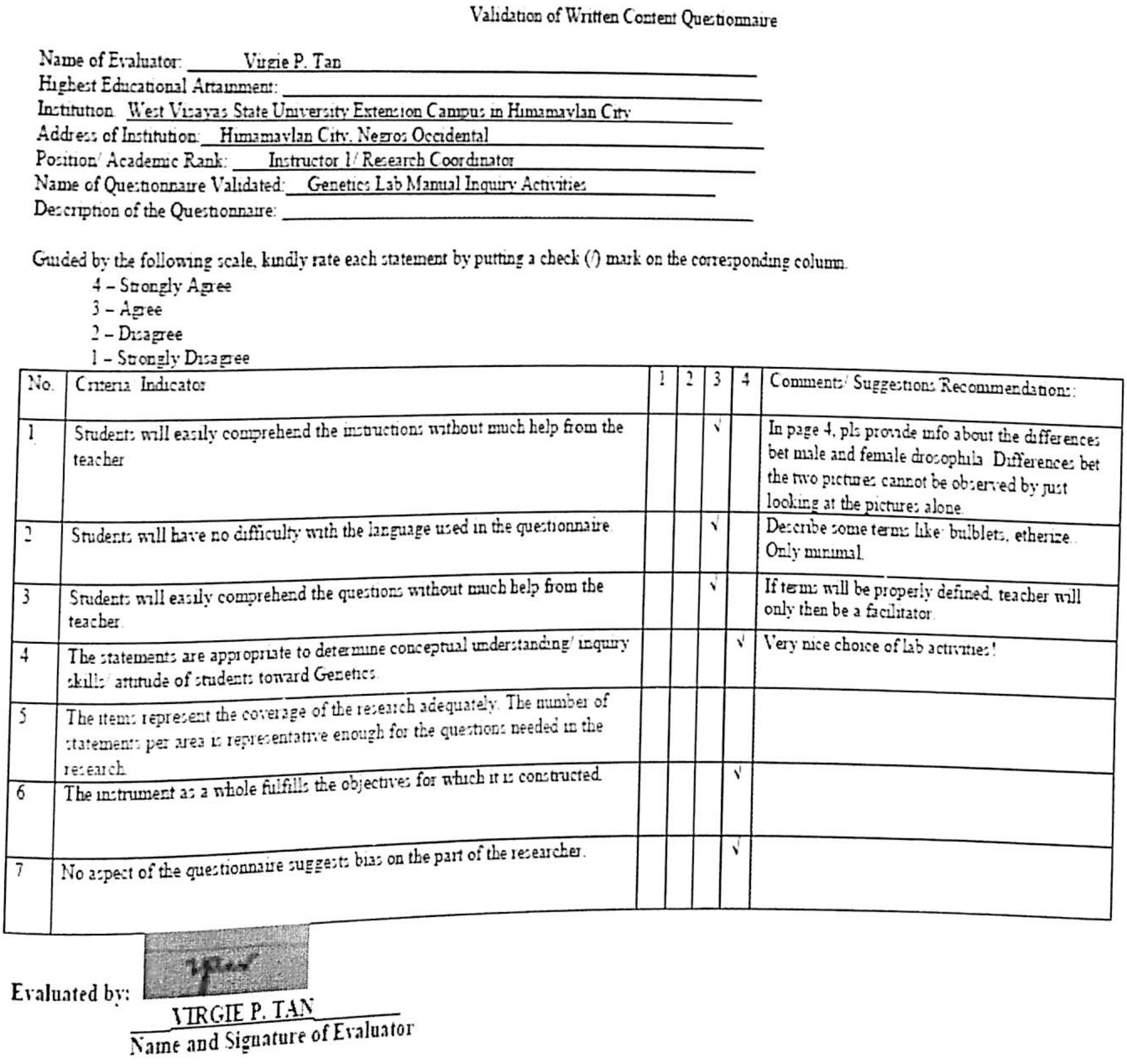
____

____

____

Signature over Printed Name

Sample of Completed Validation of Written Questionnaire on Inquiry-based Manual



Validation of Written Content Questionnaire

Name of Evaluator: Virgie P. Tan
Highest Educational Attainment:
Institution: West Visayas State University Extension Campus in Himamaylan City
Address of Institution: Himamaylan City, Negros Occidental
Position/ Academic Rank: Instructor 1/ Research Coordinator
Name of Questionnaire Validated: Genetics Lab Manual Inquiry Activities
Description of the Questionnaire:

Guided by the following scale, kindly rate each statement by putting a check (√) mark on the corresponding column.

4 – Strongly Agree
3 – Agree
2 – Disagree
1 – Strongly Disagree

No.	Criteria/ Indicator	1	2	3	4	Comments/ Suggestions/ Recommendations:
1	Students will easily comprehend the instructions without much help from the teacher			√		In page 4, pls provide info about the differences bet male and female drosophila. Differences bet the two pictures cannot be observed by just looking at the pictures alone.
2	Students will have no difficulty with the language used in the questionnaire.			√		Describe some terms like: bulblets, etherize. Only minimal.
3	Students will easily comprehend the questions without much help from the teacher.			√		If terms will be properly defined, teacher will only then be a facilitator.
4	The statements are appropriate to determine conceptual understanding/ inquiry skills/ attitude of students toward Genetics.				√	Very nice choice of lab activities!
5	The items represent the coverage of the research adequately. The number of statements per area is representative enough for the questions needed in the research.					
6	The instrument as a whole fulfills the objectives for which it is constructed.				√	
7	No aspect of the questionnaire suggests bias on the part of the researcher.				√	

Evaluated by:

VIRGIE P. TAN
Name and Signature of Evaluator

Sample of Completed Validation of Written Content Questionnaire on Genetics Inquiry Skills Test

Validation of Written Content Questionnaire

Name of Evaluator: BERNICE P. MALIAO
Highest Educational Attainment: MS BIOLOGY
Institution: WVSU
Address of Institution: LUNA ST., LA PAZ, ILOILO CITY
Position/ Academic Rank: INSTRUCTOR I
Name of Questionnaire Validated: Genetics Inquiry Skills Questionnaire
Description of the Questionnaire:

Guided by the following scale, kindly rate each statement by putting a check (/) mark on the corresponding column.

4 – Strongly Agree
3 – Agree
2 – Disagree
1 – Strongly Disagree

No.	Criteria/ Indicator	1	2	3	4
1	Students will easily comprehend the instructions without much help from the teacher.				/
2	Students will have no difficulty with the language used in the questionnaire.				/
3	Students will easily comprehend the questions without much help from the teacher.			/	
4	The statements are appropriate to determine conceptual understanding/ inquiry skills/ attitude of students toward Genetics.				/
5	The items represent the coverage of the research adequately. The number of statements per area is representative enough for the questions needed in the research.				/
6	The instrument as a whole fulfills the objectives for which it is constructed.				/
7	No aspect of the questionnaire suggests bias on the part of the researcher.				/

Comments/ Suggestions/Recommendations:

1. Make Fig. B.1 larger / clearer.
2. Questions / descriptions and choices of an item should be on the same page.

BERNICE P. MALIAO
Signature over Printed Name

Sample of Completed Validation of Written Content Questionnaire on Conceptual Understanding Test

Validation of Written Content Questionnaire

Name of Evaluator: Bryan Openia
Highest Educational Attainment: MEd (on going)
Institution: WVSU
Address of Institution: La Paz, Iloilo City
Position/ Academic Rank: Instructor I
Name of Questionnaire Validated: Conceptual Understanding Questionnaire
Description of the Questionnaire:

Guided by the following scale, kindly rate each statement by putting a check (/) mark on the corresponding column.

4 – Strongly Agree
3 – Agree
2 – Disagree
1 – Strongly Disagree

No.	Criteria/ Indicator	1	2	3	4
1	Students will easily comprehend the instructions without much help from the teacher.			✓	
2	Students will have no difficulty with the language used in the questionnaire.				✓
3	Students will easily comprehend the questions without much help from the teacher.				✓
4	The statements are appropriate to determine conceptual understanding/ inquiry skills/ attitude of students toward Genetics.				✓
5	The items represent the coverage of the research adequately. The number of statements per area is representative enough for the questions needed in the research.				✓
6	The instrument as a whole fulfills the objectives for which it is constructed.				✓
7	No aspect of the questionnaire suggests bias on the part of the researcher.				✓

Comments/ Suggestions/Recommendations:

-add space for shading

Bryan Openia
Signature over Printed Name

Sample of Completed Validation of Written Content Questionnaire on Genetics Attitude Questionnaire

Validation of Written Content Questionnaire

Name of Evaluator: BERNICE P. MALIAO
Highest Educational Attainment: MS BIOLOGY
Institution: WVSU
Address of Institution: LUNA ST., LA PAZ, ILOILO CITY
Position/ Academic Rank: INSTRUCTOR I
Name of Questionnaire Validated: Attitude Questionnaire
Description of the Questionnaire:

Guided by the following scale, kindly rate each statement by putting a check (/) mark on the corresponding column.

4 – Strongly Agree
3 – Agree
2 – Disagree
1 – Strongly Disagree

No.	Criteria/ Indicator	1	2	3	4
1	Students will easily comprehend the instructions without much help from the teacher.			✓	
2	Students will have no difficulty with the language used in the questionnaire.				✓
3	Students will easily comprehend the questions without much help from the teacher.				✓
4	The statements are appropriate to determine conceptual understanding/ inquiry skills/ attitude of students toward Genetics.				✓
5	The items represent the coverage of the research adequately. The number of statements per area is representative enough for the questions needed in the research.				✓
6	The instrument as a whole fulfills the objectives for which it is constructed.				✓
7	No aspect of the questionnaire suggests bias on the part of the researcher.				✓

Comments/ Suggestions/Recommendations:

1. Place a legend for the choices / scale.
2. Some of the questions seem redundant.

BERNICE P. MALIAO
Signature over Printed Name

Appendix F
Rubric for Instructional Material

Scoring Rubric for the Instructional Material

Criteria	Excellent = 5 points	Very good= 4 points	Satisfactory= 3 points	Below Average = 2 points	Needs Improvement = 1 point	Score	Comment
1. Information is accurate. current. and research-based.	5	4	3	2	1		
2. Provides assessment type questions and/or performance-based tasks.	5	4	3	2	1		
3. Focuses on the knowledge. skills. and abilities appropriate to the year level	5	4	3	2	1		
4. Information and directions are clearly written and explained.	5	4	3	2	1		
5. Tasks apply to the diversity of students and their abilities. interests. and learning styles.	5	4	3	2	1		
6. Questions and tasks encourage the development and application of higher-level thinking skills	5	4	3	2	1		
7. Provides access to or demonstrates concepts in multiple ways. allowing for a variety of student responses	5	4	3	2	1		
Total (35 points)							

Sample of Completed Rubric for Instructional Material

Scoring Rubric for the Instructional Material

Criteria	Excellent = 5 points	Very good= 4 points	Satisfactory= 3 points	Below Average = 2 points	Needs Improvement = 1 point	Score	Comment
1. Information is accurate. current. and research-based.		√				4	Needs some further explanations in some parts of the manual.
2. Provides assessment type questions and/or performance-based tasks.	√					5	
3. Focuses on the knowledge. skills. and abilities appropriate to the year level	√					5	
4. Information and directions are clearly written and explained.		√				4	There are other tables which needs some instructions.
5. Tasks apply to the diversity of students and their abilities. interests. and learning styles.	√					5	
6. Questions and tasks encourage the development and application of higher-level thinking skills	√					5	
7. Provides access to or demonstrates concepts in multiple ways. allowing for a variety of student responses.	√					5	
Total (35 points)						33	

Appendix G
Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials

Criterion	1	2	3	4	Score
1.Provides content aligned with the goals, objectives and/ standards	Does no match standards (displays no evidence of alignment)	Matches the topic of the standard but not the specific outcome of the desired	Matches the topic of the standard and addresses at least a part of the specific outcome desired	Matches the specific outcome of the standard	
2 Provides opportunity to develop enduring understanding of the subject matter	Covers too many concepts and abilities; Coverage(time) is insufficient to develop understanding of concepts and abilities	Focuses on several important concepts and abilities, several of which are peripheral to each inquiry. More coverage (time) may be needed to develop enduring understanding	Focuses on the specific concepts and abilities that are central to each inquiry although a few peripheral ideas are present. More coverage time may be needed to develop enduring understanding	Focuses on the specific concepts and abilities that are central to each inquiry. Material provides ample opportunity to develop enduring understanding of the important content.	
3 Contains accurate content	Contains major inaccuracies	Contains minor inaccuracies that are evident in statements and/ representations	Is scientifically accurate but may contain the potential for misconceptions to occur from implied statements or representations	Is scientifically accurate. There is minimal potential for misconceptions to occur from implied statements or representations	
4 Provides an opportunity to learn that scientists conduct investigation for a variety of reasons	Provides no mention of why investigations are conducted	Provides a discussion of why investigations are conducted but no examples (reasons for investigations)	Provides a discussion of why investigations are conducted and some examples. No connections are made to the learners work	Provides real world examples showing one or more reasons for the investigation(s) and facilitates the students in connecting the examples to the learner's work	
5 Provides an opportunity to learn that scientists use a variety of tools, technology and methods to extend the senses	Provides no mention of how the senses are extended	Provides a discussion of how the senses are extended but no examples	Provides the discussion of how the senses are extended but no connections are made to the learner's work	Provide real work examples of how the senses are extended to gather evidence, guide inquiry, and analyze data. Facilitates students in connecting the examples to the learner's work. Material demonstrates that the accuracy and precision of data depend upon the quality and choice of tools	
6 Provides an opportunity to ask questions that can be answered through scientific investigations	Allows learner to answer provided questions	Allows an opportunity to clarify provided questions	Allows an opportunity to select among provided questions and pose new questions for investigation	Allows an opportunity for learners to pose new questions for investigation relevant to their understanding (interests)	
7.Engages learner in conducting the investigation	Provides a procedure for the investigations	Provides questions, directs the learner regarding procedure and specifies what data to collect	Provides questions, engages learners in determining what constitutes correct procedure and appropriate data and in conducting the investigation to collect the data	Requires learner to self direct the full investigation based on their determination of necessary evidence and appropriate methodologies	
8 Engages learner in the use of analytical skills	Does not allow for learner the use of analytical skills	Provides exact guidelines for learners to use analytical skills, mathematics and technology to gather and analyze data	Encourages learners to use analytical skills, mathematics and technology to gather and analyze data. Minimal guidelines may be provided.	Requires learners to independently use analytical skills, mathematics and technology to gather and analyze data.	
9.Engages learners in proposing answers and explanations to questions	Provides no opportunity for learners to propose answers and explanations to questions above the knowledge level	Provide data and asks learners to analyze them specific questions	Encourages learner to collect and analyze certain data to answer questions arising from their investigation	Requires learners to analyze (use) evidence from data they gather to propose answers and explanations arising from their investigation	
10 Engages learners in linking explanations with scientific knowledge	Does not mention linking explanations with scientific knowledge	Provides guidelines for learners to examine current scientific knowledge and form links to explanations	Encourages learners to examine current scientific knowledge and form links to explanations	Requires learners to independently examine current scientific knowledge and form links to explanations	
11 Engages learners in communication of scientific procedures and explanation	Does not mention communicating inquiry	Provides an opportunity for learners to follow prescribed communication procedures	Provides an opportunity for learners to communicate some aspects of the inquiry in their own format	Provides an opportunity for learners to clearly communicate all aspects of the inquiry in their own format including the procedures, evidence proposed explanations, and the review of alternative explanations	
12 Presents science as open and subject to modification based on communication of new knowledge and methods	Contains no references to the idea of challenging previous scientific knowledge	Prompts learners to examine previously established scientific ideas, and provides explanations or examples that illustrate how new information can modify accepted scientific knowledge	Engages learners in analyzing the basis for conclusions in other investigations or in considering the consequences of the lack of openness to modification in scientific knowledge	Prompts learners to reflect on the reasoning leading to their own conclusions and to defend their thinking process	
13.Promotes respect for data (Honesty)	Does not promote respect for data	Explains and/provides examples detailing the use of honest and dishonest data from scientific investigations	Engages learners in analyzing the validity of data in other investigations or in considering the consequences of dishonest data in science	Prompts learners to reflect on the importance of reporting and recording observations accurately and to articulate the bias and limitations of their data	
		Total (52 points)			

Adapted and modified from: Council of State Science Supervisors (2001). Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials.

Sample of Completed Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials

Criterion	1=Needs Improvement	2=Good	3=Satisfactory	4=Excellent	Score
1.Provides content aligned with the goals, objectives and/ standards	Does no match standards (displays no evidence of alignment)	Matches the topic of the standard but not the specific outcome of the desired	Matches the topic of the standard and addresses at least a part of the specific outcome desired	Matches the specific outcome of the standard	4
2.Provides opportunity to develop enduring understanding of the subject matter	Covers too many concepts and abilities; Coverage(time) is insufficient to develop understanding of concepts and abilities	Focuses on several important concepts and abilities, several of which are peripheral to each inquiry. More coverage (time) may be needed to develop enduring understanding.	Focuses on the specific concepts and abilities that are central to each inquiry although a few peripheral ideas are present. More coverage time may be needed to develop enduring understanding.	Focuses on the specific concepts and abilities that are central to each inquiry. Material provides ample opportunity to develop enduring understanding of the important content.	3
3.Contains accurate content	Contains major inaccuracies	Contains minor inaccuracies that are evident in statements and/ representations	Is scientifically accurate but may contain the potential for misconceptions to occur from implied statements or representations	Is scientifically accurate. There is minimal potential for misconceptions to occur from implied statements or representations	4
4.Provides an opportunity to learn that scientists conduct investigation for a variety of reasons	Provides no mention of why investigations are conducted	Provides a discussion of why investigations are conducted but no examples (reasons for investigations)	Provides a discussion of why investigations are conducted and some examples. No connections are made to the learners work.	Provides real world examples showing one or more reasons for the investigation(s) and facilitates the students in connecting the examples to the learner's work.	4
5 Provides an opportunity to learn that scientists use a variety of tools, technology and methods to extend the senses	Provides no mention of how the senses are extended	Provides a discussion of how the senses are extended but no examples	Provides the discussion of how the senses are extended but no connections are made to the learner's work	Provide real work examples of how the senses are extended to gather evidence, guide inquiry, and analyze data. Facilitates students in connecting the examples to the learner's work. Material demonstrates that the accuracy and precision of data depend upon the quality and choice of tools.	3
6.Provides an opportunity to ask questions that can be answered through scientific investigations	Allows learner to answer provided questions	Allows an opportunity to clarify provided questions	Allows an opportunity to select among provided questions and pose new questions for investigation	Allows an opportunity for learners to pose new questions for investigation relevant to their understanding (interests)	4
7.Engages learner in conducting the investigation	Provides a procedure for the investigations	Provides questions, directs the learner regarding procedure and specifies what data to collect	Provides questions, engages learners in determining what constitutes correct procedure and appropriate data and in conducting the investigation to collect	Requires learner to self direct the full investigation based on their determination of necessary evidence and appropriate methodologies	4

			the data		
8.Engages learner in the use of analytical skills	Does not allow for learner the use of analytical skills	Provides exact guidelines for learners to use analytical skills, mathematics and technology to gather and analyze data	Encourages learners to use analytical skills, mathematics and technology to gather and analyze data. Minimal guidelines may be provided.	Requires learners to independently use analytical skills, mathematics and technology to gather and analyze data.	3
9.Engages learners in proposing answers and explanations to questions	Provides no opportunity for learners to propose answers and explanations to questions above the knowledge level	Provide data and asks learners to analyze them specific questions	Encourages learner to collect and analyze certain data to answer questions arising from their investigation	Requires learners to analyze (use) evidence from data they gather to propose answers and explanations arising from their investigation	4
10.Engages learners in linking explanations with scientific knowledge	Does not mention linking explanations with scientific knowledge	Provides guidelines for learners to examine current scientific knowledge and form links to explanations	Encourages learners to examine current scientific knowledge and form links to explanations	Requires learners to independently examine current scientific knowledge and form links to explanations	4
11.Engages learners in communication of scientific procedures and explanation	Does not mention communicating inquiry	Provides an opportunity for learners to follow prescribed communication procedures	Provides an opportunity for learners to communicate some aspects of the inquiry in their own format	Provides an opportunity for learners to clearly communicate all aspects of the inquiry in their own format including the procedures, evidence proposed explanations, and the review of alternative explanations	4
12 Presents science as open and subject to modification based on communication of new knowledge and methods	Contains no references to the idea of challenging previous scientific knowledge	Prompts learners to examine previously established scientific ideas, and provides explanations or examples that illustrate how new information can modify accepted scientific knowledge	Engages learners in analyzing the basis for conclusions in other investigations or in considering the consequences of the lack of openness to modification in scientific knowledge	Prompts learners to reflect on the reasoning leading to their own conclusions and to defend their thinking process	4
13.Promotes respect for data (Honesty)	Does not promote respect for data	Explains and/provides examples detailing the use of honest and dishonest data from scientific investigations	Engages learners in analyzing the validity of data in other investigations or in considering the consequences of dishonest data in science	Prompts learners to reflect on the importance of reporting and recording observations accurately and to articulate the bias and limitations of their data	3
		Total (52 points)			48

(Adapted and modified from: Council of State Science Supervisors, 2001. Rubric for Evaluating Essential Features of Classroom Inquiry in Instructional Materials)

Comments/ Suggestions/Recommendations:

BERNICE P. MALIAO

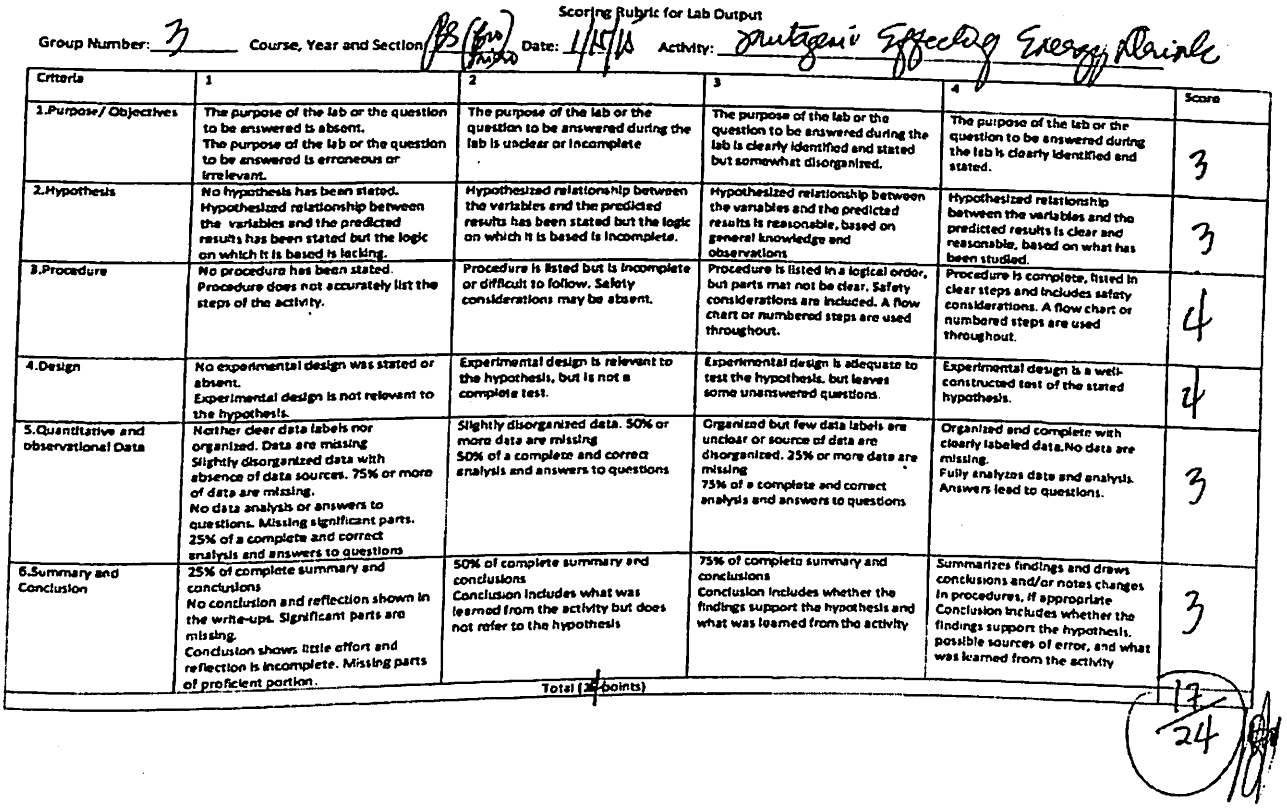
Signature Over Printed Name

Appendix H
Scoring Rubric for Laboratory Report

Group Number:_______ Course, Year and Section:_______ Date:______ Activity:_______________

Criteria	1	2	3	4	Score
1.Purpose/ Objectives	The purpose of the lab or the question to be answered is absent. The purpose of the lab or the question to be answered is erroneous or irrelevant.	The purpose of the lab or the question to be answered during the lab is unclear or incomplete	The purpose of the lab or the question to be answered during the lab is clearly identified and stated but somewhat disorganized.	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.	
2.Hypothesis	No hypothesis has been stated. Hypothesized relationship between the variables and the predicted results has been stated but the logic on which it is based is lacking.	Hypothesized relationship between the variables and the predicted results has been stated but the logic on which it is based is incomplete.	Hypothesized relationship between the variables and the predicted results is reasonable, based on general knowledge and observations	Hypothesized relationship between the variables and the predicted results is clear and reasonable, based on what has been studied.	
3.Procedure	No procedure has been stated. Procedure does not accurately list the steps of the activity.	Procedure is listed but is incomplete or difficult to follow. Safety considerations may be absent.	Procedure is listed in a logical order, but parts mat not be clear. Safety considerations are included. A flow chart or numbered steps are used throughout.	Procedure is complete, listed in clear steps and includes safety considerations. A flow chart or numbered steps are used throughout.	
4.Design	No experimental design was stated or absent. Experimental design is not relevant to the hypothesis.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is a well-constructed test of the stated hypothesis.	
5.Quantitative and observational Data	Neither clear data labels nor organized. Data are missing Slightly disorganized data with absence of data sources. 75% or more of data are missing. No data analysis or answers to questions. Missing significant parts. 25% of a complete and correct analysis and answers to questions	Slightly disorganized data. 50% or more data are missing 50% of a complete and correct analysis and answers to questions	Organized but few data labels are unclear or source of data are disorganized. 25% or more data are missing 75% of a complete and correct analysis and answers to questions	Organized and complete with clearly labeled data.No data are missing. Fully analyzes data and analysis. Answers lead to questions.	
6.Summary and Conclusion	25% of complete summary and conclusions No conclusion and reflection shown in the write-ups. Significant parts are missing. Conclusion shows little effort and reflection is incomplete. Missing parts of proficient portion.	50% of complete summary and conclusions Conclusion includes what was learned from the activity but does not refer to the hypothesis	75% of complete summary and conclusions Conclusion includes whether the findings support the hypothesis and what was learned from the activity	Summarizes findings and draws conclusions and/or notes changes in procedures, if appropriate Conclusion includes whether the findings support the hypothesis, possible sources of error, and what was learned from the activity	
		Total (28 points)			

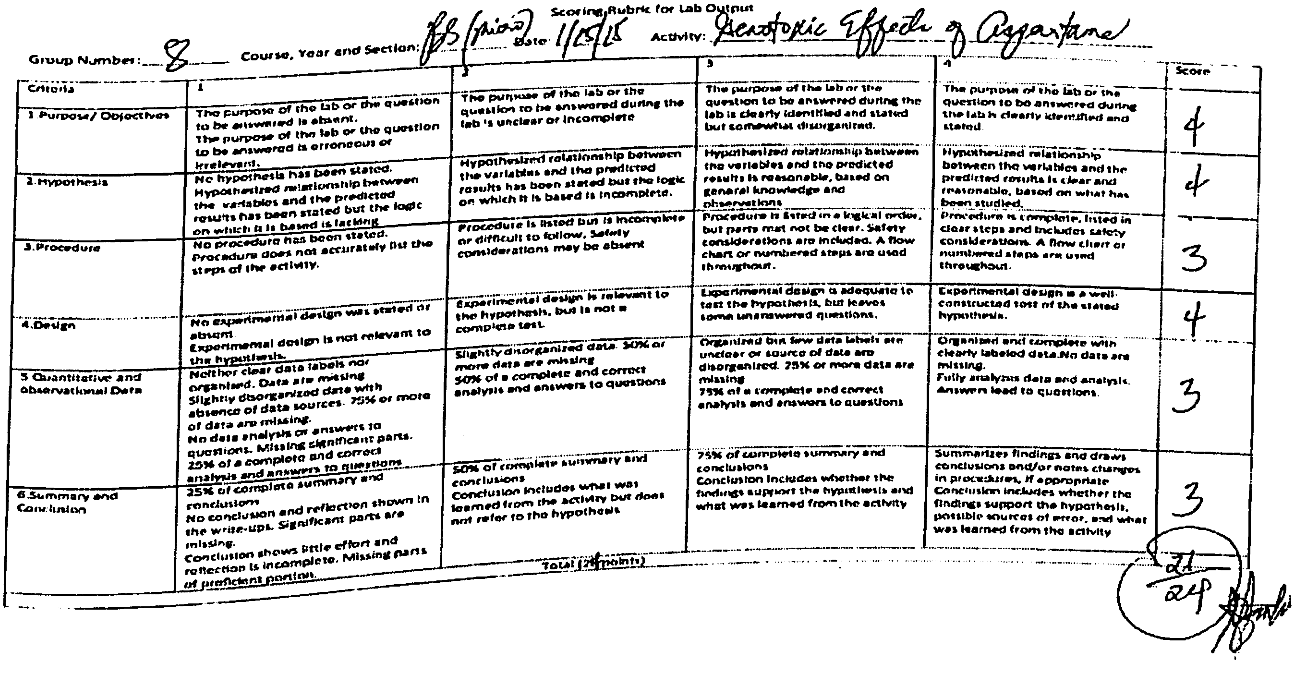
Sample of Completed Scoring Rubric for Lab Output



Scoring Rubric for Lab Output

Group Number: 7 Course, Year and Section: BS (Bio) Third Date: 1/15/15 Activity: Mutagenic Effect of Energy Drink

Criteria	1	2	3	4	Score
1.Purpose/ Objectives	The purpose of the lab or the question to be answered is absent. The purpose of the lab or the question to be answered is erroneous or irrelevant.	The purpose of the lab or the question to be answered during the lab is unclear or incomplete	The purpose of the lab or the question to be answered during the lab is clearly identified and stated but somewhat disorganized.	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.	3
2.Hypothesis	No hypothesis has been stated. Hypothesized relationship between the variables and the predicted results has been stated but the logic on which it is based is lacking.	Hypothesized relationship between the variables and the predicted results has been stated but the logic on which it is based is incomplete.	Hypothesized relationship between the variables and the predicted results is reasonable, based on general knowledge and observations	Hypothesized relationship between the variables and the predicted results is clear and reasonable, based on what has been studied.	3
3.Procedure	No procedure has been stated. Procedure does not accurately list the steps of the activity.	Procedure is listed but is incomplete or difficult to follow. Safety considerations may be absent.	Procedure is listed in a logical order, but parts mat not be clear. Safety considerations are included. A flow chart or numbered steps are used throughout.	Procedure is complete, listed in clear steps and includes safety considerations. A flow chart or numbered steps are used throughout.	4
4.Design	No experimental design was stated or absent. Experimental design is not relevant to the hypothesis.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is a well-constructed test of the stated hypothesis.	4
5.Quantitative and observational Data	Neither clear data labels nor organized. Data are missing Slightly disorganized data with absence of data sources. 75% or more of data are missing. No data analysis or answers to questions. Missing significant parts. 25% of a complete and correct analysis and answers to questions	Slightly disorganized data. 50% or more data are missing 50% of a complete and correct analysis and answers to questions	Organized but few data labels are unclear or source of data are disorganized. 25% or more data are missing 75% of a complete and correct analysis and answers to questions	Organized and complete with clearly labeled data.No data are missing. Fully analyzes data and analysis. Answers lead to questions.	3
6.Summary and Conclusion	25% of complete summary and conclusions No conclusion and reflection shown in the write-ups. Significant parts are missing. Conclusion shows little effort and reflection is incomplete. Missing parts of proficient portion.	50% of complete summary and conclusions Conclusion includes what was learned from the activity but does not refer to the hypothesis	75% of complete summary and conclusions Conclusion includes whether the findings support the hypothesis and what was learned from the activity	Summarizes findings and draws conclusions and/or notes changes in procedures, if appropriate Conclusion includes whether the findings support the hypothesis, possible sources of error, and what was learned from the activity	3
			Total (24 points)		17/24



Scoring Rubric for Lab Output

Group Number: 8 Course, Year and Section: BS (Bio) Date: 1/25/15 Activity: Genotoxic Effects of Aspartame

Criteria	1	2	3	4	Score
1.Purpose/ Objectives	The purpose of the lab or the question to be answered is absent. The purpose of the lab or the question to be answered is erroneous or irrelevant.	The purpose of the lab or the question to be answered during the lab 's unclear or incomplete	The purpose of the lab or the question to be answered during the lab is clearly identified and stated but somewhat disorganized.	The purpose of the lab or the question to be answered during the lab is clearly identified and stated	4
2.Hypothesis	No hypothesis has been stated. Hypothesized relationship between the variables and the predicted results has been stated but the logic on which it is based is lacking	Hypothesized relationship between the variables and the predicted results has been stated but the logic on which it is based is incomplete.	Hypothesized relationship between the variables and the predicted results is reasonable, based on general knowledge and observations	Hypothesized relationship between the variables and the predicted results is clear and reasonable, based on what has been studied.	4
3.Procedure	No procedure has been stated. Procedure does not accurately list the steps of the activity.	Procedure is listed but is incomplete or difficult to follow. Safety considerations may be absent	Procedure is listed in a logical order, but parts mat not be clear. Safety considerations are included. A flow chart or numbered steps are used throughout.	Procedure is complete, listed in clear steps and includes safety considerations. A flow chart or numbered steps are used throughout.	3
4.Design	No experimental design was stated or absent. Experimental design is not relevant to the hypothesis.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is a well-constructed test of the stated hypothesis.	4
5.Quantitative and observational Data	Neither clear data labels nor organized. Data are missing Slightly disorganized data with absence of data sources. 75% or more of data are missing. No data analysis or answers to questions. Missing significant parts. 25% of a complete and correct analysis and answers to questions	Slightly disorganized data. 50% or more data are missing 50% of a complete and correct analysis and answers to questions	Organized but few data labels are unclear or source of data are disorganized. 25% or more data are missing 75% of a complete and correct analysis and answers to questions	Organized and complete with clearly labeled data.No data are missing. Fully analyzes data and analysis. Answers lead to questions.	3
6.Summary and Conclusion	25% of complete summary and conclusions No conclusion and reflection shown in the write-ups. Significant parts are missing. Conclusion shows little effort and reflection is incomplete. Missing parts of proficient portion.	50% of complete summary and conclusions Conclusion includes what was learned from the activity but does not refer to the hypothesis	75% of complete summary and conclusions Conclusion includes whether the findings support the hypothesis and what was learned from the activity	Summarizes findings and draws conclusions and/or notes changes in procedures, if appropriate Conclusion includes whether the findings support the hypothesis, possible sources of error, and what was learned from the activity	3
			Total (24 points)		21/24

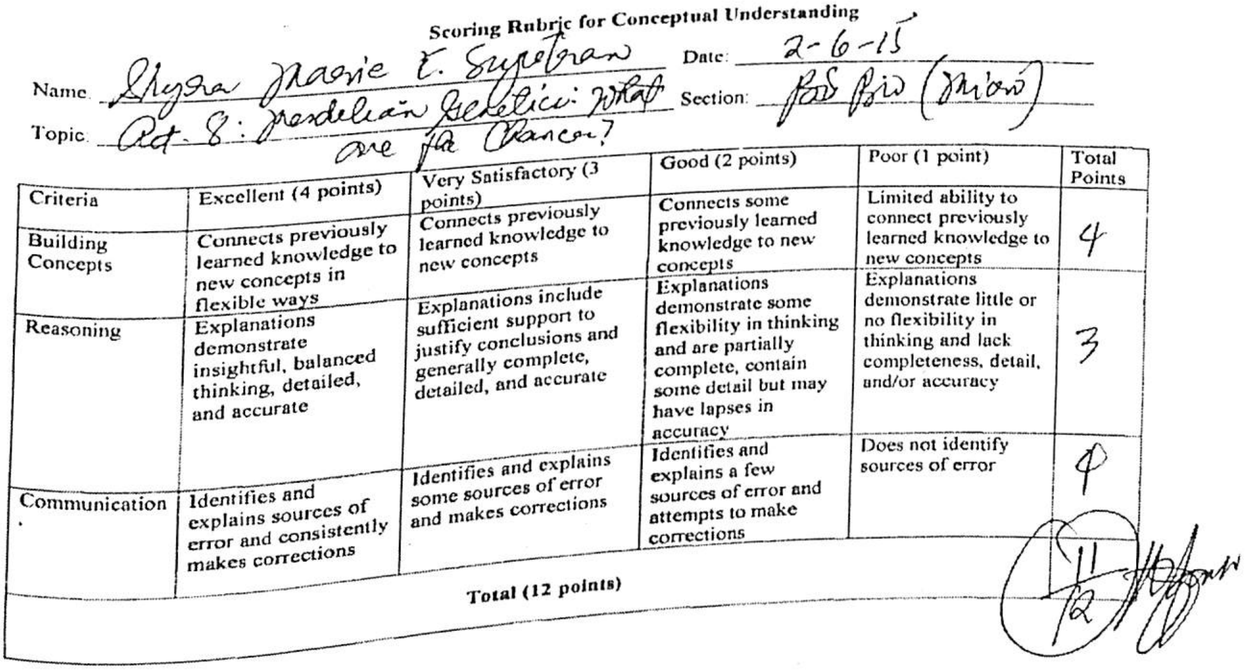
Appendix I
Scoring Rubric for Conceptual Understanding

Name: ______________________ Date: ______________________

Topic: ______________________ Section: ______________________

Criteria	Excellent (4 points)	Very Satisfactory (3 points)	Good (2 points)	Poor (1 point)	Total Points
Building Concepts	Connects previously learned knowledge to new concepts in flexible ways	Connects previously learned knowledge to new concepts	Connects some previously learned knowledge to new concepts	Limited ability to connect previously learned knowledge to new concepts	
Reasoning	Explanations demonstrate insightful, balanced thinking, detailed, and accurate	Explanations include sufficient support to justify conclusions and generally complete, detailed, and accurate	Explanations demonstrate some flexibility in thinking and are partially complete, contain some detail but may have lapses in accuracy	Explanations demonstrate little or no flexibility in thinking and lack completeness, detail and/or accuracy	
Communication	Identifies and explains sources of error and consistently makes corrections	Identifies and explains some sources of error and makes corrections	Identifies and explains a few sources of error and attempts to make corrections	Does not identify sources of error	
Total (12 points)					

Sample of Completed Scoring Rubric for Conceptual Understanding



Scoring Rubric for Conceptual Understanding

Name: Shyra Marie E. Sugetran Date: 2-6-15

Topic: Act. 8: Mendelian Genetics: What are the Chances? Section: BS Bio (Mon)

Criteria	Excellent (4 points)	Very Satisfactory (3 points)	Good (2 points)	Poor (1 point)	Total Points
Building Concepts	Connects previously learned knowledge to new concepts in flexible ways	Connects previously learned knowledge to new concepts	Connects some previously learned knowledge to new concepts	Limited ability to connect previously learned knowledge to new concepts	4
Reasoning	Explanations demonstrate insightful, balanced thinking, detailed, and accurate	Explanations include sufficient support to justify conclusions and generally complete, detailed, and accurate	Explanations demonstrate some flexibility in thinking and are partially complete, contain some detail but may have lapses in accuracy	Explanations demonstrate little or no flexibility in thinking and lack completeness, detail, and/or accuracy	3
Communication	Identifies and explains sources of error and consistently makes corrections	Identifies and explains some sources of error and makes corrections	Identifies and explains a few sources of error and attempts to make corrections	Does not identify sources of error	4
Total (12 points)					11/12

Scoring Rubric for Conceptual Understanding

Name: Randall Padasas Date: 2-6-15

Topic: Act. 7: How Can Karyotype Analysis Explain Genetic Disorders? Section: BS Bio (Micro)

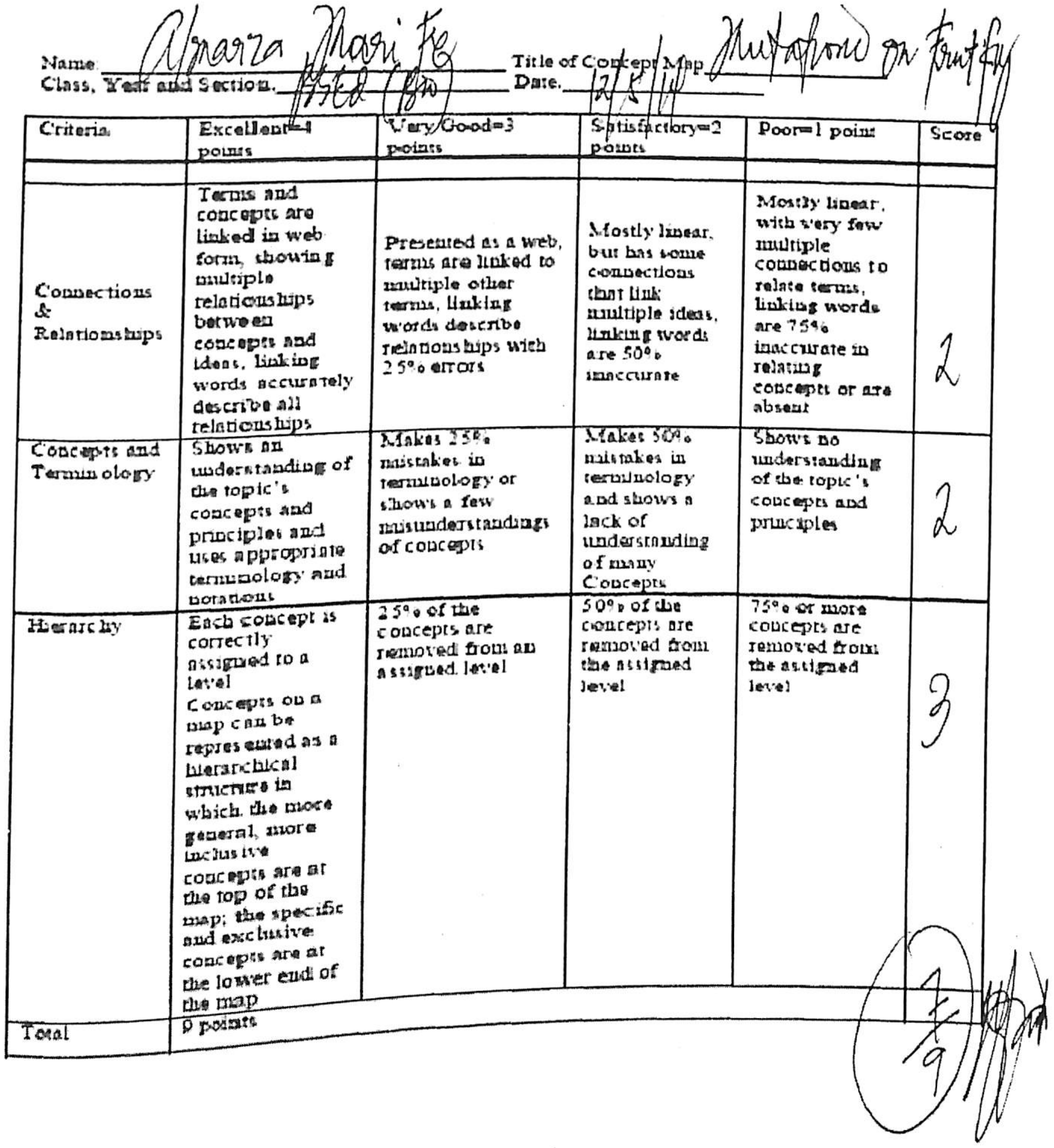
Criteria	Excellent (4 points)	Very Satisfactory (3 points)	Good (2 points)	Poor (1 point)	Total Points
Building Concepts	Connects previously learned knowledge to new concepts in flexible ways	Connects previously learned knowledge to new concepts	Connects some previously learned knowledge to new concepts	Limited ability to connect previously learned knowledge to new concepts	2
Reasoning	Explanations demonstrate insightful, balanced thinking, detailed, and accurate	Explanations include sufficient support to justify conclusions and generally complete, detailed, and accurate	Explanations demonstrate some flexibility in thinking and are partially complete, contain some detail but may have lapses in accuracy	Explanations demonstrate little or no flexibility in thinking and lack completeness, detail, and/or accuracy	3
Communication	Identifies and explains sources of error and consistently makes corrections	Identifies and explains some sources of error and makes corrections	Identifies and explains a few sources of error and attempts to make corrections	Does not identify sources of error	2
Total (12 points)					7/12

Appendix J
Scoring Rubric for Concept Mapping

Name:________________________________ Title of Concept Map_______________
Class, Year and Section:____________________ Date:____________

Criteria	Excellent=4 points	Very Good=3 points	Satisfactory=2 points	Poor=1 point	Score
Connections & Relationships	Terms and concepts are linked in web form, showing multiple relationships between concepts and ideas, linking words accurately describe all relationships	Presented as a web, terms are linked to multiple other terms, linking words describe relationships with 25% errors	Mostly linear, but has some connections that link multiple ideas, linking words are 50% inaccurate	Mostly linear, with very few multiple connections to relate terms, linking words are 75% inaccurate in relating concepts or are absent	
Concepts and Terminology	Shows an understanding of the topic's concepts and principles and uses appropriate terminology and notations	Makes 25% mistakes in terminology or shows a few misunderstandings of concepts	Makes 50% mistakes in terminology and shows a lack of understanding of many Concepts	Shows no understanding of the topic's concepts and principles	
Hierarchy	Each concept is correctly assigned to a level Concepts on a map can be represented as a hierarchical structure in which the more general, more inclusive concepts are at the top of the map; the specific and exclusive concepts are at the lower end of the map	25% of the concepts are removed from an assigned level	50% of the concepts are removed from the assigned level	75% or more concepts are removed from the assigned level	
Total	9 points				

Sample of Completed Concept Map Scoring Rubric



Name: Alnarza Mari Fe

Title of Concept Map: Mutations on Fruitfly

Class, Year and Section: BSEd (Bio)

Date: 12/5/11

Criteria	Excellent=4 points	Very Good=3 points	Satisfactory=2 points	Poor=1 point	Score
Connections & Relationships	Terms and concepts are linked in web form, showing multiple relationships between concepts and ideas, linking words accurately describe all relationships	Presented as a web, terms are linked to multiple other terms, linking words describe relationships with 25% errors	Mostly linear, but has some connections that link multiple ideas, linking words are 50% inaccurate	Mostly linear, with very few multiple connections to relate terms, linking words are 75% inaccurate in relating concepts or are absent	2
Concepts and Terminology	Shows an understanding of the topic's concepts and principles and uses appropriate terminology and notations	Makes 25% mistakes in terminology or shows a few misunderstandings of concepts	Makes 50% mistakes in terminology and shows a lack of understanding of many Concepts	Shows no understanding of the topic's concepts and principles	2
Hierarchy	Each concept is correctly assigned to a level Concepts on a map can be represented as a hierarchical structure in which the more general, more inclusive concepts are at the top of the map; the specific and exclusive concepts are at the lower end of the map	25% of the concepts are removed from an assigned level	50% of the concepts are removed from the assigned level	75% or more concepts are removed from the assigned level	3
Total	9 points				7/9

Name: Ester Joy Tagudando Title of Concept Map: Polygenic Inheritance

Class, Year and Section: BSEd (Bio) Date: 2/27/18

Criteria	Excellent=4 points	Very Good=3 points	Satisfactory=2 points	Poor=1 point	Score
Connections & Relationships	Terms and concepts are linked in web form, showing multiple relationships between concepts and ideas, linking words accurately describe all relationships	Presented as a web, terms are linked to multiple other terms, linking words describe relationships with 25% errors	Mostly linear, but has some connections that link multiple ideas, linking words are 50% inaccurate	Mostly linear, with very few multiple connections to relate terms, linking words are 75% inaccurate in relating concepts or are absent	3
Concepts and Terminology	Shows an understanding of the topic's concepts and principles and uses appropriate terminology and notations	Makes 25% mistakes in terminology or shows a few misunderstandings of concepts	Makes 50% mistakes in terminology and shows a lack of understanding of many Concepts	Shows no understanding of the topic's concepts and principles	3
Hierarchy	Each concept is correctly assigned to a level Concepts on a map can be represented as a hierarchical structure in which the more general, more inclusive concepts are at the top of the map; the specific and exclusive concepts are at the lower end of the map	25% of the concepts are removed from an assigned level	50% of the concepts are removed from the assigned level	75% or more concepts are removed from the assigned level	3
Total	9 points				9

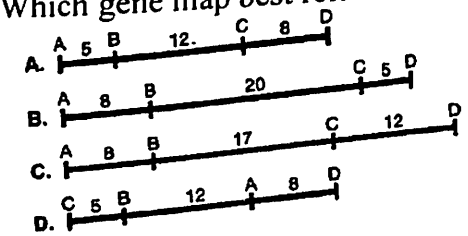
Appendix K
Genetics Inquiry Skills Test

Shade the letter of the correct answer.

Questions 1 and 2: A student calculates the recombination frequency of genes A, B, C, and D on one chromosome. The recombination frequencies are as follows: C-D: 25 map units; A-B: 12 map units; B-D: 20 map units; and A-C: 17 map units.

1. Assuming the student's calculations are correct, how many map units apart are genes A and D?
   3. 5
   4. 8
   5. 10
   6. 12.5

2. Which gene map best reflects the student's data?

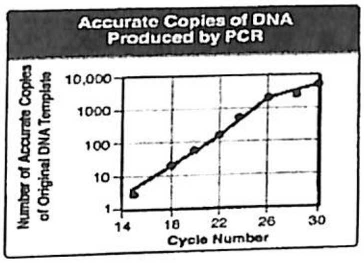


Question 3: A scientist analyzed several DNA samples to determine the relative proportions of purine and pyrimidine bases. Her data are summarized in the table below.

Percentage of Bases in 3 Samples				
Sample	**G**	**C**	**A**	**T**
A	35	35	15	15
B	40	10	40	10
C	25	25	25	25

3. Which sample(s) support(s) the base-pairing rules?
   a. Sample A only
   b. Sample B only
   c. Samples A and C
   d. Samples A,B and C

Questions 4 and 5: The graph below shows the number of accurate copies of DNA produced by polymerase chain reaction (PCR).



4. What can you conclude about cycles 18-26?
   A. PCR produced accurate copies of template DNA at an exponential rate.
   B. The amount of DNA produced by PCR doubled with each cycle of the reaction.
   C. A and B
   D. None

5. Based on the graph, which of the following might have happened between cycles 26 and 28?
   a. The rate of reaction slowed down.
   b. The template DNA was used up.
   c. PCR stopped producing accurate copies of the template.
   d. B and C

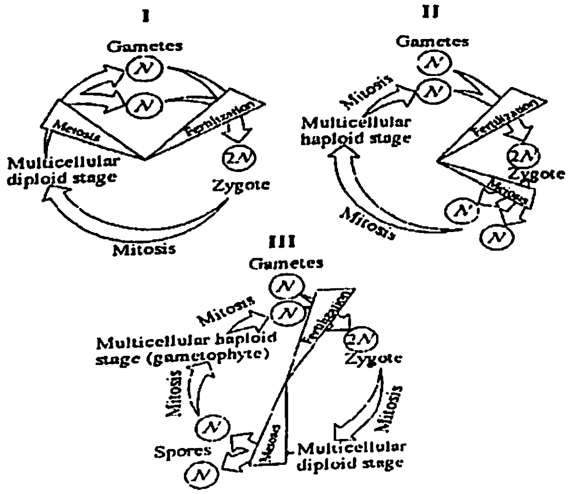
6. Smile dimples are controlled by a dominant allele on a single gene. Whitney has smile dimples, but her husband Alberto and son Pedro do not. What is the chance that Whitney and Alberto's next child will have smile dimples?
   a. Next child has a 25% chance of having smile dimples
   b. Next child has a 50% chance of having smile dimples
   c. Next child has a 75% chance of having smile dimples
   d. Next child has a 100% chance of having smile dimples

7. If a horticulturist breeding gardenias succeeds in having a single plant with a particularly desirable set of traits, which of the following would be her most probable and efficient route to establishing a line of such plants?
   a. Breed this plant with another plant with much weaker traits.
   b. Clone the plant asexually to produce an identical one.
   c. Force the plant to self-pollinate to obtain an identical one.
   d. Backtrack through her previous experiments to obtain another plant with the same traits.

8. Marfan syndrome in humans is caused by an abnormality of the connective tissue protein fibrillin. Patients are usually very tall and thin, with long spindly fingers, curvature of the spine, sometimes weakened arterial walls, and sometimes ocular problems, such as lens dislocation. Which of the following would you conclude about Marfan syndrome from this information?
   a. It is recessive.

b. It is dominant.
c. It is pleiotropic
d. It has a late age of onset (> 60).

Questions 9-10: Refer to the life cycles illustrated in Figure, overleaf, to answer the following questions.

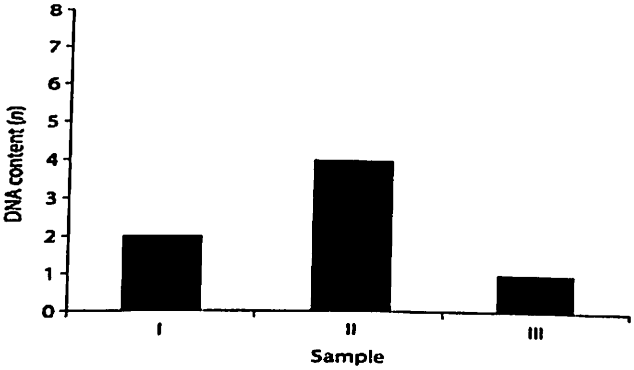


9. Which of the life cycles is typical for animals?
   a. I only
   b. II only
   c. III only
   d. I and II

10. Which of the life cycles is typical for plants and some algae?
    a. I only
    b. II only
    c. III only
    d. I and II

11. Which of the life cycles is typical for most fungi and some protists?
    a. I only
    b. II only
    c. III only
    d. I and II

Questions 12-14: You have isolated DNA from three different cell types of an organism, determined the relative DNA content for each type, and plotted the results on the graph shown in Figure below. Refer to the graph to answer the following questions.



12. Which sample of DNA might be from a nerve cell arrested in G_0 of the cell cycle?
    a. I
    b. II
    c. III
    d. either I or II

13. Which sample might represent an animal cell in the G_2 phase of the cell cycle?
    a. I
    b. II
    c. III
    d. both I and II

14. Which sample might represent a zygote?
    a. I
    b. II
    c. III
    d. either I or II

15. An obstetrician knows that one of her patients is a pregnant woman whose fetus is at risk for a serious disorder that is detectable biochemically in fetal cells. The obstetrician would most reasonably offer which of the following procedures to her patient?
    a. amniocentesis
    b. blood transfusion
    c. chorionic villi sampling
    d. ultrasound imaging

16. Phenylketonuria (PKU) is a recessive human disorder in which an individual cannot appropriately metabolize a particular amino acid. The amino acid is not otherwise produced by humans. Therefore, the most efficient and effective treatment is which of the following?
    a. Feed them the substrate that can be metabolized into this amino acid.
    b. Transfuse the patients with blood from unaffected donors.
    c. Regulate the diet of the affected persons to severely limit the uptake of the amino acid.
    d. Feed the patients the missing enzymes in a regular cycle, such as twice per week.

17. Hutchinson-Gilford progeria is an exceedingly rare human genetic disorder in which there is very early senility and death, usually from coronary artery disease, at an average age of approximately 13. Patients look very old even as children and do not live to reproduce. Which of the following represents the most likely assumption?
    5. All cases must occur in relatives; therefore, there must be only one mutant allele.
    6. Successive generations of a family will continue to have more and more cases over time.
    7. The disorder may be due to mutation in a single protein-coding gene.
    8. Each patient will have had at least one affected family member in a previous generation.
18. One of two major forms of a human condition called neurofibromatosis (NF 1) is inherited as a dominant gene, although it may range from mildly to very severely expressed. If a young child is the first in her family to be diagnosed, which of the following is the best explanation?
    a. The condition skipped a generation in the family.
    b. The mother carries the gene but does not express it at all.
    c. One of the parents has very mild expression of the gene.
    d. The child has a different allele of the gene than the parents.

Questions 19-21: Use Figure 14.1 and the following description to answer the questions below.

In a particular plant, leaf color is controlled by gene locus *D*. Plants with at least one allele *D* have dark green leaves, and plants with the homozygous recessive *dd* genotype have light green leaves. A true-breeding dark-leaved plant is crossed with a light-leaved one, and the F_1 offspring is allowed to self-pollinate. The predicted outcome of the F_2 is diagrammed in the Punnett square shown in Figure below where 1, 2, 3, and 4 represent the genotypes corresponding to each box within the square.

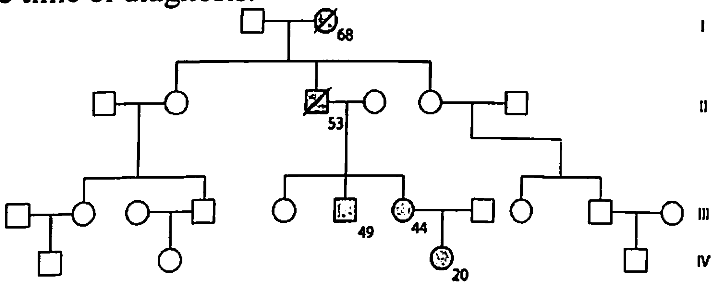
	D	*d*
D	1	2
d	3	4

19. Which of the boxes marked 1-4 correspond to plants with dark leaves?
    a. 1 only
    b. 1 and 2
    c. 2 and 3
    d. 1, 2, and 3

20. Which of the boxes correspond to plants with a heterozygous genotype?
    a. 1
    b. 1 and 2
    c. 1, 2, and 3
    b. 2 and 3

21. Which of the plants will be true-breeding?
   a. 1 only
   b. 1 and 4 only
   c. 2 and 3 only
   d. 1, 2, 3, and 4

Question 22: Use the pedigree below for a family in which dark-shaded symbols represent individuals with one of the two major types of colon cancer. Numbers under the symbols are the individual's age at the time of diagnosis.



22. In each generation of this family after generation I, the age at diagnosis is significantly lower than would be found in nonfamilial (sporadic) cases of this cancer (~ 63 years). What is the most likely reason?
   a. This cancer requires mutations in more than this one gene.
   b. Members of this family know to be checked for colon cancer early in life.
   c. Hereditary (or familial) cases of this cancer typically occur at earlier ages than do nonfamilial forms.
   d. This is pure chance; it would not be expected if you were to look at a different family.

23. One species of green plant, with frondlike leaves, a spine-coated stem, and purple cup-shaped flowers, is found to be self-pollinating. Which of the following is true of this species?
   8. The species must be haploid.
   9. Its reproduction is asexual.
   10. All members of the species have the same genotype.
   11. Some of the seeds would have true-breeding traits.

24. If the environmental parameters (independent variables), such as temperature, humidity, atmosphere, sunlight, and so on, are mostly Earthlike, which of the following do you expect of its types of leaves, stems, and flowers (dependent variables)?
   a. Such plants could be safely eaten by humans.
   b. The genes for them would have originated on Earth.
   c. Genes for these traits would have a common ancestor with those from Earth.
   d. Phenotypes would be selected for or against by these environmental factors.

25. Duchenne muscular dystrophy (DMD) is caused by a gene on the human X chromosome. The patients have muscles that weaken over time because they have absent or decreased dystrophin, a muscle protein. They rarely live past their 20s. How likely is it for a woman to have this condition?
    1. Women can never have this condition.
    2. One-half of the daughters of an affected man could have this condition.
    3. One-fourth of the children of an affected father and a carrier mother could have this condition.
    4. Very rarely would a woman have this condition; the condition would be due to a chromosome error.

26. A phenotypically normal prospective couple seeks genetic counseling because the man knows that he has a translocation of a portion of his chromosome 4 that has been exchanged with a portion of his chromosome 12. Although he is normal because his translocation is balanced, he and his wife want to know the probability that his sperm will be abnormal. What is your prognosis regarding his sperm?
    a. All will carry the same translocation as the father.
    b. None will carry the translocation since abnormal sperm will die.
    c. His sperm will be sterile and the couple might consider adoption.
    d. 1/4 will be normal, 1/4 will have the translocation, and 1/2 will have duplications and deletions.

27. Abnormal chromosomes are frequently found in malignant tumors. Errors such as translocations may place a gene in close proximity to different control regions. Which of the following might then occur to make the cancer worse?
    a. an increase in nondisjunction
    b. expression of inappropriate gene products
    c. a decrease in mitotic frequency
    d. death of the cancer cells in the tumor

28. A couple has a child with Down syndrome. The mother is 39 years old at the time of delivery. Which of the following is the most probable cause of the child's condition?
    a. The woman inherited this tendency from her parents.
    b. One member of the couple carried a translocation.
    c. One member of the couple underwent nondisjunction in somatic cell production.
    d. One member of the couple underwent nondisjunction in gamete production.

29. For a science fair project, two students decided to repeat the Hershey and Chase experiment, with modifications. They decided to label the nitrogen of the DNA, rather than the phosphate. They reasoned that each nucleotide has only one phosphate and two to five nitrogens. Thus, labeling the nitrogens would provide a stronger signal than labeling the phosphates. Why won't this experiment work?
    a. There is no radioactive isotope of nitrogen.
    b. Radioactive nitrogen has a half-life of 100,000 years, and the material would be too dangerous for too long.
    c. Avery et al. have already concluded that this experiment showed inconclusive

results.

d. Amino acids (and thus proteins) also have nitrogen atoms; thus, the radioactivity would not distinguish between DNA and proteins.

30. An experimenter has altered the 3' end of the tRNA corresponding to the amino acid methionine in such a way as to remove the 3' AC. Which of the following hypotheses describes the most likely result?
    8. tRNA will not form a cloverleaf.
    9. The nearby stem end will pair improperly.
    10. The amino acid methionine will not bind.
    11. The anticodon will not bind with the mRNA codon.
31. In prophase I of meiosis in female *Drosophila*, studies have shown that there is phosphorylation of an amino acid in the tails of histones of gametes. A mutation in flies that interferes with this process results in sterility. Which of the following is the most likely hypothesis?
    a. These oocytes have no histones.
    b. Any mutation during oogenesis results in sterility.
    c. All proteins in the cell must be phosphorylated.
    d. Histone tail phosphorylation prohibits chromosome condensation.

32. You are given an experimental problem involving control of a gene's expression in the embryo of a particular species. One of your first questions is whether the gene's expression is controlled at the level of transcription or translation. Which of the following might best give you an answer?
    a. You explore whether there has been alternative splicing by examining amino acid sequences of very similar proteins.
    b. You measure the quantity of the appropriate pre-mRNA in various cell types and find they are all the same.
    c. You assess the position and sequence of the promoter and enhancer for this gene.
    d. An analysis of amino acid production by the cell shows you that there is an increase at this stage of embryonic life.

33. Your brother has just purchased a new plastic model airplane. He places all the parts on the table in approximately the positions in which they will be located when the model is complete. His actions are analogous to which process in development?
    a. Determination
    b. Induction
    c. Morphogenesis
    d. Pattern formation

34. A researcher found a method she could use to manipulate and quantify phosphorylation and methylation in embryonic cells in culture. In one set of experiments using this procedure in *Drosophila*, she was readily successful in increasing phosphorylation of amino acids adjacent to methylated amino acids in histone tails. Which of the following results would she most likely see?

a. increased chromatin condensation
b. decreased chromatin condensation
c. abnormalities of mouse embryos
d. decreased binding of transcription factors

35. A greenhouse manager wants to speed up the production of tomato plants to meet the demands of anxious gardeners. She plants tomato seeds in several trays. Her hypothesis is that the more moisture seeds receive the faster they sprout. How can she test her hypothesis?
    a. Count the number of days it takes seeds receiving different amounts of water to sprout.
    b. Measure the height of the tomato plants a day after each watering.
    c. Measure the amount of water used by plants in different trays.
    d. Count the number of tomato seeds placed in each of the trays

36. A gardener notices that his squash plants are being attacked by aphids. He needs to get rid of the aphids. His brother tells him that "Aphid-Away" powder is the best insecticide to use. The county agent says "Squash-Saver" spray works the best. The gardener selects six squash plants and applies the powder to three and the spray to three. A week later he counts the number of live aphids on each of the plants. How is the effectiveness of the insecticides measured in this study?
    a. Measuring the amount of spray or powder used.
    b. Weighing the squash each plant produces.
    c. Determining the condition of the plants after spraying or dusting.
    d. Counting the number of aphids remaining on the plants.

37. A biologist tests this hypothesis: the greater the amount of vitamins given to rats the faster they will grow. How can the biologist measure how fast rats will grow?
    3. Measure the speed of the rats.
    4. Measure the amount of exercise the rats receive.
    5. Weigh the rats every day.
    6. Weigh the amount of vitamins the rats will eat.

38. A study was done to see if leaves added to soil have an effect on tomato production. Tomato plants were grown in four large tubs. Each tub had the same kind and amount of soil. One tub had 15 kg of rotted leaves mixed in the soil and a second had 10 kg. A third tub had 5 kg and the fourth had no leaves added. Each tub was kept in sun and watered the same amount. The number of kilograms of tomatoes produced in each tub was recorded. What is the hypothesis being tested?
    11. The greater the amount of sunshine the greater the amount of tomatoes produced.
    12. The larger the tub, the greater the amount of leaves added.
    13. The greater the amount of water added, the faster the leaves rotted in the tubs.
    14. The greater the amount of leaves added, the greater the amount of tomatoes produced.

39. What is a controlled variable in this study?
   A. Amount of soil in each tub.
   B. Amount of leaves added to the tubs.
   C. Number of tubs receiving rotted leaves.
   D. Amount of tomatoes produced in each tub.

40. What is the dependent or responding variable?
   a. Amount of soil in each tub.
   b. Amount of leaves added to the tubs.
   c. Number of tubs receiving rotted leaves.
   d. Amount of tomatoes produced in each tub.

Appendix L
Inquiry Skills Reliability – Cronbach Alpha Value of Genetics Inquiry Skills Questionnaire

```
****** Method 1 (space saver) will be used for this analysis ******
_

 R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

  1.   VAR00001
  2.   VAR00002
  3.   VAR00003
  4.   VAR00005
  5.   VAR00006
  6.   VAR00007
  7.   VAR00008
  8.   VAR00009
  9.   VAR00010
 10.   VAR00011
 11.   VAR00012
 12.   VAR00013
 13.   VAR00014
 14.   VAR00015
 15.   VAR00016
 16.   VAR00017
 17.   VAR00018
 18.   VAR00019
 19.   VAR00020
 20.   VAR00021
 21.   VAR00022
 22.   VAR00023
 23.   VAR00024
 24.   VAR00025
 25.   VAR00026
 26.   VAR00027
 27.   VAR00028
 28.   VAR00029
 29.   VAR00033
 30.   VAR00034
 31.   VAR00035
 32.   VAR00036
 33.   VAR00037
 34.   VAR00038
 35.   VAR00041
 36.   VAR00042
 37.   VAR00043
 38.   VAR00044
 39.   VAR00045
 40.   VAR00046
_
```

```
RELIABILITY ANALYSIS - SCALE (ALPHA)

                     Mean      Std Dev     Cases

  1.   VAR00001        1.0333      .1803     120.0
  2.   VAR00002        1.1833      .3886     120.0
  3.   VAR00003        1.1417      .3502     120.0
  4.   VAR00005        1.0750      .2645     120.0
  5.   VAR00006        1.0667      .2505     120.0
  6.   VAR00007        1.0583      .2354     120.0
  7.   VAR00008        1.1250      .3321     120.0
  8.   VAR00009        1.1083      .3121     120.0
  9.   VAR00010        1.1000      .3013     120.0
 10.   VAR00011        1.1000      .3013     120.0
 11.   VAR00012        1.0917      .2898     120.0
 12.   VAR00013        1.1250      .3321     120.0
 13.   VAR00014        1.1167      .3224     120.0
 14.   VAR00015        1.0667      .2505     120.0
 15.   VAR00016        1.1000      .3013     120.0
 16.   VAR00017        1.0417      .2007     120.0
 17.   VAR00018        1.1167      .3224     120.0
 18.   VAR00019        1.0250      .1568     120.0
 19.   VAR00020        1.0333      .1803     120.0
 20.   VAR00021        1.1333      .3414     120.0
 21.   VAR00022        1.1500      .3586     120.0
 22.   VAR00023        1.0917      .2898     120.0
 23.   VAR00024        1.0667      .2505     120.0
 24.   VAR00025        1.1667      .3742     120.0
 25.   VAR00026        1.1250      .3321     120.0
 26.   VAR00027        1.1417      .3502     120.0
 27.   VAR00028        1.1000      .3013     120.0
 28.   VAR00029        1.0583      .2354     120.0
 29.   VAR00033        1.0750      .2645     120.0
 30.   VAR00034        1.0917      .2898     120.0
 31.   VAR00035        1.1500      .3586     120.0
 32.   VAR00036        1.1000      .3013     120.0
 33.   VAR00037        1.1500      .3586     120.0
 34.   VAR00038        1.1250      .3321     120.0
 35.   VAR00041        1.1417      .3502     120.0
 36.   VAR00042        1.1167      .3224     120.0
 37.   VAR00043        1.0750      .2645     120.0
 38.   VAR00044        1.0750      .2645     120.0
 39.   VAR00045        1.1250      .3321     120.0
 40.   VAR00046        1.0917      .2898     120.0

                                                        N of
Statistics for      Mean    Variance    Std Dev    Variables
    SCALE        44.0583     19.8033     4.4501           40
```

```
R E L I A B I L I T Y   A N A L Y S I S  -  S C A L E   (A L P H A)
Item-total Statistics
            Scale        Scale      Corrected
            Mean        Variance      Item-         Alpha
            if Item     if Item       Total        if Item
            Deleted     Deleted    Correlation     Deleted

VAR00001    43.0250     19.5204       .1572         .8377
VAR00002    42.8750     18.3456       .3926         .8322
VAR00003    42.9167     18.2451       .4799         .8296
VAR00005    42.9833     18.9577       .3368         .8341
VAR00006    42.9917     19.3193       .1913         .8373
VAR00007    43.0000     18.8908       .4190         .8326
VAR00008    42.9333     18.4829       .4238         .8314
VAR00009    42.9500     18.9723       .2698         .8358
VAR00010    42.9583     18.7630       .3638         .8333
VAR00011    42.9583     18.7966       .3506         .8336
VAR00012    42.9667     19.0745       .2548         .8361
VAR00013    42.9333     18.2812       .4971         .8293
VAR00014    42.9417     18.7445       .3421         .8338
VAR00015    42.9917     18.9999       .3392         .8342
VAR00016    42.9583     19.0823       .2395         .8365
VAR00017    43.0167     19.4451       .1796         .8374
VAR00018    42.9417     18.8117       .3174         .8345
VAR00019    43.0333     19.5619       .1563         .8377
VAR00020    43.0250     19.6548       .0726         .8390
VAR00021    42.9250     18.8263       .2905         .8353
VAR00022    42.9083     18.8403       .2681         .8361
VAR00023    42.9667     19.3098       .1608         .8384
VAR00024    42.9917     18.9495       .3627         .8336
VAR00025    42.8917     18.8369       .2544         .8367
VAR00026    42.9333     18.9199       .2676         .8359
VAR00027    42.9167     18.7661       .3015         .8350
VAR00028    42.9583     18.8134       .3441         .8338
VAR00029    43.0000     19.1933       .2689         .8357
VAR00033    42.9833     18.7560       .4266         .8321
VAR00034    42.9667     19.0241       .2750         .8355
VAR00035    42.9083     18.3865       .4189         .8314
VAR00036    42.9583     18.6285       .4169         .8319
VAR00037    42.9083     18.8907       .2515         .8366
VAR00038    42.9333     18.8359       .2973         .8351
VAR00041    42.9167     18.6821       .3299         .8342
VAR00042    42.9417     18.8117       .3174         .8345
VAR00043    42.9833     19.5123       .0946         .8396
VAR00044    42.9833     18.9745       .3293         .8343
VAR00045    42.9333     18.6846       .3512         .8335
VAR00046    42.9667     18.5535       .4670         .8307

R E L I A B I L I T Y   A N A L Y S I S  -  S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =    120.0                    N of Items = 40

Alpha =    .8382
```

Appendix M
Genetics Conceptual Understanding Test

Shade the letter of the correct answer.

4. Starting with a fertilized egg (zygote), how many cells will a zygote with a series of five cell divisions of an early embryo produce?
   A) 4
   B) 8
   C) 16
   D) 32
   E) 64

5. At which of the following phases are centrioles beginning to move apart in animal cells?
   A) anaphase
   B) metaphase
   C) prophase
   D) prometaphase
   E) telophase

6. At which stage will mitosis be arrested if cells in the process of dividing are subjected to colchicine, a drug that interferes with the formation of the spindle apparatus?
   A) anaphase
   B) prophase
   C) telophase
   D) metaphase
   E) interphase

7. Taxol is an anticancer drug extracted from the Pacific yew tree which stops mitiosis. In animal cells, Taxol disrupts microtubule formation by binding to microtubules and accelerating their assembly from the protein precursor, tubulin. Surprisingly, this stops mitosis. Specifically, which of the following does Taxol affect?
   A) Anaphase
   B) Chromatid assembly
   C) formation of the centrioles.
   D) the S phase of the cell cycle.
   E) the formation of the mitotic spindle.

8. Which of the following are primarily responsible for cytokinesis in plant cells but not in animal cells?
   A) kinetochores
   B) actin and myosin
   C) centrioles and centromeres
   D) cyclin-dependent kinases
   E) Golgi-derived vesicles

9. Which of the following explains why chromosomes coil during mitosis?
   A) to increase their potential energy
   B) to allow the chromosomes to move without becoming entangled and breaking
   C) to allow the chromosomes to fit within the nuclear envelope
   D) to allow the sister chromatids to remain attached
   E) to provide for the structure of the centromere

10. In which is the human genome minimally contained?
    A) every human cell

B) each human gene
C) each human chromosome
D) the entire DNA of a single human
E) the entire human population

11. At which stage of mitosis are chromosomes usually photographed in the preparation of a karyotype?
A) anaphase
B) interphase
C) metaphase
D) prophase
E) telophase

12. Which of the following is the best conclusion for an organism which has 46 chromosomes in its karyotype?
A) It must be human.
B) It must be a primate.
C) It must be an animal.
D) It must be sexually reproducing.
E) Its gametes must have 23 chromosomes.

13. Which of the following best describes a karyotype?
A) a pictorial representation of all the genes for a species
B) a display of each of the chromosomes of a single cell
C) the combination of all the maternal and paternal chromosomes of a species
D) the collection of all the chromosomes in an individual organism
E) a photograph of all the cells with missing or extra chromosomes

14. When does the synaptonemal complex disappear?
A) during fertilization or fusion of gametes
B) early anaphase of meiosis I
C) mid-prophase of meiosis II
D) late metaphase of meiosis II
E) late prophase of meiosis I

15. In which of the following does independent assortment of chromosomes occurs?
A) The statement is true for mitosis only.
B) The statement is true for meiosis I only.
C) The statement is true for meiosis II only.
D) The statement is true for mitosis and meiosis I.
E) The statement is true for mitosis and meiosis II.

16. How many unique gametes could be produced through independent assortment by an individual with the genotype *AaBbCCDdEE*?
A) 4
B) 8
C) 16
D) 32
E) 64

17. Two plants are crossed, resulting in offspring with a 3:1 ratio for a particular trait. What does this suggest?
A) that the parents were true-breeding for contrasting traits
B) that the trait shows incomplete dominance
C) that a blending of traits has occurred
D) that the parents were both heterozygous for a single trait
E) that each offspring has the same alleles for each of two traits

18. A sexually reproducing animal has two unlinked genes, one for head shape (*H*) and one for tail length (*T*). Its genotype is *HhTt*. Which of the following genotypes is possible in a gamete from this organism?
A) *tt*
B) *Hh*
C) *HhTt*
D) *T*
E) *HT*

19. Which of the following phases of cell division does Mendel's observation of the segregation of alleles in gamete formation has its basis?
A) anaphase of mitosis
B) anaphase I of meiosis
C) anaphase II of meiosis
D) metaphase I of meiosis
E) prophase I of meiosis

20. In certain plants, tall is dominant to short. What is the probability that the offspring will be short if a heterozygous plant is crossed with a homozygous tall plant?
A) 0
B) 1
C) 1/2
D) 1/4
E) 1/6

21. What is the probability of producing the genotype *AABBCC* in the cross *AaBbCc* × *AaBbCc*?
A) 1/4
B) 1/8
C) 1/16
D) 1/32
E) 1/64

22. A woman is found to have 47 chromosomes, including three X chromosomes. Which of the following describes her expected phenotype?
A) sterile male
B) normal female
C) enlarged genital structures
D) excessive emotional instability
E) masculine characteristics such as facial hair

23. Red-green color blindness is a sex-linked recessive trait in humans. Two people with normal color vision have a color-blind son. What are the genotypes of the parents?
A) $X^b X^b$ and $X^b Y$
B) $X^b X^b$ and $X^B Y$
C) $X^B X^B$ and $X^b Y$
D) $X^B X^B$ and $X^B Y$
E) $X^B X^b$ and $X^B Y$

24. Cinnabar eyes is a sex-linked recessive characteristic in fruit flies. What percentage of the F_1 males will have cinnabar eyes if a female having cinnabar eyes is crossed with a wild-type male?
A) 0%
B) 25%
C) 50%
D) 75%
E) 100%

25. What do you call the alteration when one possible result of chromosomal breakage is for a fragment to join a nonhomologous chromosome?
A) deletion
B) duplication
C) inversion
D) translocation
E) transversion

26. Which of the following human aneuploidies has the most severe impact on the health of the individual?
A) 45, X
B) 47, +21
C) 47, XXY
D) 47, XXX
E) 47, XYY

27. What is the source of the extra chromosome 21 in an individual with Down syndrome?
A) nondisjunction in the mother only
B) nondisjunction in the father only
C) duplication of the chromosome
D) nondisjunction or translocation in either parent
E) It is impossible to detect with current technology.

28. What else may occur in an inversion in a human chromosome that has no demonstrable phenotypic effect in the individual?
A) There may be deletions later in life.
B) Some abnormal gametes may be formed.
C) All inverted chromosomes are deleted.
D) There is an increased frequency of mutation.
E) The individual is more likely to get cancer.

29. What is the percentage of Thymine in the nucleotides in the sample where Cytosine makes up 42% of the nucleotides in a sample of DNA from an organism?
A) 8%
B) 16%
C) 31%
D) 42%
E) It cannot be determined from the information provided.

30. Which of the following will be found in an analysis of the nucleotide composition of DNA?
A) A = C
B) A = G and C = T
C) A + C = G + T
D) G + C = T + A
E. None of the above

31. Which enzyme catalyzes the elongation of a DNA strand in the 5' → 3' direction?
A) helicase
B) primase
C) DNA ligase
D) DNA polymerase III
E) topoisomerase

32. At a specific area of a chromosome, the sequence of nucleotides below is present where the chain opens to form a replication fork:

3' C C T A G G C T G C A A T C C 5'

An RNA primer is formed starting at the underlined T (T) of the template. Which of the following represents the primer sequence?

A) 5' G C C T A G G 3'
B) 3' G C C T A G G 5'
C) 5' G C C U A G G 3'
D) 5' A C G T T A G G 3'
E) 5' A C G U U A G G 3'

33. Polytene chromosomes of *Drosophila* salivary glands each consist of multiple identical DNA strands that are aligned in parallel arrays. How could these arise?
A) replication followed by mitosis
B) replication without separation
C) meiosis followed by mitosis
D) fertilization by multiple sperm
E) special association with histone proteins

34. Which of the following help(s) to hold the DNA strands apart while they are being replicated?
A) ligase
B) primase
C) exonuclease
D) DNA polymerase
E) single-strand binding proteins

35. Which of the following strands is looped into domains by scaffolding in a linear eukaryotic chromatin sample?
A) DNA with H1 only
B) the 10-nm chromatin fiber
C) the 30-nm chromatin fiber
D) the metaphase chromosome
E) DNA without attached histones

36. Which result would be consistent with the base-pairing rules in analyzing the number of different bases in a DNA sample?
A) A = G
B) A= C
C) G = T
D) A + G = C + T
E) A + T = G + T

37. Which group of the nitrogenous base adenine is found in all members?
A) ATP, RNA, and DNA
B) proteins, ATP, and DNA
C) α glucose, ATP, and DNA
D) proteins, carbohydrates, and ATP
E) proteins, triglycerides, and testosterone

38. A pregnant woman is told by a genetic counselor that her baby has equal chances of being blood group A or blood group AB. What are possible genotypes of the woman and her husband?
A) AA and BO
B) AB and BO
C) AO and BB
D) AB and AO
E. None of the above

39. Which blood group genotype is homozygous dominant?

A) I^AI^O
B) I^AI^B
C) I^BI^B
D) I^OI^O
E. None of the above

40. A man is blood group A and his wife is blood group AB. What are the possible blood groups of their children?

A) A only
B) AB only
C) A, B and AB
D) A and AB only
E) None of the above

Appendix N

Conceptual Understanding Reliability- Cronbach Alpha Value of Conceptual Understanding Questionnaire

```
RELIABILITY ANALYSIS - SCALE (ALPHA)

 1.  C1
 2.  C3
 3.  C4
 4.  C5
 5.  C6
 6.  C7
 7.  C8
 8.  C9
 9.  C11
10.  C12
11.  C13
12.  C14
13.  C15
14.  C16
15.  C17
16.  C19
17.  C20
18.  C21
19.  C22
20.  C23
21.  C24
22.  C25
23.  C27
24.  C28
25.  C29
26.  C30
27.  C31
28.  C32
29.  C33
30.  C34
31.  C35
32.  C36
33.  C37
34.  C38
35.  C40
36.  C41
37.  C42
38.  C43
39.  C44
40.  C45
```

```
RELIABILITY ANALYSIS - SCALE (ALPHA)

                    Mean      Std Dev    Cases

  1.   C1          1.3833      .4882     120.0
  2.   C3          1.6917      .4637     120.0
  3.   C4          1.5917      .4936     120.0
  4.   C5          1.4667      .5010     120.0
  5.   C6          1.6750      .4703     120.0
  6.   C7          1.5500      .4996     120.0
  7.   C8          1.6417      .4815     120.0
  8.   C9          1.6333      .4839     120.0
  9.   C11         1.4250      .4964     120.0
 10.   C12         1.6750      .4703     120.0
 11.   C13         1.7000      .4602     120.0
 12.   C14         1.5833      .4951     120.0
 13.   C15         1.6750      .4703     120.0
 14.   C16         1.3667      .4839     120.0
 15.   C17         1.4417      .4987     120.0
 16.   C19         1.5583      .4987     120.0
 17.   C20         1.3750      .4862     120.0
 18.   C21         1.6000      .4920     120.0
 19.   C22         1.7083      .4564     120.0
 20.   C23         1.5000      .5021     120.0
 21.   C24         1.6667      .4734     120.0
 22.   C25         1.2750      .4484     120.0
 23.   C27         1.5417      .5004     120.0
 24.   C28         1.5250      .5015     120.0
 25.   C29         1.5083      .5020     120.0
 26.   C30         1.5000      .5021     120.0
 27.   C31         1.5167      .5018     120.0
 28.   C32         1.3750      .4862     120.0
 29.   C33         1.5250      .5015     120.0
 30.   C34         1.4417      .4987     120.0
 31.   C35         1.3667      .4839     120.0
 32.   C36         1.5750      .4964     120.0
 33.   C37         1.3583      .4815     120.0
 34.   C38         1.3833      .4882     120.0
 35.   C40         1.2667      .4441     120.0
 36.   C41         1.3083      .4637     120.0
 37.   C42         1.2833      .4525     120.0
 38.   C43         1.3333      .4734     120.0
 39.   C44         1.4083      .4936     120.0
 40.   C45         1.2250      .4193     120.0

                                                N of
Statistics for     Mean    Variance   Std Dev  Variables
   SCALE         59.6250   63.7658    7.9853      40
```

RELIABILITY ANALYSIS - SCALE (ALPHA)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
C1	58.2417	61.3445	.2854	.8742
C3	57.9333	59.3064	.5942	.8685
C4	58.0333	60.7720	.3574	.8728
C5	58.1583	61.1764	.2984	.8740
C6	57.9500	60.2160	.4560	.8710
C7	58.0750	60.2380	.4227	.8716
C8	57.9833	60.6720	.3815	.8724
C9	57.9917	60.9663	.3395	.8732
C11	58.2000	61.9933	.1952	.8759
C12	57.9500	60.1319	.4678	.8708
C13	57.9250	60.4901	.4280	.8716
C14	58.0417	60.2924	.4199	.8716
C15	57.9500	58.7370	.6669	.8671
C16	58.2583	62.5125	.1332	.8770
C17	58.1833	62.6720	.1070	.8776
C19	58.0667	59.0039	.5891	.8683
C20	58.2500	61.3151	.2908	.8741
C21	58.0250	60.0750	.4522	.8710
C22	57.9167	59.4384	.5853	.8688
C23	58.1250	60.9002	.3335	.8733
C24	57.9583	59.4856	.5555	.8692
C25	58.3500	61.9437	.2297	.8750
C27	58.0833	61.4552	.2626	.8747
C28	58.1000	61.6706	.2341	.8752
C29	58.1167	60.2552	.4181	.8717
C30	58.1250	62.4632	.1324	.8771
C31	58.1083	59.3579	.5375	.8693
C32	58.2500	61.2311	.3021	.8739
C33	58.1000	60.5950	.3739	.8725
C34	58.1833	61.4787	.2607	.8747
C35	58.2583	61.6218	.2514	.8748
C36	58.0500	60.4513	.3975	.8721
C37	58.2667	61.3232	.2931	.8740
C38	58.2417	60.7226	.3686	.8726
C40	58.3583	61.6604	.2736	.8743
C41	58.3167	61.1090	.3368	.8732
C42	58.3417	61.9411	.2274	.8751
C43	58.2917	60.4268	.4232	.8716
C44	58.2167	59.8014	.4874	.8703
C45	58.4000	61.1832	.3669	.8727

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =    120.0              N of Items = 40

Alpha =    .8755
```

Appendix O
Genetics Attitude Questionnaire

Name:____________________________ **Track:**___________ **Date:**__________________

Please check the appropriate response of your choice based on your perception. Be honest!

Legend: SA= Strongly Agree; A = Agree; D=Disagree; SD = Strongly Disagree

Statements	SA	A	D	SD
1. I would prefer to find out why something happens by doing an experiment in Genetics than by being told.				
2. Genetics laboratory activities are fun.				
3. Doing experiment in Genetics is not as good as finding out information from teachers.				
4. I dislike Genetic lab activities.				
5. I would prefer to do experiments in Genetics than to read about them.				
6. School should have more Genetics lab activities each week.				
7. I would rather agree with other people than do an experiment in Genetics to find out for myself.				
8. Genetics lab activities bore me.				
9. I would prefer to do my own experiments in Genetics than to find out information from a teacher.				
10. Genetics lab activity is one of the most interesting school subjects.				
11. I would rather find out about things by asking an expert than by doing an experiment in Genetics.				
12. Genetics lab activities are a waste of time.				
13. I would rather solve a problem by doing an experiment in Genetics than be told the answer.				
14. I really enjoy going to Genetics lab activities.				
15. It is better to ask the teacher the answer than to find it out by doing experiments in Genetics.				
16. The material covered in Genetics lab activities is uninteresting.				
17. I would prefer to do an experiment in Genetics on a topic than to read about it in science magazines.				
18. I look forward to Genetics lab activities.				
19. It is better to be told scientific facts than to find them out from Genetics experiments.				
20. I would enjoy school more if there were no Genetics lab activities.				

Appendix P

Genetics Attitude Reliability – Cronbach Alpha Value of Genetics Attitude Questionnaires

```
****** Method 1 (space saver) will be used for this analysis ******

 R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

   1.     VAR00001
   2.     VAR00002
   3.     VAR00003
   4.     VAR00004
   5.     VAR00005
   6.     VAR00006
   7.     VAR00007
   8.     VAR00008
   9.     VAR00009
  10.     VAR00010
  11.     VAR00011
  12.     VAR00012
  13.     VAR00013
  14.     VAR00014
  15.     VAR00015
  16.     VAR00016
  17.     VAR00017
  18.     VAR00018
  19.     VAR00019
  20.     VAR00020

                          Mean        Std Dev       Cases

   1.     VAR00001      3.7667         .4804        120.0
   2.     VAR00002      3.7583         .4299        120.0
   3.     VAR00003      3.0833        1.0174        120.0
   4.     VAR00004      2.7917        1.3022        120.0
   5.     VAR00005      3.6667         .5551        120.0
   6.     VAR00006      3.5583         .6324        120.0
   7.     VAR00007      2.9250        1.1893        120.0
   8.     VAR00008      2.7583        1.3221        120.0
   9.     VAR00009      3.3333         .8335        120.0
  10.     VAR00010      3.6833         .5183        120.0
  11.     VAR00011      3.0667         .9143        120.0
  12.     VAR00012      2.3750        1.4027        120.0
  13.     VAR00013      3.5583         .6711        120.0
  14.     VAR00014      3.6250         .5807        120.0
  15.     VAR00015      2.9833        1.1226        120.0
  16.     VAR00016      2.6667        1.1976        120.0
  17.     VAR00017      3.3667         .6602        120.0
  18.     VAR00018      3.5583         .5469        120.0
  19.     VAR00019      3.1083         .9684        120.0
  20.     VAR00020      2.7500        1.3237        120.0
```

```
                                                            N of
Statistics for          Mean    Variance       Std Dev   Variables
      SCALE          64.3833    213.0451       14.5961          20
_

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Item-total Statistics

                  Scale          Scale        Corrected
                  Mean          Variance        Item-              Alpha
                 if Item        if Item         Total             if Item
                 Deleted        Deleted      Correlation          Deleted

VAR00001         60.6167        206.1039        .4865              .9661
VAR00002         60.6250        205.7994        .5725              .9658
VAR00003         61.3000        186.6655        .9117              .9614
VAR00004         61.5917        178.3949        .9474              .9609
VAR00005         60.7167        203.0283        .6137              .9652
VAR00006         60.8250        199.6414        .7276              .9641
VAR00007         61.4583        182.2335        .9155              .9613
VAR00008         61.6250        177.9674        .9449              .9610
VAR00009         61.0500        193.3420        .8201              .9628
VAR00010         60.7000        203.5563        .6234              .9652
VAR00011         61.3167        190.9913        .8397              .9624
VAR00012         62.0083        182.5798        .7518              .9647
VAR00013         60.8250        199.9775        .6648              .9646
VAR00014         60.7583        202.2688        .6320              .9650
VAR00015         61.4000        183.7042        .9228              .9612
VAR00016         61.7167        185.4989        .8005              .9631
VAR00017         61.0167        199.4955        .7032              .9643
VAR00018         60.8250        206.0784        .4246              .9665
VAR00019         61.2750        187.2767        .9369              .9611
VAR00020         61.6333        177.8980        .9458              .9610


Reliability Coefficients
                                          N of Items = 20
N of Cases =      120.0

Alpha =      .9652
```

Appendix Q
Genetics Teacher Observation Checklist Questionnaire

Activity Observed: ___________________________________

Date and Time of Observation: ___________________________

Section: **BS Biology (Microbiology/ Premed-Biotech)/ BSEd (Major in Biology)**

Please check (/) the appropriate box.

	Observation	Yes	No
1	Did the teacher encourage the learners to use their senses (sight, touch, smell, taste, and listen) to collect data in a practical situation?		
2	Did the teacher encourage the learners to describe an event in general or to identify its similarities or differences?		
3	Did the teacher promote student independence in contributing an investigable question to develop their thinking?		
4	Did the teacher encourage the learners to ask an investigable question?		
5	Did the teacher encourage the learners to make any predictions to respond to "what if" questions?		
6	Did the teacher promote student independence to carry out instructions, follow procedures and collecting data?		
7	Did the teacher encourage the students to record the results that they obtained from the investigation?		
8	Did the teacher employ strategies to motivate the learners to reflect, or construct meaning to their ideas? To evaluate and communicate their findings?		
9	The metaphor "teacher as listener" was very characteristic of this classroom.		
10	Intellectual rigor, constructive criticism, and the challenge of ideas were valued.		

Comments:

1. ___________________________________

2. ___________________________________

3. ___________________________________

Observed by: ___________________________
Name and Signature

Sample of Completed Genetics Teacher Observation Checklist - Control Group

Activity Observed: Activity #3

Date and Time of Observation: December 12, 2014 1-4 pm RH 201

Section: BS Biology (Microbiology/ [✓ Premed-Biotech])/ BSEd (Major in Biology)

Please check (/) the appropriate box.

	Observation	**Yes**	**No**
1	Did the teacher encourage the learners to use their senses (sight, touch, smell, taste, and listen) to collect data in a practical situation?	/	
2	Did the teacher encourage the learners to describe an event in general or to identify its similarities or differences?		/
3	Did the teacher promote student independence in contributing an investigable question to develop their thinking?		/
4	Did the teacher encourage the learners to ask an investigable question?		/
5	Did the teacher encourage the learners to make any predictions to respond to "what if" questions?		/
6	Did the teacher promote student independence to carry out instructions, follow procedures and collecting data?	/	
7	Did the teacher encourage the students to record the results that they obtained from the investigation?	/	
8	Did the teacher employ strategies to motivate the learners to reflect, or construct meaning to their ideas? To evaluate and communicate their findings?		/
9	The metaphor "teacher as listener" was very characteristic of this classroom.		/
10	Intellectual rigor, constructive criticism, and the challenge of ideas were valued.		/

Comments:

1. ____________________

2. ____________________

3. ____________________

Observed by: Bryan Opena
Name and Signature

Sample of Completed Genetics Teacher Observation Checklist - Control Group

Activity Observed: Activity No. 8

Date and Time of Observation: Feb. 12, 2015 10-1Pm RH 106

Section: BS Biology (Microbiology/ Premed-Biotech)/ [✓ BSEd (Major in Biology)]

Please check (/) the appropriate box.

	Observation	Yes	No
1	Did the teacher encourage the learners to use their senses (sight, touch, smell, taste, and listen) to collect data in a practical situation?	✓	
2	Did the teacher encourage the learners to describe an event in general or to identify its similarities or differences?	✓	
3	Did the teacher promote student independence in contributing an investigable question to develop their thinking?	✓	
4	Did the teacher encourage the learners to ask an investigable question?	✓	
5	Did the teacher encourage the learners to make any predictions to respond to "what if" questions?	✓	
6	Did the teacher promote student independence to carry out instructions, follow procedures and collecting data?	✓	
7	Did the teacher encourage the students to record the results that they obtained from the investigation?	✓	
8	Did the teacher employ strategies to motivate the learners to reflect, or construct meaning to their ideas? To evaluate and communicate their findings?	✓	
9	The metaphor "teacher as listener" was very characteristic of this classroom.	✓	
10	Intellectual rigor, constructive criticism, and the challenge of ideas were valued.	✓	

Comments:

1. ______________________

2. ______________________

3. ______________________

Observed by: BERNIE MALIAO
Name and Signature

Appendix R
Genetics Students Observation Checklist Questionnaire

Activity Observed: ________________________________

Date and Time of Observation: ________________________________

Section: **BS Biology (Microbiology/ Premed-Biotech)/ BSEd (Major in Biology)**

Please check (/) the appropriate box.

Areas	Statement of Observation	Yes	No
Lesson Design and Implementation	1. The lesson was designed to engage student as members of a learning community.		
	2. In this lesson, student exploration preceded formal presentation.		
	3. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.		
	4. The focus and direction of the lesson was often determined by ideas originating with students.		
Content: Propositional Knowledge	5. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.		
	6. Connections with other content disciplines and/or real world phenomena were explored and valued.		
Content: Procedural Knowledge	7. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.		
	8. Intellectual rigor, constructive criticism, and the challenging of ideas were valued.		
Communicative Interaction	9. Students were involved in the communication of their ideas to others using a variety of means and media.		
	10. There was a high proportion of student talk and a significant amount of it occurred between and among students.		
	11. Student questions and comments often determined the focus and direction of classroom discourse.		
	12. Active participation of students was encouraged and valued.		
Student-Teacher Relationship	13. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.		

Comments:

1. ________________________________
2. ________________________________
3. ________________________________

Observed by: ________________________________
Name and Signature

Sample of Completed Genetics Students Observation Checklist - Control Group

Activity Observed: Activity No. 9

Date and Time of Observation: February 20, 2015 RH 201 1-4 PM

Section: BS Biology (Microbiology/ [✓ Premed-Biotech]/ BSEd (Major in Biology)

Please check (/) the appropriate box.

Areas	Statement of Observation	Yes	No
Lesson Design and Implementation	1. The lesson was designed to engage student as members of a learning community.		✓
	2. In this lesson, student exploration preceded formal presentation.	✓	
	3. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.		✓
	4. The focus and direction of the lesson was often determined by ideas originating with students.		✓
Content: Propositional Knowledge	5. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.	✓	
	6. Connections with other content disciplines and/or real world phenomena were explored and valued.	✓	
Content: Procedural Knowledge	7. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.		✓
	8. Intellectual rigor, constructive criticism, and the challenging of ideas were valued.		✓
Communicative Interaction	9. Students were involved in the communication of their ideas to others using a variety of means and media.		✓
	10. There was a high proportion of student talk and a significant amount of it occurred between and among students.		✓
	11. Student questions and comments often determined the focus and direction of classroom discourse.		✓
Student-Teacher Relationship	12. Active participation of students was encouraged and valued.	✓	
	13. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.		✓

Comments:

1. ______________________________

2. ______________________________

3. ______________________________

Observed by: Bryan
Name and Signature

Sample of Completed Genetics Students Observation Checklist - Experimental Group

Activity Observed: Activity # 4

Date and Time of Observation: January 8, 2015 1-4 pm RH 105

Section: **BS Biology ([✓ Microbiology]/ Premed-Biotech)/ BSEd (Major in Biology)**

Please check (/) the appropriate box.

Areas	Statement of Observation	Yes	No
Lesson Design and Implementation	1. The lesson was designed to engage student as members of a learning community.	/	
	2. In this lesson, student exploration preceded formal presentation.	/	
	3. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	/	
	4. The focus and direction of the lesson was often determined by ideas originating with students.	/	
Content: Propositional Knowledge	5. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.	/	
	6. Connections with other content disciplines and/or real world phenomena were explored and valued.	/	
Content: Procedural Knowledge	7. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	/	
	8. Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	/	
Communicative Interaction	9. Students were involved in the communication of their ideas to others using a variety of means and media.	/	
	10. There was a high proportion of student talk and a significant amount of it occurred between and among students.	/	
	11. Student questions and comments often determined the focus and direction of classroom discourse.	/	
Student-Teacher Relationship	12. Active participation of students was encouraged and valued.	/	
	13. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	/	

Comments:

1. ________________________

2. ________________________

3. ________________________

Observed by: BERNICE P. MALIAO

Name and Signature

Appendix S
Genetics Interview Questionnaire

Name of the Student ________________________________ **Track:** ________

1. What are your responses to the overall lab activities? Check (/) one for each.

Criteria	1 (Strongly Disagree)	2 (Disagree)	3 (Agree)	4 (Strongly Agree)
Challenging				
Interesting				
Overwhelming				
Intellectually stimulating				

2. Do lab activities enhance your conceptual understanding? _____

   What concepts are now clear to you based on the lab activities you performed? (Please specify)

   Do lab activities enhance your science skills in Genetics? Explain.

   Do lab activities change your attitudes towards science? If yes, what are those changes that occur? (Please elaborate)

3. Are you comfortable with the level of required work for this course? Explain.

4. What activities did you find more helpful in understanding Genetics concept?

5. Did you find the lab activities helpful in retaining information for the lab? Explain by citing the lab activities that help you retain the information.

Sample of Completed Genetics Interview Questionnaire – Control Group

1. What are your responses to the overall lab activities? Check (/) one for each.

Criteria	1 (Strongly Disagree)	2 (Disagree)	3 (Agree)	4 (Strongly Agree)
Challenging			✓	
Interesting				✓
Overwhelming			✓	
Intellectually stimulating				✓

2. Do lab activities enhance your conceptual understanding? YES

What concepts are now clear to you based on the lab activities you performed? (Please specify)

I understand more about Mitosis and Meiosis. I learned deeper information about them. Also I find the Topics about. Law of independent assortment and Law of segregation more fun and Interesting.

Do lab activities enhance your science skills in Genetics? Explain

I know that knowledge cannot only be extracted from books or from the internet. As a student I am thankful of these lab activities because It enhanced my science skills. I understand things a lot better when I applied some techniques in the lab.

Do lab activities change your attitudes towards science? If yes, what are those changes that occur? (Please elaborate)

The lab activity specifically in genetics that I found the most challenging is that the activity involving yarns. It did change my attitude towards my approach in science. Because of these lab activities I was able to focus even on small details of the lab activity. I knew that even a ~~singe~~ single small mistake could affect our results.

3. Are you comfortable with the level of required work for this course? Explain.

Yes I am. This level of required work might be hard sometimes but I'm thankful because ~~It~~ it enhanced my skills during lab activities. I find this level more challenging and it makes me want to do better.

4. What activities did you find more helpful in understanding Genetics concept?

The activities involving yarns like simulation. It took us a lot of time to finish the said activity but with the "slowly but surely" steps we did in this activity we learned along the way.

5. Did you find the lab activities helpful in retaining information for the lab? Explain by citing the lab activities that help you retain the information.

Yes. Lab activities like mitosis and meiosis. It made me realize that this hard topic can be made even simple. {Mitosis Meiosis}

Sample of Completed Genetics Interview Questionnaire – Experimental Group

1. What are your responses to the overall lab activities? Check (/) one for each.

Criteria	1 (Strongly Disagree)	2 (Disagree)	3 (Agree)	4 (Strongly Agree)
Challenging		~~✓~~	✓	
Interesting			✓	
Overwhelming			✓	
Intellectually stimulating				✓

2. Do lab activities enhance your conceptual understanding? Yes

What concepts are now clear to you based on the lab activities you performed? (Please specify)

non-Mendelian Genetics: multiple alleles wherein explains the concepts of multiple allele and relate actual examples of patterns of multiple allelic traits.

Do lab activities enhance your science skills in Genetics? Explain.

Yes, lab activities enhance my science skill in Genetics because in doing activities we are applying the concept and learnings that we learned, by this activities we are experiencing hands-on activities and we can really appreciate the essence of experiment.

Do lab activities change your attitudes towards science? If yes, what are those changes that occur? (Please elaborate)

Yes, lab activities changes my attitude toward science and these changes are, I became more engagable in doing science experiments, wanted to know everything by doing experiment to find out by myself, and by lab activities, it really answer the question that was formed in my mind by the help of actual doing of activities.

3. Are you comfortable with the level of required work for this course? Explain.

Yes, I'm comfortable with the level of required work for this course because this course only gives us enough knowledge that fits to the capacity of our intellect and skills. By this we are not pressured and can handle well the activities in set schedule.

4. What activities did you find more helpful in understanding Genetics concept?

The non-medelian genetics that shows patterns of multiple allelic Traits. that this activity demonstrate the concep of multiple allele in bloody types in different individuals and how multiple allele in blood types can occur even within a family.

5. Did you find the lab activities helpful in retaining information for the lab? Explain by citing the lab activities that help you retain the information.

Yes, the lab activities helpful in retaining information. example of this is the multiple allele in non-mendelian genetics that demonstrate the multiple allele in blood type of every individual.

Appendix T

Sample of Students' Completed Inquiry-based Laboratory Activities 1 to 10

Sample of Student's Laboratory Activities, Learning Progression, and Concept Mapping

Activity No. 1

Activity No. 1: Mutations on Fruit fly (*Drosophila melanogaster)* as Sources of Variations

Concepts:

Variation is a ubiquitous feature of natural populations. All organisms exhibit variation for a significant number of morphological, biochemical, and behavioral characteristics. Genetic variation is essential for the process of natural selection to produce evolutionary change. This is a teaching cliché thought, but anyway-look around the classroom and you will immediately notice a great deal of variation among members of this class. Some of this variation is morphological: hair color, height, eye color, etc. Some is behavioral: preference for certain foods, knowledge of languages, choice of clothing, etc. For centuries, biologists have sought an explanation for the existence of variation. Much of it has a basis in our genes, a fact that is of tremendous evolutionary significance. Other variation is primarily due to environmental influences on our development. For nearly every trait, however, both genes and environment interact to some extent to produce the organism's phenotype.

Genetic variation is essential to biodiversity and the stability of a population. Genetic variation is ensured by the formation of gametes and their combination to form a zygote.

Opportunities for genetic variation also occur during cell division when chromosomes exchange genetic material causing permanent changes in the DNA sequences of the chromosomes. Random mutations in DNA structure caused by the environment are another source of genetic variation.

Without genetic variation, some of the basic mechanisms of evolutionary change cannot operate.

There are three primary sources of genetic variation, which we will learn more about:

1. Mutations are changes in the DNA. A single mutation can have a large effect, but in many cases, evolutionary change is based on the accumulation of many mutations.
2. Gene flow is any movement of genes from one population to another and is an important source of genetic variation.
3. Sex can introduce new gene combinations into a population. This genetic shuffling is another important source of genetic variation.

Mutation is a change in DNA, the hereditary material of life. An organism's DNA affects how it looks, **how it behaves**, and its physiology — all aspects of its life. So a change in an organism's DNA can cause **changes** in all aspects of its life.

Mutations are random. Mutations can be beneficial, neutral, or harmful for the organism, but mutations **do not** "try" to supply what the organism "needs." In this respect, mutations are random — whether a particular **mutation** happens or not is unrelated to how useful that mutation would be.

Problem:

Design an experiment to examine the effects of exposure to chemical mutagen on the phenotypes of fruit fly.

Objectives:

1. To identify the source of variations in *Drosophila melanogaster.*
2. To develop a hypothesis to predict the effects of chemical mutagen on the phenotypes of fruit fly.
3. To design an experiment to test this hypothesis.
4. To identify a control in the experiment.
5. To draw conclusions from the experiment.

Prelab Activity:

Students will complete the activity consisting of the following parts:

- Introduction
    - Background of the Study (About the mutation, the mutagen used)
    - Objectives/ Statement of the problem:
    - Significance of the Study
    - Scope and Delimitations
- Review of Related Literature
- Methodology

p 2 : Belmonte, Gito, Pamplona, Pelaez, Refugio, Sabid, Sotiar
BSBIO 3B FRUITFLY (Drosophila melanogaster)

ssion:

- What is/are the Independent variables?
  > Amount of mutagen used (lime powder)
  > Amount of control media used (fruits, etc.)
- What is/are the Dependent variables?
  > the emergence of mutant fruitflies
  > " " " wild-type fruitflies
- What is/are the Hypothesis (-es)?
  The mutagen will have mutagenic effects on the fruitfly.
- How will the experiment be done to test your hypothesis?
  The fruitflies will be subjected to the culture media with the mutagen in it to test for its mutagenic effects.
- What are the different components of the setup(s)?
  > We will have one control group and one experimental group.
  > The culture media as the bases of the set-up will have the mutagen in it.
- Enumerate the materials needed?
  Wide-mouthed jar, Fruits (preferably banana), microscope, petri dish
- What will be the data involved? What type of graph will be used?
  Frequency and Percentage of mutant and wild-type fruitflies. Presentation of the data will be interpreted through a bar graph.
- What statistical tools involved?
  Chi-square Test
- What happens in a normal cell in the DNA which has mutations?
  There will be an alteration in the DNA or chromosome structure resulting to the emergence of new alleles.
- What would happen if cells with mutated DNA replicate?
  It wouldn't first undergo DNA repair, but sometimes these mutations can still be passed through generations. And the resulting genes could give life to cancer and other genetic disorder
- How do cells monitor integrity?
  Cells have enzyme that search for errors. then certain endo- and exo nucleases

Activity No. 2

Activity No. 2: Determination of Genotypes from Phenotypes in Humans

Concepts:

An organism can be thought of as a large collection of phenotypes. A phenotype is the appearance of a trait and is determined by pairs of genes. The pairs of genes represent the genotype for the trait. If you were told a large enough number of phenotypic traits that belong to another person, you would be able to recognize that person.

The genotype of an animal represents the gene or the set of genes responsible for a particular trait. In a more general sense, the genotype describes the entire set of genes inherited by an individual. In contrast, the phenotype is the value taken by a trait; in other words, it is what can be observed or measured. For example, the phenotype may be an individual cow's milk production, the percentage of fat in the milk or a classification score for conformation.

Problem:

You will determine some of your own phenotypic traits. From these you will be able to determine what your genotypes are for some of the traits. If a trait is dominant and you possess that trait, you will not be able to determine your exact genotype because you could be either homozygous or heterozygous for the gene. However, if a trait is determined by incomplete dominance, you can tell if you are homozygous or heterozygous. Genotypes of recessive traits can be identified. By comparing your genotypes and phenotypes with other people in your class, you will see why you are unique individual. Given the almost limitless number of gene combinations, it is almost impossible that anyone would have all the same traits as you.

Objectives:

1. Determine your phenotype for nine different characteristics.
2. Determine your possible genotypes for the nine different characteristics.
3. Compare your phenotypes and genotypes with those of other students in the class.
4. Evaluate your uniqueness as an individual.

Procedure:

1. For each of the following traits, observe and record your phenotype in the table. Then record your possible genotypes.
    a. Hairline – The widow's peak hairline comes to a point in the center of the forehead (WW/ Ww). Individuals that lack the trait are ww.
    b. Eye shape – Almond-shaped eyes (AA/Aa) are dominant to round eyes (aa).
    c. Eyelash length – Long eyelashes (EE/Ee) are dominant to short eyelashes (ee).
    d. Tongue rolling – The ability to roll the tongue (CC/Cc) is dominant to the lack of this ability (cc).
    e. Thumb – One whose thumb tip bends backward more than 30 degrees (hitch-hiker's thumb) is dominant (BB/Bb) to a straight thumb (bb).
    f. Lip thickness – Thick lips (LL/Ll) are dominant to thin lips (ll).
    g. Hair texture – Curly hair (HH) is incompletely dominant to straight hair (SS). Those that have wavy hair are HS.
    h. Inter-eye distance – The distance between the eyes is an example of incomplete dominance. Close-set eyes are DD, eyes set far apart are FF, and medium-set eyes are DF.
    i. Lip protrusion – Protruding lips (PP) are incompletely dominant to nonprotruding lips (NN). Slightly protruding lips are PN.

Table 1. Human Phenotypes and Genotypes

Part	Trait			Your phenotype	Your possible genotypes
	Dominant		Recessive		
Hairline	Widow's peak		Straight line	Straight line	ww
Eye shape	Almond		Round	Almond	AA
Eyelash length	Long		Short	Long	Ee
Tongue dexterity	Can roll		Unable to roll	Unable to roll	cc.
Thumb	Hitchhiker's thumb		Straight thumb	Hitchhiker's thumb	BB
Lip thickness	Thick		Thin	thin lips	ll
Hair texture	Curly	Wavy	Straight	Wavy hair	HS
Inter-eye distance	Close together	Medium distance	Far apart	Medium-set eyes	DF
Lip protrusion	Protruding	Slightly protruding	Not protruding	Slightly protruding lips	PN

- ○ Which traits do you have that are dominant?

  Almond eye shape, long eyelash, Hitchhiker's thumb, Wavy hair, medium-set eyes, Slightly protruding lips.

- ○ Which traits do you have that are recessive?

  Straight hairline, unable to roll tongue, thin lip thickness

- ○ Which of your traits are governed by incomplete dominance?

  Wavy hair texture, medium-set eyes, slightly protruding lips

- ○ Which of your traits do you share with one or more of your classmates?

  Straight hairline, Almond eye shape, unable to roll tongue, Hitchhiker's thumb, medium-set eyes

- ○ Which of your traits are unique to you?

  Wavy hair, thin lips

- ○ If you and your classmate shared all of the same traits examined in this activity, what traits could you describe to prove your uniqueness?

  teeth structure, pointed nose

- ○ What determines your trait?

  Genes, from both your mother and father.

- ○ With knowledge of phenotype of a human, how can a person's genotype be determined?

  We can use the traits from its other Family members. We can create a pedigree Analysis for confirmation.

Name: Almaize, Ami K. A. Year and Section: BSEd 3B (Biology)

7/10

Activity On	**Concepts/ Ideas**	**Connecting Ideas**		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	**Cytogenetics (Explain it at the cellular level)**	**Molecular Genetics (Explain at the molecular level)**
Activity No. 1: Mutations on Fruit fly (*Drosophila melanogaster*) as Sources of Variations	Mutations result to genetic variations. • Mutations (changes in an organism's DNA) are the original source of genetic diversity • Mutations create different versions of genes called alleles • Reshuffling of alleles during sexual reproduction produces genetic variation.	Law of Independent Assortment, Law of Segregation, Dominance/ recessiveness of a trait. Theory of Inheritance 4/5	Chromosomes behavior during meiosis. It can inherit its parent traits during meiosis or the trait can be affected if their is a presence of mutant.	Alteration of base sequences; point mutations, error in base pairing or during replication, transcription or translation. Alteration of mutants on the pairing of chromosomes; as the crossing over occurs.

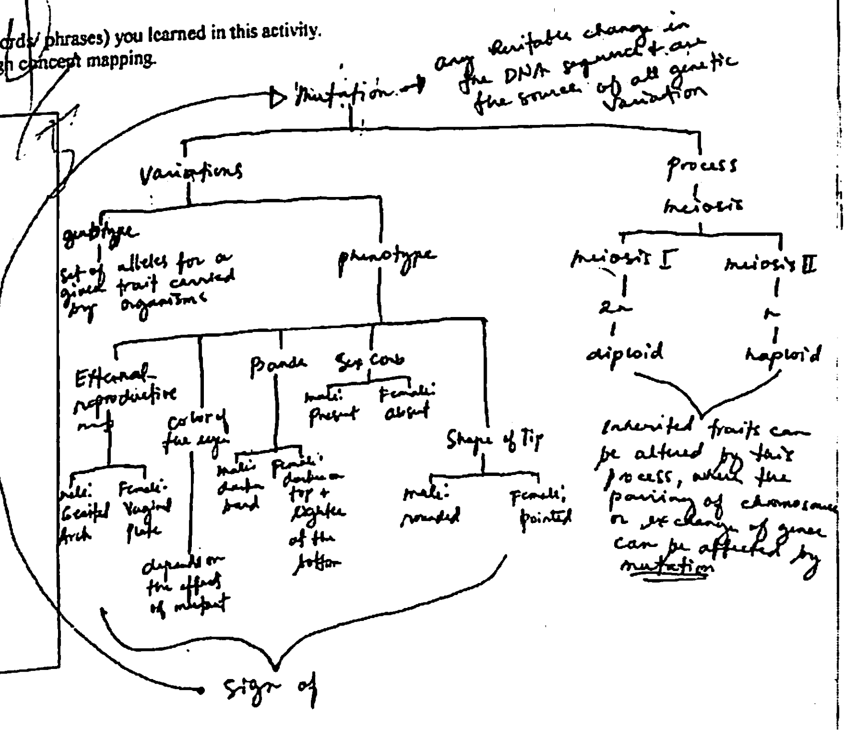
Name: Olmayo, Nairi Fe A. **Year and Section:** BSEd 3E (Biology)

Topic:

A. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping.

mutation
Variation
DNA sequence
classical
Cytogenetics
molecular Genetics
meiosis I + II
traits
Genotype
phenotype
chromosomes
genes
alleles



Name: Jlaisa Jane K. [illegible] Year and Section: BSEd - SE

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 2: Determination of Genotypes from Phenotypes in Humans	Genotype – set of alleles for a given trait carried by an organism Phenotype -it refers to the physical appearance of the individual	Genetic traits, classified as dominant (always expressed), recessive (subordinate to a dominant trait), intermediate (partially express) or polygenic (due to multiple genes), are transmitted in plants and animals. - Law of Segregation - Law of Independent Assortment - Dominance / Recessiveness two unlike unit factors responsible for a single character are present in a single individual, or unit factor is dominant to the other, w/c is said to be recessive.	chromosomes and the way in which they duplicate and separate during cell division at about the same time that geneticists began to understand the behavior of genes at the cellular level.	Along the DNA, base sequences provide the code for building different proteins, which then determine particular features. Specific sections of the DNA determine individual features such as flower color. Variations in the feature are due to differences in sequence of the bases making up a gene.

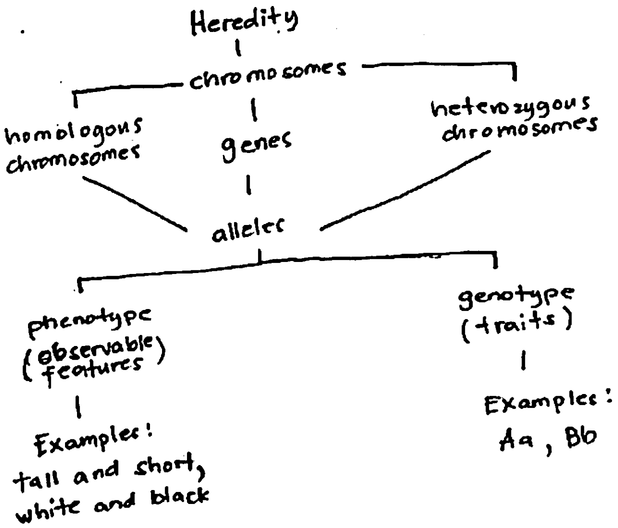
Name: Shaira Jane N. Hinolan **Year and Section:** BSEd- 3E (Biology)

Topic: Heredity

A. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping.

heredity
chromosomes
homologous chromosomes
heterozygous chromosomes
genes
alleles
phenotype
genotype



Activity No. 3

Activity No. 3: Using DNA Evidence: Who did it?

Concepts:

An individual's DNA forms a unique pattern of bands that can be used to identify the person. This unique banding pattern produced by fragments of your DNA is called DNA fingerprinting. Genetic markers can help identify the differences between two DNA samples. Genetic markers are specific stretches of DNA that vary among individuals.

Scientists use polymerase chain reactions (PCR) and gel electrophoresis to make a DNA fingerprint. PCR allows many copies of a certain segment of DNA to be made without using living cells. PCR can make multiple copies of one particular segment from within a larger length of DNA. The DNA fragments are then separated by gel electrophoresis. In this process, the molecules or portions of molecules are separated according to length.

These two techniques, when used together. Allow law enforcement to gather the smallest amount of evidence at a crime scene DNA gathered from a blood or hair sample can then be compared to DNA from a suspect's blood or saliva.

Problem:

The figure shown is an example of DNA patterns made by gel electrophoresis derived from a DNA database. A series of bank robberies were linked and if any of the suspects now in custody are the guilty parties.

Objectives:

1. To use models to represent DNA fingerprints.
2. To infer why DNA patterns differ between individuals.
3. To draw conclusions about which suspect was present in a crime scene.

Procedure:

Figure 1 is an example of DNA patterns made by gel electrophoresis derived from a DNA database

1. Figure 1 is an example of DNA patterns made by gel electrophoresis derived from a DNA database. A series of bank robberies took place in one town during the past four days. Your job will be to A series of bank robberies took place in one town during the past four days. Your job will be to determine if the robberies were linked and if any of the suspects now in custody are the guilty parties.

2. The First National Bank was robbed at noon on Monday. The bank robber ran up to the drive-through window and demanded money. The robber made off with an unspecified amount of money but cut a finger smashing the surveillance camera. Police detectives analyzed the blood sample. The DNA sample is the sample shown in the first column in Figure 1. It is labeled *Bank 1*.

3. The Second National Bank was robbed at 11 A.M. on Tuesday. This time, the bank robber entered the bank and handed the teller a note for an unspecified amount of money. The teller handed over the money but kept the envelope. Luckily for detectives, the robber licked the envelope and left behind a DNA sample. This sample is in the second column of Figure 1. It is labeled *Bank 2*.

4. The Third National Bank was robbed at 10 A.M. on Wednesday. The robber demanded money and left without leaving any evidence at the teller's station. However, the robber had been chewing gum and, just before stepping up to the teller, dropped the gum in the trash barrel. Observant bank patrons alerted the police, and the gum was collected and analyzed. DNA was extracted, and this DNA sample is seen in the third column of Figure 1. It is labeled *Bank 3*.

The police have found three possible suspects, and the suspects have consented to give DNA samples.

5. The police have found three possible suspects, and the suspects should be arrested for the crime or crimes.

6. Examine the DNA strands and see if any of the suspects should be arrested for the crime or crimes. Indicate in the table

7. Record your conclusions in Table 1, and answer the questions that follow. Indicate in the table whether or not the DNA from each suspect was found at a crime scene. Use an X to indicate a positive match.

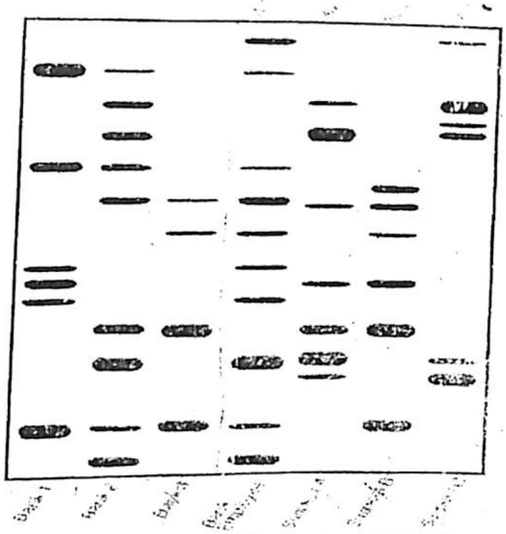


Figure1. DNA Gel Electrophoresis Result

- Constructing hypothesis:
  - What is the hypothesis?

    The Bank 1's suspect is suspect C while the Bank 3's suspect is suspect B.

Table 1. Data and Observations

Suspects	DNA Data			
	Bank 1	Bank 2	Bank 3	
				Bank Employee
Suspect A			X	
Suspect B				
Suspect C	X			

- Were any of the bank robberies committed by the same person? Explain how you know.

  No, because the DNA sample taken from the three banks have no similarities from each other.

- Is there a definite suspect for each bank robbery? Should any of the suspects be released?

  Yes, Suspect B matches with the DNA sample collected in Bank 3. Suspect C in Bank 1. Yes, Suspect A should be released because his|her DNA sample did not match on either of the three Banks.

- Do detectives need to gather more evidence in any of the cases? Explain.

  Yes. The Bank employee's DNA matched with the DNA sample from Bank 2.

- Suppose detectives learn that Suspect A has an identical twin. How will this change their investigation?

  They will investigate both of them. They cannot just based it on their fingerprints because they are just identical to each other. Rather, they will just trace back their whereabouts on the time the incidence happened to verify the event.

- Each suspect had a very different DNA fingerprint. Why do DNA fingerprints vary so much from person to person?

  DNA fingerprints vary so much from person to person because each has its own uniqueness and different types of genes.

Name: Rachel Ann Estanislao Year and Section: BSED III-E

Top

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 3: Using DNA Evidence: Who did it?	Deoxyribonucleic acid, the macromolecule, usually composed of two polynucleotide chains in a double helix, which is the carrier of the genetic information in all cells and many viruses.	• An organisms DNA is made up of its parents genes, but mixed. Some traits of the parents may be also seen in the offspring (actually) sometimes an organisms traits depend on their environment. • The traits of a living thing depend on the complex mixture of interacting components inside it. Proteins do much of the chemical work inside cells, so they largely determine what those traits are. But those proteins owe their existence to the DNA (deoxyribonucleic acid) so that is where we must look for the answer. • It starts with understanding how DNA is organized to start with its basic building blocks. DNA consists of four different sugars that interact with each other in specific ways. These four sugars are called nucleotide bases and have the names (A) adenine (T) thymine (C) cytosine and (G) guanine.	The presence or absence of DNA evidence at a crime scene could mean the difference between a guilty verdict and an acquittal. Changes in the DNA of cells in multi-cellular organisms produce variation in the characteristics of a species. Over long periods of time, natural selection acts on these variations to evolve or change the species	It starts with understanding how DNA is organised to start with its basic building blocks. DNA consists of four different sugars that interact with each other in specific ways. These four sugars are called nucleotide bases and have the names A (adenine) T (thymine) C (cytosine) G (guanine)

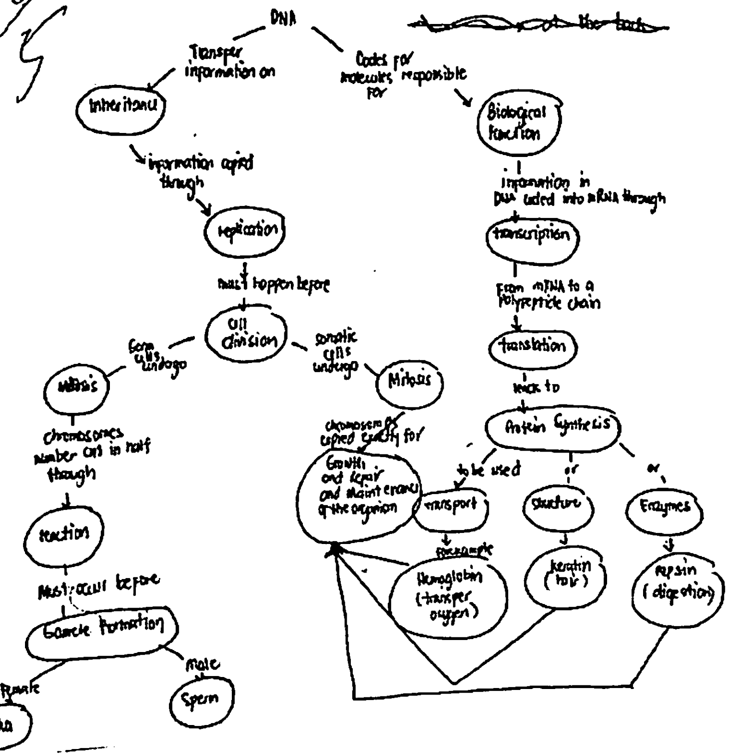
Name: Rachel Ann Estanislao **Year and Section:** BSED II-E

Topic: DNA Evidence: Who did it?

A. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping.

DNA
Inheritance
Biological Function
Replication
Trans
Cell division
mitosis
meiosis
Reduction
Gamete Formation
female (Ova)
male (sperm)
Translation
Protein Synthesis
Growth and Repair and maintenance of the Organism
Transport, Structure, Enzymes
Hemoglobin
Keratin
Pepsin



Activity No. 4

Alejandria, Poral, Cerillo, Azcona, Babayen-on, Caquilgan
GROUP 3

Activity No. 4: Genotoxicity on Chromosome Morphology using *Allium* Test

Concepts:

A chromosome is a structure that occurs within cells and that contains the cell's genetic material. That genetic material, which determines how an organism develops, is a molecule of deoxyribonucleic acid (DNA). A molecule of DNA is a very long, coiled structure that contains many identifiable subunits known as genes. In prokaryotes, or cells without a nucleus, the chromosome is merely a circle of DNA. In eukaryotes, or cells with a distinct nucleus, chromosomes are much more complex in structure.

The term "chromosome" was first suggested in 1888 by the German anatomist Heinrich Wilhelm Gottfried von Waldeyer-Hartz (1836–1921). Waldeyer-Hartz used the term to describe certain structures that form during the process of cell division (reproduction).

A chromosome is an organized structure of DNA and protein that is found in cells. A chromosome is a single piece of coiled DNA containing many genes, regulatory elements and other nucleotide sequences. Chromosomes also contain DNA-bound proteins, which serve to package the DNA and control its functions. The word *chromosome* comes from the Greek chroma - color and soma - body due to their property of being very strongly stained by particular dyes. Chromosomes vary widely between different organisms. Typically eukaryotic cells (cells with nuclei) have large linear chromosomes and prokaryotic cells (cells without defined nuclei) have smaller circular chromosomes, although there are many exceptions to this rule.

Problem:

Design an experiment to examine the effects of exposure to chemical agents on the increase of the number of cells in mitosis and morphology of chromosomes.

Objectives:

1. To identify the normal and abnormal chromosome morphology as induced by different chemical agents used.
2. To develop a hypothesis to predict the effect of chemical exposure on the rate of mitosis and morphology of chromosomes.
3. To design an experiment to test this hypothesis.
4. To identify a control in the experiment.
5. To draw conclusions from the experiment.

[illegible] Activity

- **Preparation** of the reagents needed:
    - Farmer's fluid:
        - Mix 3 parts ethanol and 1 part glacial acetic acid
    - Acetocarmine stain:
        - 1 g carmine dye; 100 ml glacial acetic acid
        - Mix carmine dye and acetic acid. Boil for 5 to 10 minutes. Cool for 6 hours to whole morning. Filter.
- **Students** will complete the activity consisting of the following parts:
    - **Introduction**
        - **Background** of the Study (About the mutation, the mutagen used)
        - **Objectives**/ Statement of the problem:
        - **Significance** of the Study
        - **Scope** and Delimitations
    - **Review of Related** Literature
    - **Methodology**
    - **Results and Discussion**
    - **Conclusions**, Implications and Recommendations

Procedure

A. Preparing Onion Root Tips:

1. Fill two jars with water. Label one jar "control" and the other "experimental."
2. Prepare the bulblets by peeling of the dried outer skin.
3. Cut off the green leaves.

[illegible] roots back to the bulb base with a razor blade.

or Group Activity:

- What is/are the independent variables?

  50% concentration of mutagen (grapejuice)

- What is/are the dependent variables?

  Abnormalities in morphology of chromosome of onion root tips.

- What is/are the hypothesis (-es)?

  Ha - There is a genotoxic effect in chromosome morphology on onion (Allium cepa) root tips.

  Ho - There is no genotoxic effect in chromosome morphology on onion (Allium cepa) root tips.

- How will the experiment be done to test your hypothesis?

  Comparison of the control and experimental set-up of their chromosome.

- What are the different components of the setup(s)?

  water, farmer's fluid, 1M HCl, carbolfuschin, acetocarmine

- Enumerate the materials needed.

  glass slide, coverslip, razor blade, glass jar, microscope

  onion bulb

- Data Analyses: Acquiring and Processing Data, Constructing graph, and Analyzing Investigations
  - What will be the data involved? What kind of graph will be constructed?

    The frequency and percentage of onion root tips, the observed and expected value for the calculation of chi-square, kind of graph is ~~parabola~~ bargraph.

  - What statistical tool(s) involved?

    Chi-square

  - Was there a significant difference between the groups?

    Exposure of mutagen in onion root tips affects the morphology of chromosome. There is a significant difference between the 2 groups (experimental & control).

    expected value is higher than observed value

  - Did the mutagen used increase the number of cells in mitosis?

    yes

  - What other experiments should you do to verify your findings?

    Electron microscopy and other staining methods.

  - Did an increased number of cells in mitosis mean that these cells are dividing faster than the cells in the roots with a lower number of cells in mitosis?

    Yes

  - What other way could you determine how fast the rate of mitosis is occurring in root tips?

    comparison of Interphase and mitotic index.

Guide Questions:

- How are normal cells and cancer cells different from each other?

  The rate of mitotic division of cancer cells are faster than normal cells.

- What are the main causes of cancer?

  Radiation, mutagens, carcinogens

- What goes wrong during the cell cycle in cancer cells?

  Interphase stage because in this stage cells are ~~ele~~ check for their readiness to divide.

- What makes some genes responsible for increased risk of certain cancers?

  [illegible]

9

Name: CONNIE C. DURAN Year and Section: BSBS-3B

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 4: Genotoxicity on Chromosome Morphology using *Allium* Test	Chromosomes are structures that contain the genetic material, which is DNA In eukaryotic species, the chromosomes are found in sets. Eukaryotic cells are often diploid which means that each type of chromosome occurs in a homologous pair.	CHROMOSOMAL THEORY OF INHERITANCE; the genetic material in living organisms is contained within the chromosomes, which are transmitted from generation to generation; the behavior of chromosomes during meiosis to the Mendelian principle of segregation and independent assortment; separation of chromosomes during meiosis could serve as cytological basis.	Chromosomes inside the cell carry DNA. There are two copies of each chromosome in every cell of an organism. One set of chromosome originates from the mother and one set from the father. Chromosome size, position of centromere, and the characteristic banding patterns of alternating light and dark bands (through staining). Chromosomes have various parts: telomeres, the ends of the chromosome; centromere, the primary constriction of the chromosome; chromatid, a single molecule of DNA. Identification of chromosome based on size and position of centromere: metacentric if it's in the middle; submetacentric if it divides the chromosome into 1/3 and 2/3; and acrocentric if it's near the end.	Eukaryotic cells contain their DNA within the nuclear membrane. The DNA double helix is bound to proteins called histones. The histones have positively charged (basic) amino acids to bind the negatively charged (acidic) DNA. The DNA wrapped around the histone core of eight protein subunits forming the nucleosome. The nucleosome is clamped by histone H1. About 200 base pairs (bp) of DNA coil around one histone. The coil "unwinds" so as to generate one negative supertwist per nucleosome. This form of DNA is active chromatin. It can be "expressed" (transcribed and translated) to make RNA and proteins. We can "read" the chromatin on how the cell knows which genes to use: Methylation of histone or of DNA usually turns a gene off; acetylation of histone usually turns a gene on. Phosphorylation. After DNA has been replicated for mitosis (cell division), the chromatin condenses. The nucleosomes zig-zag back and forth to form a flat ribbon. The ribbon forms a coil, which then loops back and forth attached to a nuclear matrix - similar to the protein core of bacteria, but greatly extended. During mitosis, several more layers of coiling results in fully condensed chromatin.

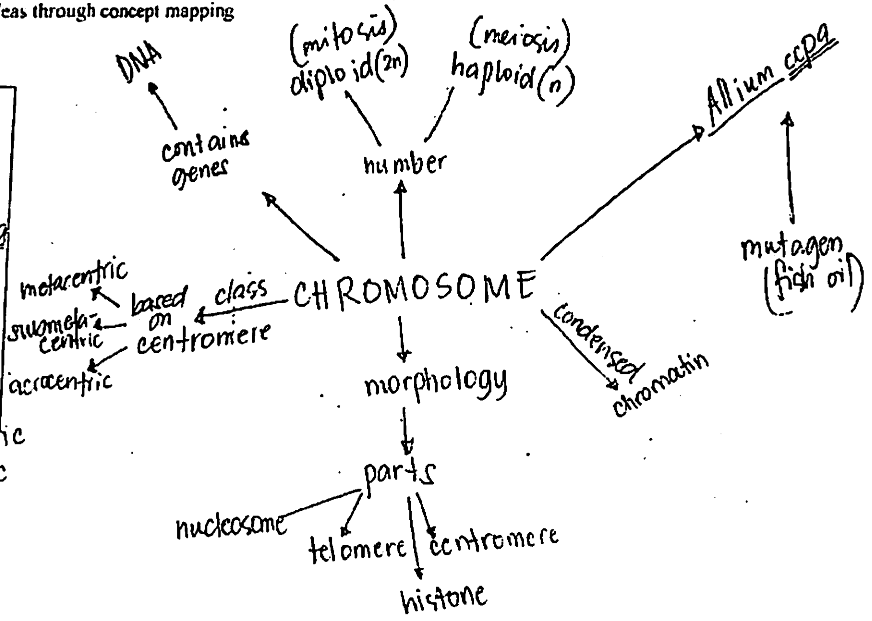
CONNIE C. DURANA Year and Section: BSBS - 3B

Topic: Genotoxicity on Chromosome Morphology using Allium Test

B. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping

CHROMOSOME
haploid diploid
chromatin
histone Allium cepa
DNA genes
mitosis meiosis
telomere centromere
nucleosome
mutagen metacentric
submetacentric
acrocentic



Activity 5

GROUP 1 - BSED-3F

Activity No. 5: Altering the Rate of Mitosis

Concepts:

All biological systems are affected by complex biotic and abiotic interactions involving the exchange of matter and energy.

Mitosis is the division of the nucleus of eukaryotic cells followed by the division of the cytoplasm (cytokinesis). If the division proceeds correctly, it produces two cells that are genetically identical to the original cell. Mitosis is responsible for the growth of an organism from a fertilized egg to its final size and is necessary for the repair and replacement of tissue. Anything that influences mitosis can impact the genetic continuity of cells and the health of organisms.

Problem:

Design and conduct an investigation to determine what abiotic factors (salinity, temperature, and pH) might increase or decrease the rate of mitosis in onion roots.

How do environmental factors affect the rate and quality of mitotic division? Scientists are perhaps most keenly interested in this question from the perspective of disease, specifically, the uncontrolled division of cells known as cancer. This investigation will allow you to make a simplified study of the relationship between the environment and mitosis.

Objectives:

1. To determine the factors that will change the rate of mitosis.
2. To design an experiment to test the hypothesis.
3. To make a hypothesis to describe the effect of abiotic factor on mitosis.
4. To compare growth of onion roots in water and in other factor.

Prelab Activity

Students will complete the activity consisting of the following parts:

- Introduction
    - Background of the Study
    - Objectives/ Statement of the problem:
    - Significance of the Study
- Review of Related Literature
- Methodology
- Results and Discussion
- Conclusions, Implications and Recommendations

Procedure

Comparing Rates of Growth:

1. Put on a laboratory apron and goggles. Label the small glass jars A, B, C, and D.
2. Insert a toothpick into opposite sides of each onion bulb so that each bulb can be balanced over the mouth of a jar, as shown in Figure 1 below.

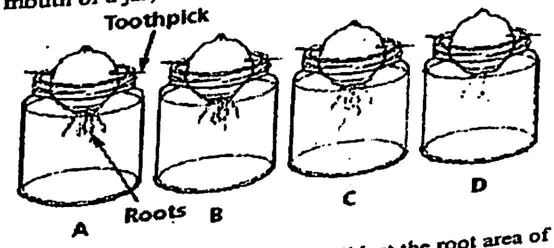


Figure 1. The Setup

3. Then pour water into each jar until just the root area of the bulb is immersed. Wash your hands thoroughly.
4. Examine the bulbs each day. Record the number of roots that emerge from each bulb and the average of their lengths.
5. When the roots have grown to 1 cm in length, pour the water out of jars B, C, and D. You prepare (mutagen to use) solutions of three different concentrations.

6. Fill jar B with the 1% solution, jar C with the 3% solution, and jar D with the 5% solution. Once again, balance the bulbs over the mouth of jars B, C, and D so that the roots are immersed.
7. Measure the roots for 3 more days, each time recording the average length of the roots for each of the treatments (that is, water and the three concentrations of sodium hypochlorite in Table 1.)

For Group Activity: Genetic Inquiry Skills:

- Identify the variables and describe the relationships between these variables
  - What is/are the independent variables?
    - Set up A with an onion and water.
  - What is/are the dependent variables?
    - Set up B with an onion and a concentration of 800ml water mixed with 1ml cigarette
    - Set up C with an onion and a concentration of 800 ml water mixed with 3ml Cigarette.
    - Set up D with an onion and a concentration of 800 ml water mixed with 5ml cigarette.
- Constructing hypothesis:
  - What is/are the hypothesis (-es)?
    - Roots from Set up A would have a longer length compared to set up B, C and D.
    - Roots from Set up B, C and D would have a difference on length.
- Designing investigations and Experimentation
  - How will the experiment be done to test your hypothesis?

    There would be four set-ups. Set-up A contains water alone. Set-up B, C and D contains the mutagen. All of the set-ups (roots) will be measured for 3 days. Finally, the roots will be analyzed and interpreted.
  - What are the different components of the setup(s)?

    Set-up A contains 800 ml pure water with the onion immersed on the opening of the bottle. Set-up B contains 1 ml of cigarette and 800 ml water. Set-up C with 3 ml cigarette and 800 ml water. Set-up D contains 5 ml cigarette with 800 ml water.
  - Enumerate the materials needed?

    4 Onions with the same sizes, toothpicks, four glass bottles, cigarette as a mutagen, measuring tools (ruler or tape measure)
- Data Analyses: Acquiring and processing data, Constructing graph, and Analyzing Investigations
  - What will be the data involved?
    - the measured length of the roots after three days
  - What statistical tools involved?
    - graphs and Mann Whitney Test

Table 1. Number of Roots and Average Length in Water

Day	Bulb A (Water)		Bulb B (1% mutagen)		Bulb C (3% mutagen)		Bulb D (5% mutagen)	
	Number of Roots	Average Length	Number of Roots	Average Length	Number of Roots	Average Length	Number of Roots	Average Length
Day 1								
Day 2								
Day 3								

Guide Questions: Environmental Effects on Mitosis

- What benefit would a plant pathogen derive from excreting a mitosis promoter?

  The possible benefit that can be derived by a plant pathogen from excreting a mitosis promoter are nutrients needed for their reproduction of offspring.
- Explain in terms of rapid cell division on the overall health of the plant.
  - In a good condition, the plant will have a continuous mitotic activity and the plant will grow progressively.
  - In a condition wherein the plant is exposed in undesirable ways, its mitotic activity will be altered and there would be a change in their cellular make-up

Name: Joven J. Loja 8 Year and Section: BSEd 3E

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 5: Altering the Rate of Mitosis	Mitosis is the division of the nucleus of eukaryotic cells followed by the division of the cytoplasm (cytokinesis). If the division proceeds correctly, it produces two cells that are genetically identical to the original cell. Mitosis is responsible for the growth of an organism from a fertilized egg to its final size and is necessary for the repair and replacement of tissue. Anything that influences mitosis can impact the genetic continuity of cells and the health of organisms.	Law of Independent Assortment and Law of Segregation only applies to the process of meiosis only.	During mitosis, parent cell (2n) divides and produces 2 diploid (2n) daughter cells. Stages of mitosis include prophase, metaphase, anaphase and telophase During prophase, there are 4 chromosomes (4 sister chromatids. During metaphase ~~anaphase~~, 4 chromosomes (4 sister chromatids align at the metaphase plate. During anaphase, 4 chromosomes (4 sister chromatids) separates and produces 8 chromatids and each 4 chromatids move oppositely towards different poles During telophase, there are two daughter cells containing 4 chromatids each	alteration in mitosis usually happens at the molecular level particularly in the DNA (replication, translation and transcription - central dogma of molecular biology) If something happens or alters this processes ~~&~~ ~~so~~ (i.e. incorrect base pairing, lack of base pair.) there would be also errors in protein encoding which plays an important in cellular activity - then eventually it would affect / cause abnormality in somatic cells.

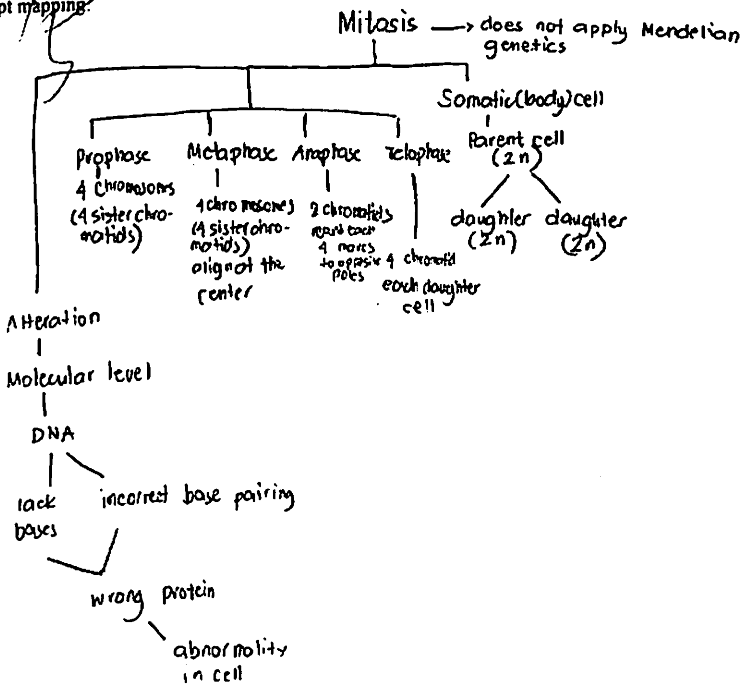
Name: Joven J. Loja **Year and Section:** BSEd 3E

Topic: Altering the Rate of Mitosis

A. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping.

Mitosis
parent cell
daughter cell
prophase
metaphase
anaphase
telophase
DNA
protein
chromosomes
alteration
chromatids
somatic cell
Mendelian genetics



Activity No. 6

Aley Genieveve Dayon

Activity No. 6: Identifying the Stages of Meiosis in Diffprent Specimen

Concepts:

- Meiosis is a special type of cell division that occurs in sexually reproducing organisms.
- Meiosis reduces the chromosome number by half, enabling sexual recombination to occur.
    - Meiosis of diploid cells produce haploid daughter cells, which may function as gametes.
    - Gametes undergo fertilization, restoring the diploid number of chromosomes in the zygote
- Meiosis and fertilization introduce genetic variation in three ways:
    - Crossing over between homologous chromosomes at prophase I.
    - Independent assortment of homologous pairs at metaphase I:
        - Each homologous pair can orient in either of two ways at the plane of cell division.
        - The total number of possible outcomes = 2n (n = number of haploid chromosomes).
    - Random chance fertilization between any one female gamete with any other male gamete.

Problem:

How does the process of meiosis result in gametes (egg and sperm) that are genetically different when they are coming from the same person?

Objectives:

1. To comprehend the mechanism of meiotic division.
2. To differentiate the different stages of meiotic division.
3. To describe the stages of meiosis in different specimen.
4. To determine the chromosome number at the end of each stage of meiosis.

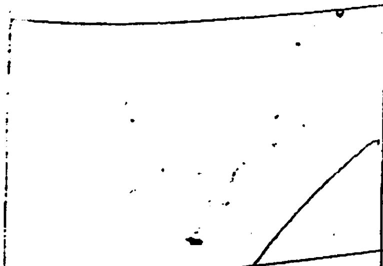
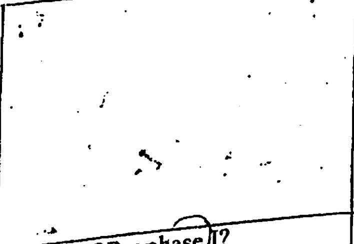
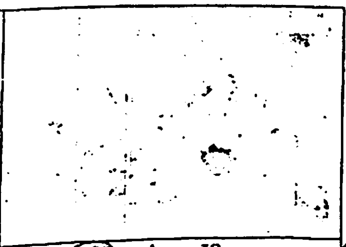
Prelab Activity

Students will be provided with the necessary materials for this activity. Lecture in meiosis will also be discussed

Procedure:

You will label the pictures provided on the different stages of meiosis, cite evidences for such stage, and complete analysis questions at the end.

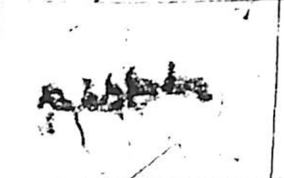
Identify the following stages of Prophase in Meiosis I of the grasshopper testis (If n=12):

		
Stage of Prophase I? Diplonema	Stage of Prophase I? Zygonema	Stage of Prophase I? Pachynema
Chromosome Number = ___	Chromosome Number = ___	Chromosome Number = ___
Evidences: Chromatin material begins to condense.	Evidences: Continue to shorten and thicken ; undergo Initial alignment	Evidences: Chromosomes continue to coil and shorten.

	
Stage of Prophase I? ~~Diplonema~~ Leptotene	Stage of Prophase I? Diakinesis
Chromosome Number = 24	Chromosome Number = 24
Evidences: - Thin threads of chromosome visible w/in the nucleus - progressive condensation and coiling of chromosome takes place	Evidences: The chromosomes pull farther apart .

2.

Identify the following stages of Meoisis II in lily anther: (If n=12)

			
Stage of Meiosis? ~~Prophase~~ Metaphase II	Stage of Meiosis? Anaphase II	Stage of Meiosis? Anaphase II	Stage of Meiosis? ~~Telophase~~ Telophase II
Chromosome Number n=10	Chromosome Number = n=12	Chromosome Number = n=12 .	Chromosome Number =
Evidences centromeres are positioned in metaphase plate	Evidences: sister chromatids are pulled to opposite poles.	Evidences:	Evidences: one member of each of homologous chromosomes are found at the end of the pole -

10

Identify the following stages of Meiosis I in lily anther: (If n =12)

		
Stage of Meiosis? Anaphase I	Stage of Meiosis? Prophase I	Stage of Meiosis? Telophase
Chromosome Number = 24	Chromosome Number = 24	Chromosome Number = 24
Evidences: one half of each tetrad is pulled toward each pole of the cell.	Evidences: Chromosomes coiled up and condense.	Evidences: Nuclear membrane forming around dyad

6

6 **Investigations:**

If there are only three chromosomes in an organism's cell, like in this simulation, how many possible combinations of chromosomes would there be in their gametes?

the possible combinations of chromosomes will be 23 or 16.

0.5

2. How many possible combinations are there in human gamete formation?

Human gametes w/ 23 pairs of chromosomes, the number of possible combinations II 232 or 8 388 608.

3. How does the process of meiosis form cells that are genetically different?

meiosis Is highly specific since it only happens in haploid gametes or spores certain precisely one member of each homologous pair of chromosomes thus ensuring genetic diversity. It can be expressed into two mechanisms: (1) independent assortment of chromosome and (2) crossing over results in genetic exchange between members of each homologous pair of chromosome

4. How is meiosis different from mitosis?

Meiosis occurs in sexually reproducing organisms. Meiosis reduces chromosomes number by half thereby producing haploid daughter cells. These gametes will return into diploid no. of chromosomes after undergoing fertilization. whereas mitosis produces daughter cells with full diploid complement.

5. Females only produce one egg a month, what about the other three cells produced?

The other three cells produced are called polar bodies. Polar bodies have no function and eventually deteriorate.

6. What two sexual sources of variation occur during meiosis and how might these events affect the outcome of meiosis?

Homologous Recombination - two homologous chromosome from the male and female parent cross over one another and exchange genetic material. Chromosomal crossover is random and is governed by its own set of genes that code for when crossover can occur (in cis) and for the mechanism behind the exchange of DNA (in trans)

Polyploidy - Having one or more than two homologous chromosome allows for even more recombination during meiosis allowing for even more genetic variability in one's offspring

Name: ZOE BEA DAIRO Year and Section: BSEd 3-E

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 6: Identifying the Stages of Meiosis in Different Specimen	Meiosis is a type of cell division that reduces the number of chromosomes to half the number found in body cells This reduction in chromosome number occurs during gamete production and is necessary in order to maintain a stable number of chromosomes in cells from generation to generation.	The process of cell division in gametogenesis or sporogenesis during w/c the diploid number of chromosomes is reduced to the haploid number. - Mendel's principles of segregation and independent assortment.	Two successive divisions of diploid cell of a sexually reproducing organism that result in four haploid progeny cells, each w/ half the genetic material of the original cell.	transcription & replication. of DNA

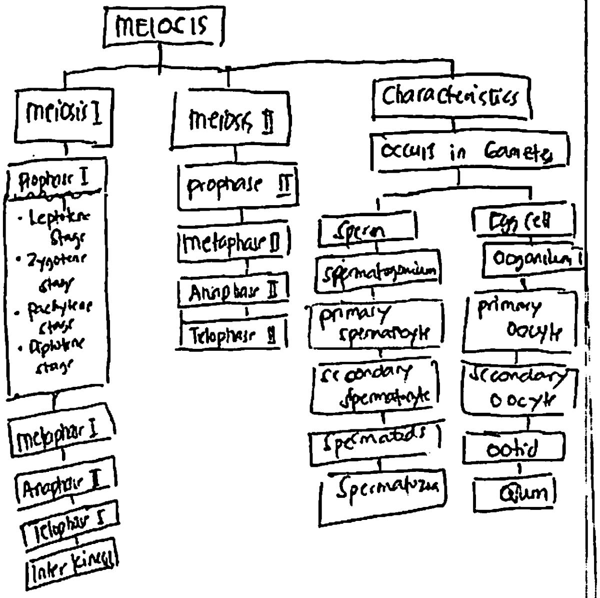
Name: ZOE BEA ONIRO **Year and Section:** BSEd 3-E

Topic: Identifying the stages of Meiosis in Different Specimen

A. **Concept Mapping**
   - ○ List down the concepts (words/ phrases) you learned in this activity.
   - ○ Connect these ideas through concept mapping.

meiosis I
meiosis II
~~[illegible]~~.
~~[illegible]~~.
Prophase I
Prophase II
Metaphase I
Metaphase II
Anaphase I
Anaphase II
Telophase I
Telophase II
Interkinesis
Leptotene Stage
Zygotene Stage
Pachytene "
Diplotene "
~~Diplotene~~ "
Gametes
Sperm

Egg cell
Oogonium
primary Spermatocyte
Secondary Spermatocyte
Spermatids
Spermatozoa
primary oocyte
" Secondary
ootid
ovum



Activity No. 7

Activity No. 7: How Can Karyotype Analysis Explain Genetic Disorders?

20
23

Concepts:

A karyotype is a picture in which the chromosomes of a cell have been stained so that the banding pattern of the chromosomes appears Cells in metaphase of cell division are stained to show distinct parts of the chromosomes The cells are then photographed through the microscope, and the photographed is enlarged. The chromosomes are cut from the photograph and arranged in pairs according to size, arm length, centromere position, and banding patterns Karyotypes have become of increasing importance to genetic counselors as disorders and disease have been traced to specific visible abnormalities of the chromosomes

The study of karyotypes is made possible by staining Usually, a suitable dye is applied after cells have been arrested during cell division by a solution of colchicine. For humans, white blood cells are used most frequently because they are easily induced to divide and grow in tissue culture.

A full account of a karyotype may therefore include the number, type, shape and banding of the chromosomes, as well as other cytogenetic information. Variation is often found:

1. between the sexes
2. between the germ-line and soma (between gametes and the rest of the body)
3. between members of a population (chromosome polymorphism)
4. geographical variation between races
5. mosaics or otherwise abnormal individuals

Objectives:

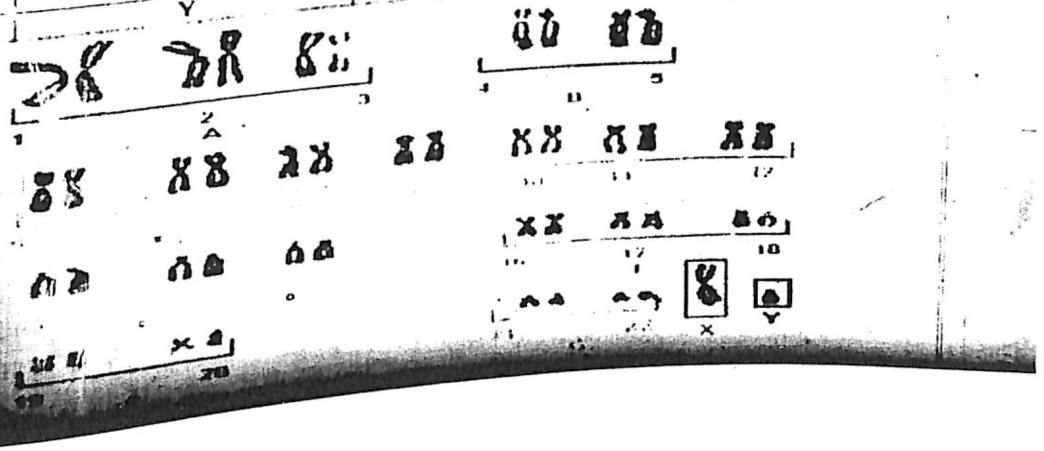
- Construct a karyotype from the metaphase chromosomes of three individuals.
- Analyze prepared karyotypes for chromosome abnormalities.
- Identify the normal and genetic disorders of three individuals by using the provided karyotypes.
- Hypothesize how karyotype analysis can be used to explain the presence of a genetic disorder

Prelab Activity:

- The students will be provided with the standard format or arrangement of the chromosomes as shown in Table 1.
- The students will also obtain copies of the metaphase chromosomes of the three individuals and arrange them as shown in Figure 1.
- Write a hypothesis to describe how karyotype analysis can be used to explain the presence of a genetic disorder. Write your hypothesis in the space provided.

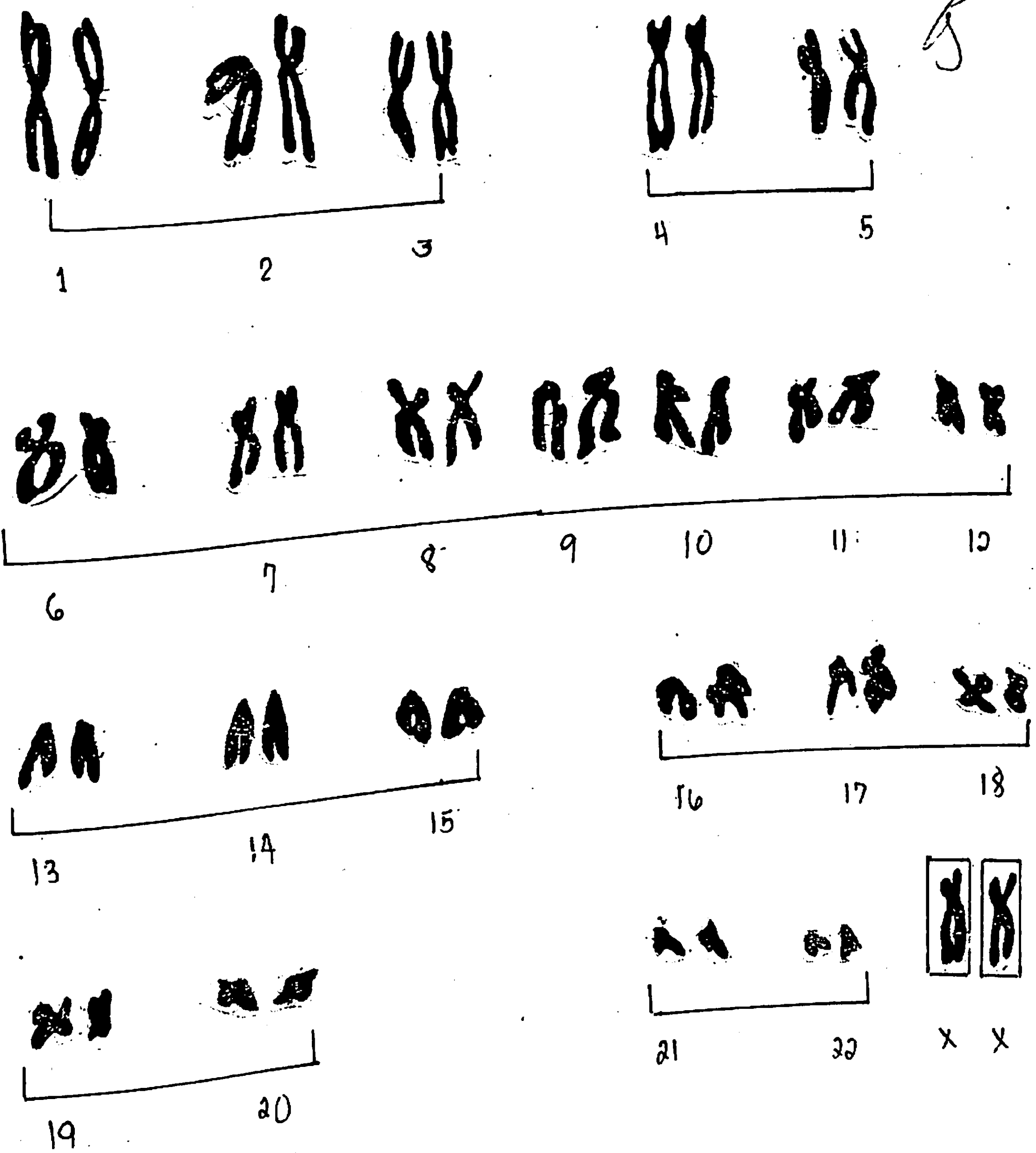
Table 1. General characteristics of the different chromosome groups in the human karyotype.

Group	Chromosome Number	Description
	1,3	Large metacentrics
A	2	Large submetacentrics
B	4,5	Medium submetacentrics
C	6-12, x	Medium acrocentrics with satellites
D	13-15	Small submetacentrics
E	16-18	Small submetacentrics
F	19,20	Small acrocentrics with satellites
G	Y	Small acrocentric without satellites



Group No: 2
Chromosome Set: A (46)
[✓ Normal] / Abnormal: Normal Female

8/8



Group Activity: Genetic Inquiry Skills

- Identify the Variables

  What is the independent variable? Homologons Chromosomes. 7

  What is the dependent variable? chromosomal mutations 7

- What is/ are the hypothesis (-es)

  Any deletion in the structure of the chromosome, additional and subtraction in the number of the chromosome are indications of mutation that could lead to genetic disorders and are observe through karyotype analysis. 8

- Analyzing Investigations

➢ What are the proofs that such set of chromosomes belong to that person i.e. either normal or abnormal?

Normal people should have : normal set of chromosomes . 23 pairs of chromosomes , 46 chromosomes , no deletion in the structure of any of the chromosomes and no additional / lacking chromosomes.

Abnormal people should have : abnormal set of chromosomes , numbers of chromosomes could be monosomy or trisomy , and mutation in the structure of any of the chromosomes in form of deletion

➢ What kind of information would be required if karyotype analysis were to be used to detect the genetic disorders of real organisms?

Cytogenetics contains the concepts and information needed in karyotype analysis . And knowledge in genetics and the structure , number and properties of the chromosomes would be vital.

➢ What characteristics did you use to match up similar chromosomes known as homologous chromosomes?

Location of the centromere whether metacentric , acrocentric or telocentric , size of the chromosomes , the banding patterns of each chromosomes are the characteristics used to match up homologous chromosomes.

➢ Down Syndrome is known as trisomy 21. What does this mean in terms of the numbers of chromosome and the type of abnormality?

Trisomy 21 means that there is an additional chromosome in the 21st pair of chromosomes and the type of abnormality would be aneuploidy.

➢ Why do you think that monosomy or trisomy of the autosomes is more detrimental to survival than monosomy or trisomy of the sex chromosomes?

ng or trisomy of the autosomes has less chances of survival than the monosomy or trisomy of the omes because the genetic disorders that they exhibit has complications on the physical appea- itive ability , diseases and , various multi organ system failure that could be fatal.
may exhibit

and that includes the Down Syndrome affected trisomy affected persons survived for long-term

Name: Ma. May Rose B. Rodriguez Year and Section: BSEd 3-P

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 7: How Can Karyotype Analysis Explain Genetic Disorders?	A display of each of the chromosomes of a single cell Some of the abnormalities associated with chromosomic structure and number can be detected by a test called a *karyotype*. A karyotype can show prospective parents whether they have certain abnormalities that could be passed on to their offspring, or it may be used to learn the cause of a child's disability It can also reveal the gender of a fetus or test for certain defects through examination of cells from uterine fluid – a procedure called amniocentesis – or through sampling of placental membranes.	The process that produces an alteration in DNA or chromosome structure; in genes, the source of new alleles is what we called mutation. Mutations and resulting alleles affect an organism's phenotype and traits are passed from parents to offspring. Chromosome is the unit of genetic transmission, chromosome mutations/ alterations are passed to the offspring in a predictable manner resulting in many genetic outcomes..	Nondisjunction is a cell division error in which homologous chromosomes or the sister chromatids fail to separate and migrate to opposite poles, responsible for defects such as monosomy and trisomy. Chromosome variation originates as a random error during production of gametes. This process disrupts the normal distribution of chromosomes into gametes. Abnormal gametes can form that contain either two members of the affected chromosome or none at all. The unusual characteristic pairing configuration are formed during meiotic synapsis. If there is no loss or gain of genetic material occurs, individuals bearing the aberration heterozygously are likely to be unaffected phenotypically.	Replication slippage can occur anywhere in the DNA but seems distinctly more common in regions containing repeated sequences. Repeat sequences are hot spots for DNA mutation and in some cases contribute to hereditary diseases, such as fragile-X syndrome. The hypermutability of repeat sequence in non coding regions of the genome is the basis for current methods of forensic DNA analysis.

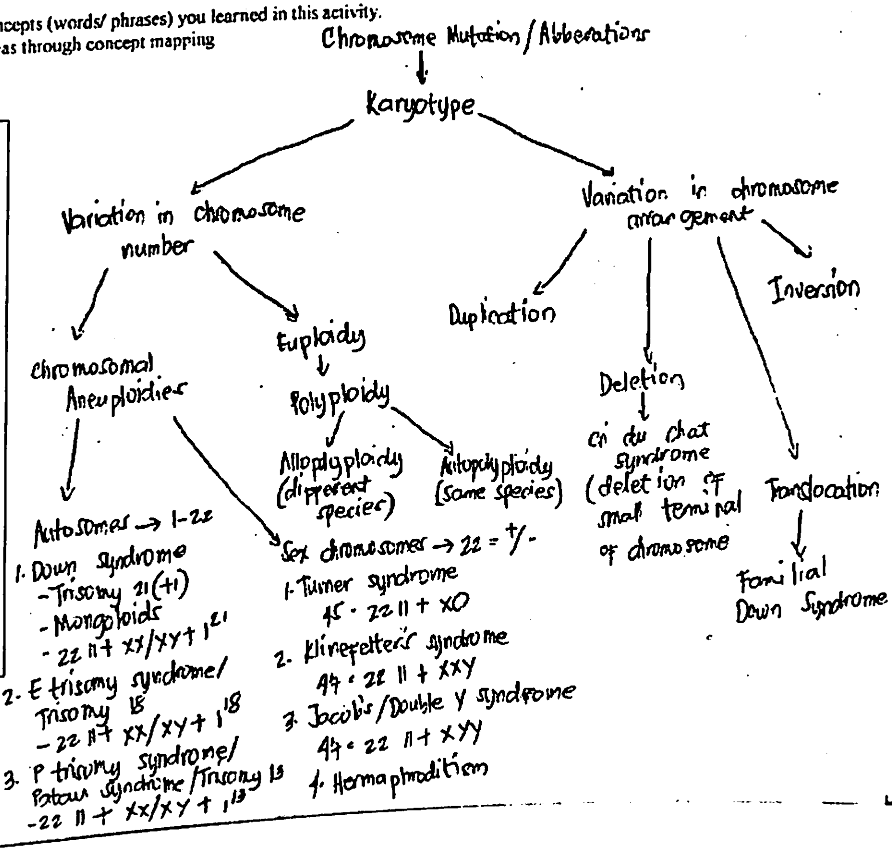
Name: Ma. May Rose B. Rodriguez Year and Section: BSEd 2-F

Topic: How Can karyotype Analysis Explain Genetic Disorders

B. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping

Chromosome Mutation or Abberations
Karyotype
Variation in chromosome number
Chromosomal Aneuploidies
Autosomes
Down Syndrome
Edward trisomy syndrome
Patau syndrome
Exploidy
Polyploidy
Alopolyploidy
Autopolyploidy
Sex chromosomes
Turner's syndrome
Klinefelter's syndrome
Jacob's/Double-Y syndrome
Variation in chromosome arrangement
Duplication
Deletion
Cri du chat syndrome
Inversion
Translocation
Familial Down Syndrome
Hermaphroditism



Activity No. 8

SUMIKATII
SAMANO

Activity No. 8: Mendelian Genetics: What are the chances?

Concepts:

Genetic disorders are abnormal conditions that are inherited through genes or chromosomes. Some genetic disorders are caused by mutations in the DNA of genes. Others are caused by changes in the overall structure or number of chromosomes.

Cystic fibrosis is a genetic disorder in which the body produces unusually thick mucus in the lungs and intestines. This makes it difficult for a person with cystic fibrosis to breathe or digest food. Cystic fibrosis is caused by a recessive allele. At this time, the symptoms of cystic fibrosis can be controlled, but there is no cure for this disease

Problem

In this lab, you will determine the probability that cystic fibrosis will appear in the children of a couple who carry the traits for the disease.

Objectives:

- Construct a pedigree for a family
- Determine the probability of a couple having a child with the genetic disorder.

8 2/12/

Prelab Activity:

- ○ Each group will be provided with a passage for each group to analyze.

Procedure:

1 Read the following family history:
Kathryn has been diagnosed with cystic fibrosis.
Anthony and Emma have a daughter named Kathryn. Anthony's parents are both healthy. Emma's parents are both healthy.
Anthony and Emma are both healthy.
Anthony has a brother, named Corbin, who has cystic fibrosis.

2 In the space in the *Data and Observations* section, draw a pedigree that shows all the family members mentioned here. Use circles to represent the females and squares to represent the males. Shade the circles or squares representing the people who currently have cystic fibrosis.

3 Use the index cards to create a set of cards to represent the alleles. Cut three index cards of each color into fourths. On the 12 blue cards, write *F* to represent the dominant normal allele. On the 12 pink cards, write *f* for the recessive allele.

4 Use the cards to represent Kathryn's alleles. Write her genotype next to the pedigree symbol for Kathryn

5 Use the cards to show Corbin's alleles and write the genotype next to his symbol.

6 Use the cards to determine what genotypes Anthony and Emma must have. Write their genotypes next to their pedigree symbol.

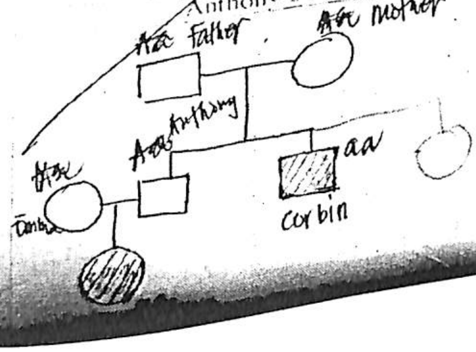
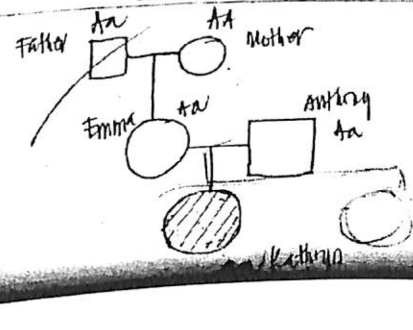
7 . Use the index cards to determine the genotypes of the other family members. Write in all possible genotypes. Fill in each person's genotype next to their symbol in the pedigree.

For Group Activity:

- Constructing hypothesis:
  - ○ What is your hypothesis for the situation given?

    Cystic Fibrosis is an autosomal rececive gene.

- Acquiring and Processing Data:
  - ○ Draw the pedigree of Anthony and Emma's Family

Anthony's Family	Emma's Family
	

Analyses and Conclusions:

- Analyzing Investigations

1. What were the genotypes of Anthony's parents? What were the genotypes of Emma's parents?

Anthony's Parents : A a - Father
A a - mother

Emma's Parents: A a - Father
A A - mother

2. Anthony also has a sister, Zoe. What is the probability that she has cystic fibrosis? Explain.

	A	a
A	AA	Aa
a	Aa	aa

Zoe has 25 % chance of being a carrier of cystic fibrosis.

There is no probability that Zoe will have cystic fibrosis but she could be a carrier of cystic fibrosis. Corbin inherited the cystic fibrosis gene.

3. What is the probability that Anthony and Emma will have another child with cystic fibrosis?

There is 25 % chance that their another child will have cystic fibrosis since Kathryn got a homozygous recessive cystic fibrosis gene. But there is a possibility that she/ or he will be a carrier.

4. Why is information about several generations of family members necessary to get a good idea about a hereditary condition? Explain.

Inorder for them to know the possible conditions of their future offsprings. Also for them to be aware of the genetic background of their future partners.

5. Do you think cystic fibrosis is a sex-linked genetic disorder? Explain.

No. cysticfibrosis is an autosomal recessive genetic disorder. The cause of Kathryn's disease is due to the recessive alleles of both parents.

Name: Ednalyn Tan Year and Section: BSEd 3-E Biology

Activity On	Concepts/ Ideas	Connecting Ideas		
Activity No. 8: Mendelian Genetics: What are the chances?	1 Mendel postulated that unit factors segregate during gamete formation, such that each gamete receives one or the other factor with equal probability 2 Mendel's postulate of independent assortment, states that each pair of unit factors segregates independently of other such pairs	Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level) → Chromosome theory of inheritance	Molecular Genetics (Explain at the molecular level)
Autosomal recessive - manifest only when an individual has two copies of the mutant allele.	Autosomal Dominant conditions are expressed in individuals who have just one copy of the mutant allele. X-linked recessive - traits are not clinically manifest when there is a normal copy of a gene.	Single Gene or Mendelian - Genetic conditions caused by a mutation in a single gene follow predictable patterns of inheritance within families. Single gene inheritance is also referred to a Mendelian inheritance. Four types: Autosomal (Dominant) the gene responsible for the phenotype is located on one of the ~~two~~ 22 pairs of autosomes (non-sex determining chromosome) X-linked - the gene that encodes for the trait is located on the ~~recessive~~ X chromosome.	Walter Sutton proposed a connection between trait inheritance and path that chromosomes travel in meiotic cell division and gamete formation. Observing the testes of lubber grasshopper. He noted that it was possible to distinguish and trace the individual chromosomes in these cells. Both chromosomes existed in pairs that could be distinguished from pair by their size and that upon the union of gametes during fertilization, the chromosomes in the newly fertilized cell maintained their original form. - formation of germ cells (egg & sperm) involves unique type of cell division (meiosis) in which only one pair is transmitted to its progeny cell. The behavior of chromosome pairs thus parallel to that of their genes leading to the conclusion that genes are carried on the chromosomes.	Avery-MacLeod-McCarty experiment. Identified DNA as the molecule responsible for transformation. The role of the nucleus as the repository of genetic information in eukaryotes had been established by Hammerling in 1943 in his work on the single celled called alga Acetabularia. The Hershey-Chase exp. in 1952 confirmed that DNA (rather than protein) is the genetic material of the viruses that infect bacteria providing further evidence that DNA is the molecule responsible for inheritance. → The two strands of parental DNA separate, and each serves as a template for synthesis of a new daughter (new) strand by complementary base pairing.

X-linked Dominant
- Because the gene is located on the X chromosome, there is no transmission from father to son but there can be transmission from father to daughter.

e: ______________________________ Year and Section: ______________

Topic: ______________________________

B. Concept Mapping

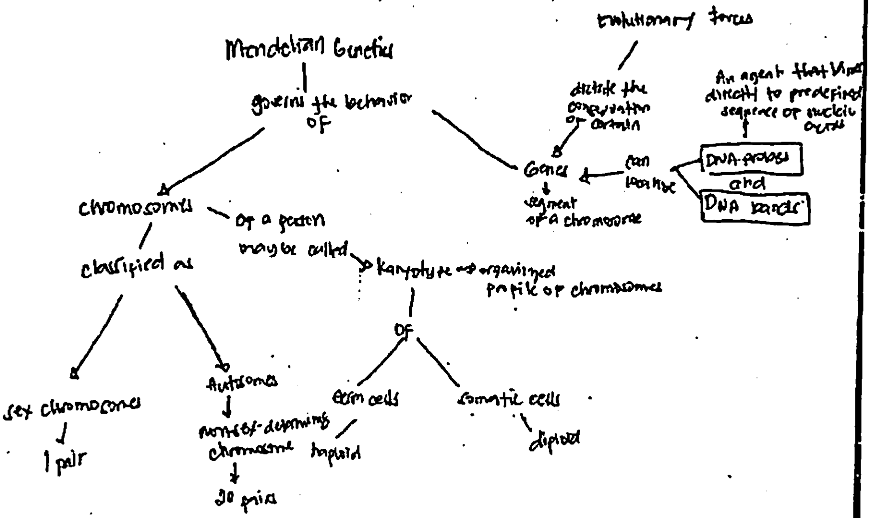
- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping

Mendelian genetics
chromosomes
- sex chromosomes
- autosomes

- Karyotype
  - germ cells
  - Somatic cells

Genes
- locus

Evolutionary forces
DNA probes
DNA bands



Activity No. 9

BSBS - M1 BIOLOGY

Activity No. 9: Multiple Alleles: Using Blood Types to Solve a Mystery

Concepts

In classical Mendelian genetics, each gene has two possible alleles. However, some genes have more than two alleles. In human blood typing (A, B, AB, and O), the gene for the blood type protein has three alleles (A, B, and O). One eye color gene in fruit flies has many alleles.

Human blood types are determined by proteins on the surface of the red blood cells. Alleles A and B, for A type and B-type glycoproteins, are co-dominant; that is, a person who inherits a A allele from one parent and a B allele from the other parent will have type AB blood. The o allele is recessive. The o allele produces no glycoproteins. Thus a person with the genotype Ao will make some type A glycoproteins, and have type A blood. A person with the genotype oo will make neither the A-type nor the B-type glycoproteins, and will have type O blood.

Problem

You are a lawyer for the following:

Mr Cash died and left all of his money to his two children. Because of Mr. Cash's prominent role in society, his death made headlines. Shortly after, a young man named Charlie, who claims to be Mr. Cash's long lost son arrives and demands his share of the inheritance. Mr. Cash's two children and their lawyers are skeptical and refuse this young man the money, so he sues. The judge orders blood tests for all of the family. Mr Cash's blood type, as it appears on his hospital records, is AB. His wife had blood type A. Mr. Cash's two known children were both type B. The young man claiming to be a long lost son had blood type O. Based on the blood tests, prove to the judge whether or not Charlie could be a child of Mr. Cash.

Objectives:

1. To perform Punnett Square crosses for blood type, a multiple allele trait.
2. To apply this knowledge to mystery scenario.
3. To explain what a multiple allele trait is.
4. To identify blood type as a multiple allele trait.

For Group Activity:

- Constructing Hypothesis
  - What is your hypothesis from the given situation?

Charlie is not a son of Mr Cash

- Acquiring and Processing Data and Analyzing Investigations

Create a case (1 paragraph) defending your conclusion

Charlie is not a son of Mr. Cash since Mr. Cash has a Blood type AB and we don't know whats the blood type of the mother of charlie. Since his death made headlines many people have interest in his money, and blood type AB is a rare kind of Blood type. And if we cross the blood type AB and A it will not produce blood type O.

Determine the genotypes for each individual involved, and use at least two Punnett Squares as evidence

	I^A	I^B
I^A	I^AI^A	I^AI^B
I^A	I^AI^A	I^AI^B

	I^A	I^B
I^O	I^AI^A	I^AI^B
I^O	I^AI^9	I^AI^B

Construct a Punnett Square for the cross between a man with type O blood and a woman with type AB blood. If this man and woman have a baby, what possible blood types could the baby have? What is the probability that the baby will have each of these blood types?

	I^A	I^B
I^O	I^AI^O	I^OI^B
I^O	I^AI^9	I^OI^B

The possible blood types the for offsprings of Mr-Cash are blood type [illegible] A & B

Name: JACQUELINE B. NARRA Year and Section: BSED3F

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 9: Multiple Alleles: Using Blood Types to Solve a Mystery	In a population of organisms, the presence of three or more alleles of the same gene An individual may carry only 2 alleles for a given gene. In a population there may be any number of alleles for a gene. ABO blood type gene is an example of a gene with multiple alleles: I^A, I^B or i In classical Mendelian genetics, each gene has two possible alleles. However, some genes have more than two alleles. In human blood typing (A, B, AB, and O), the gene for the blood type protein has three alleles (A, B, and O). One eye color gene in fruit flies has many alleles	Each gene has two possible alleles. Some genes has more than two alleles. The information stored in any gene is specific and mutations can modify the information in many ways. Each change produces a different alleles within members of a population need not be restricted to two. When three or more alleles of same gene are found, multiple alleles are present that create a unique mode of inheritance. Multiple alleles occur in blood type. In human, blood groups are determined by a single gene w/ three possible alleles: A, B, or O.	The simple case of multiple alleles is that in which three alternative alleles of one gene exist. The ABO groups in human consists of a protein on the surface of the blood cell which is called the antigen at is located at chromosome 9. This antigen signal the white blood cell. An individual diploid organism, has, at most, two homologous gene loci that may be occupied by different alleles of the same gene. Among many members of a species, numerous alternative forms of the same gene can exist.	When individuals are tested using antisera that contain antibodies against A or B antigen, four phenotypes are revealed. Each individual has either the A antigen, the B antigen, the A and B antigens or neither antigen. The biochemical basis of the ABO blood-type system has been carefully worked out. The A and B antigens are actually carbohydrates groups that are bound to lipid molecules protruding from the membrane of the red blood cell. The specificity of the A and B antigens is based on terminal sugar of the carbohydrate group. Both A and B antigens are derived from a precursor molecule called H substance.

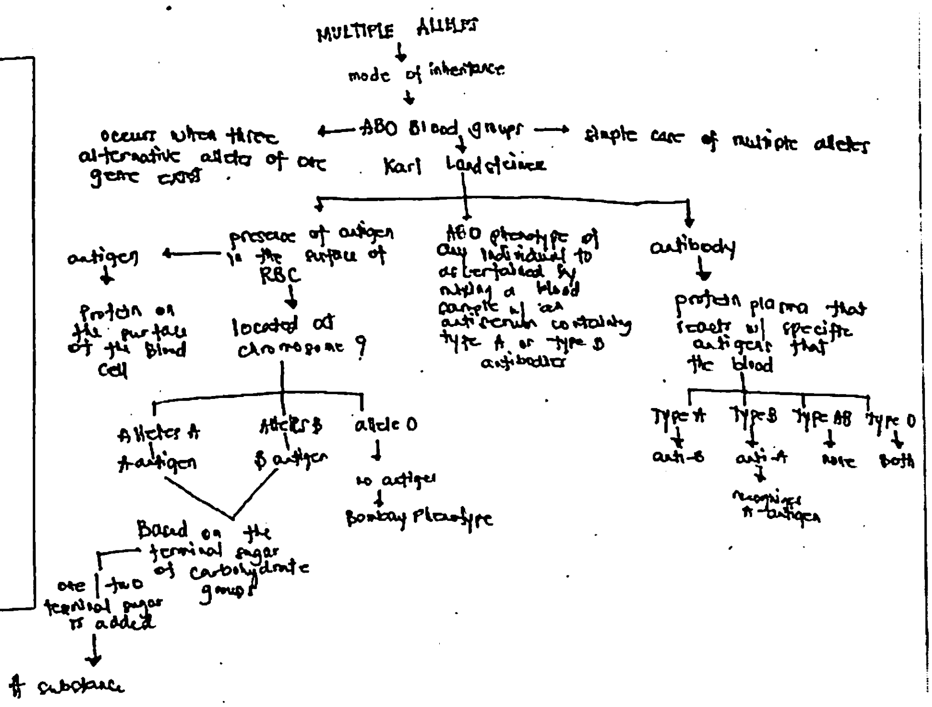
Name: JACOUELINE B. NAPURA **Year and Section:** BSEDBE

Topic: MULTIPLE ALLELES: USING BLOOD TYPES TO SOLVE A MYSTERY

B. Concept Mapping

- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping

Multiple Alleles
ABO Blood groups
Karl Landsteiner
antigen
antibody
chromosome 9
H substance
Bombay Phenotype
ABO phenotype
mode of inheritance



Activity No. 10

SUSBILLA, JOVE **Activity No. 10: Polygenic Inheritance: Tossing Coin**

Concepts:

Polygenic traits are traits that are controlled by more than one gene, i.e. height, weight, hair color, skin color (basically, anything that deals with size, shape and color). This allows for a wide range of physical traits. For example, if height was controlled by one gene A and if AA= 6 feet and aa= 5 feet, then people would be one of two different heights. Since height is controlled by more than one gene, a wide range of heights is possible.

Most human traits are controlled by several genes. Some, such a skin color, eye color, and hair color, are controlled by multiple copies of the same gene. In skin color, for example there are several pairs of genes that code for the pigment melanin. The more copies of the dominant allele a person has, the darker their skin. Some traits, such as human height, are controlled by the activities of many different genes.

Problem:

Why are there so many different forms of the characteristics of height, eye color, and hair color?

Objective:

To understand polygenic traits, how they work, and how parents determine the polygenic trait of a child.

Prelab Activity:

Use coins to represent genes (heads are dominant or active alleles, tails are recessive or inactive alleles), this can be shown to students on how people fall into a bell curve arrangement and how different heights (or other traits) are passed on to children.

Procedure:

Once the coins have been handed out (six per each group) and the procedures have been reviewed, the class result table will be posted on the board, so that the class can collect the data. Each group will record the number of times the following situations occurred when the coins were flipped. Each coin represents a different gene that height is inherited from.

1. Each group will carefully flip all six coins on the lab table. One person will shake the coins in their hand and have them gently spill onto the table. One person will record the heads and tails.
2. Record the number of heads and tails that result from the flip in table 1.
3. Continue to flip the six coins and continue to record the number of heads and tails that result from the flip until table 1 is complete.
4. Complete table 2 by adding up the number of times the following situations occurred.
   - **0 Tails and 6 Heads**
   - **1 Tail and 5 Heads**
   - 2 Tails and 4 Heads
   - 3 Tails and 3 Heads
   - 4 Tails and 2 Heads
   - 5 Tails and 1 Head
   - 6 Tails and 0 Heads
5. Record your results from table 2 on the board with the class results.
6. Record the class results in table 2.

125
73

Results:

Table 1: Group results

Flip (Group)	1	2	3	4	5
Number of tails	5	3	2	3	5
Number of heads	1	3	4	3	1

Table 1 continued

Flip (Group)	6	7	8	9	10
Number of tails	1	3	4	1	3
Number of heads	5	3	2	5	3

Table 2. Group and class results

Flip Situation	0 T 6 H	1 T 5 H	2 T 4 H	3 T 3H	4 T 2 H	5 T 1 H	6 T 0 H
Your Group Total	0	2	1	4	1	2	0
Class Total	2	12	18	33	25	14	[illegible]

For Group Activity:

- Acquiring and Processing Data, Constructing a Table of Data, and Constructing a Graph
  - Construct a bar graph from the class data. The number of heads and tails will go on the X axis (the independent variable), while the number of times the situation occurred will go on the Y axis (the dependent variable).
  - Results: Tabulate the result of your coin flips and the coin flips of your group. Construct a Graph for both your results and the class results.

- Analyzing Investigations

8

1. Do parents give (All or Half) of their genetic material to their children?

Yes, parents give their half genetic material to their children.

2. If a male is 5 feet 9 inches tall, it means that he has 4 dominant genes and 2 recessive. He will only give 3 genes to his child. What are the possible combinations of genes that he can give?

He can give 2 dominant and 1 recessive
He can give 3 dominant and 0 recessive
He can give 1 dominant and 2 recessive

3. The male is 5 feet 7 inches and the female is 5 feet 5 inches. Is it possible for them to give their child the necessary genes so the child can be 5 feet 11 inches tall? Explain your answer. Diagrams are often useful.

Yes, because it depends on the genes acquired by the children.

4. If 2 parents are 5 feet 7 inches, is it possible to have a child that is 6 feet tall? Explain how this is possible. Yes, because human traits are controlled by several genes. And also the child can have the combination of his parents genes.

5. If the male is 5 feet 5 inches tall and the female is 5 feet 3 inches tall, what is the tallest height that their child could attain? Explain. 5 feet and 4 inches tall because his parents think the child is this height will be attained by this child were not so tall and

6. If the male is 5 feet 7 inches tall and the mother is 5 feet 3 inches tall, what is the shortest height their child could attain? Explain.

Maybe. It will be also 5 feet & 3 inches tall, similar to his mother. It is because maybe the child could get the genes from his mother.

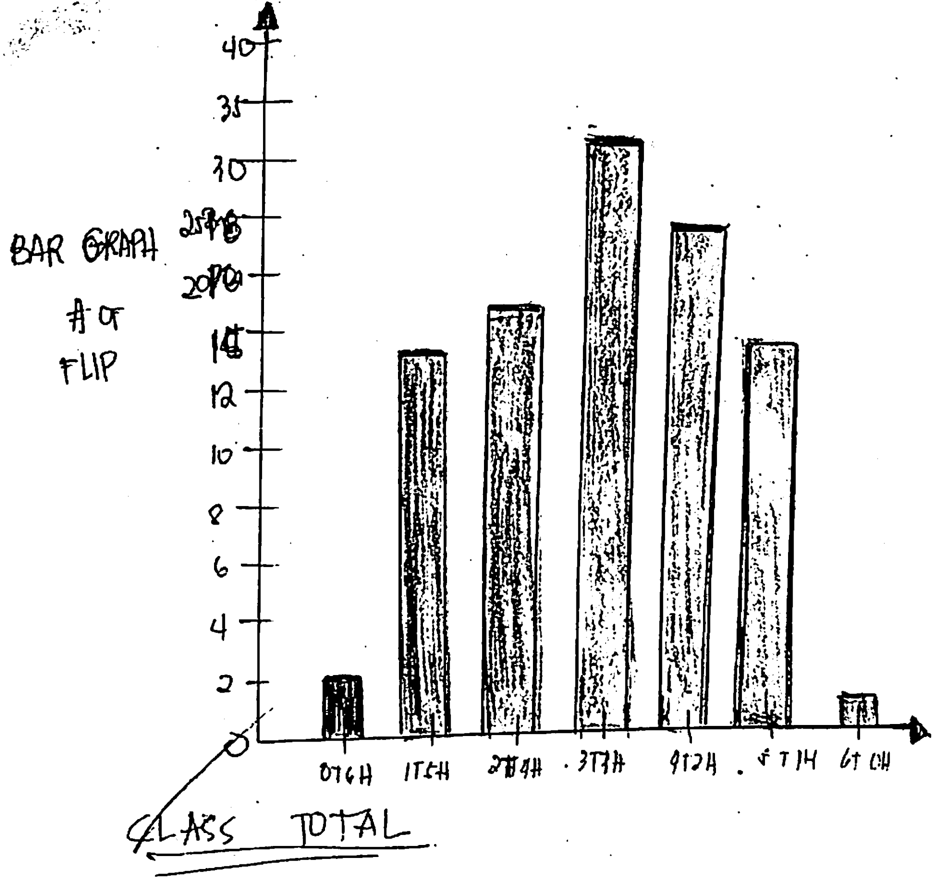
7. List 3 other polygenic traits

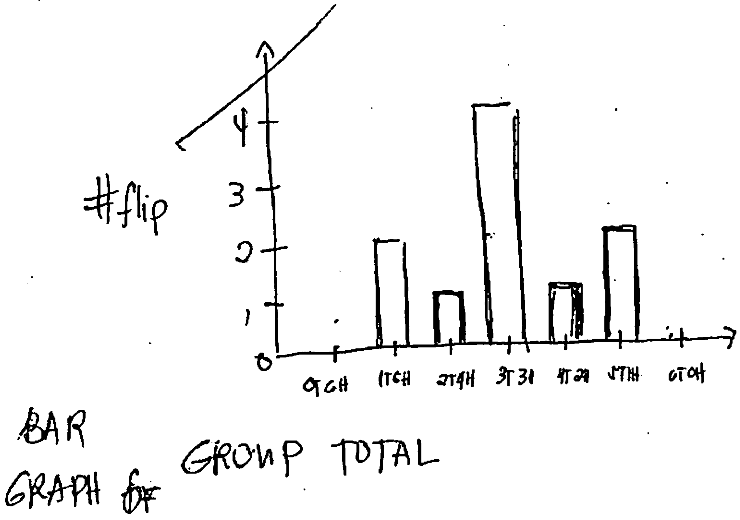
① height
② weight
③ hair color

8. How are polygenic traits different from traits that only require 2 genes? Polygenic traits are traits that are controlled by more than one gene, while those that requires only 2 genes needs only 2 gene to be acquired by an individual.

9. Why do you think that some children are taller than their parents?

It is because of genetic ~~[illegible]~~ combination of her/his parents and the influence of environmental conditions and also And the diff. genes from his/her parents have been acquired by him/her so there is the possibility that some children that so there is the maybe possibility taller than their parents


BAR GRAPH
of
FLIP
40
35
30
25
20
15
12
10
8
6
4
2
0
0T6H
1T5H
2T4H
3T3H
4T2H
5T1H
6T0H
CLASS TOTAL


#flip
4
3
2
1
0
0T6H
1T5H
2T4H
3T3H
4T2H
5T1H
6T0H
BAR
GRAPH for
GROUP TOTAL

Name: AYESHA CARL C. DESCARTIN Year and Section: BSED 3E

Activity On	Concepts/ Ideas	Connecting Ideas		
		Classical Genetics/ Mendelian Genetics (Explain how the trait is transmitted)	Cytogenetics (Explain it at the cellular level)	Molecular Genetics (Explain at the molecular level)
Activity No. 10: Polygenic Inheritance: Tossing Coin	Polygenic Inheritance is a term used to describe cases where many genes contribute to an observed phenotype. Examples of traits that have been described as polygenically inherited include; intelligence, height, fingerprint pattern and skin color. What this really means is that traits under polygenic control don't often fall into discrete categories, i.e. they show continuous variation. Expression of polygenic traits is often markedly affected by the environment, causing them to be referred to as multifactorial traits	The principle of segregation of Mendelian Genetics states that for any particular trait, ~~the particular that~~ the pair of alleles of each parent separate & only one allele passes on to. ~~an~~ offspring. Another principle is the independent assortment, postulates that different pairs of alleles are passed to offspring independently of each other. The phenotypes ~~of~~ that is positively associated w/ SNPs (single nucleotide polymorphisms) that vary from one person to the next may indicate ~~[illegible]~~ to the trait that is located in a chromosomal region close to a genetic variant (mutation) that contributed to the trait.	Mitosis & Meiosis The genotype of each parent having different phenotypes that is associated w/ SNPs (single nucleotide polymorphisms) w/c is positively associated w/ it, can indicate mutation on the trait product of ~~chromosomal ab~~ ~~Another cause of~~ ~~polyg~~	Chromosomal aberrations ~~alteration~~ in the normal chromosomal content of a cell major cause of genetic condition in human. The presence of SNP ~~[illegible]~~ (single nucleotide polymorphisms) w/c is positively associated w/ phenotype ~~[illegible]~~ of individuals may help indicate the traits located in a chromosomal region.

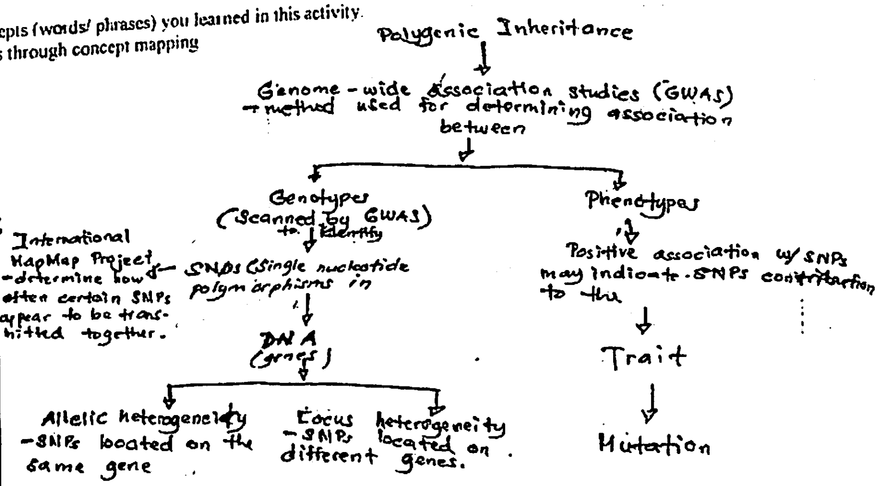
Name: AYESHA CARL C. DESCARTIN Year and Section: BSED 3E

Topic: Polygenic Inheritance

B. Concept Mapping

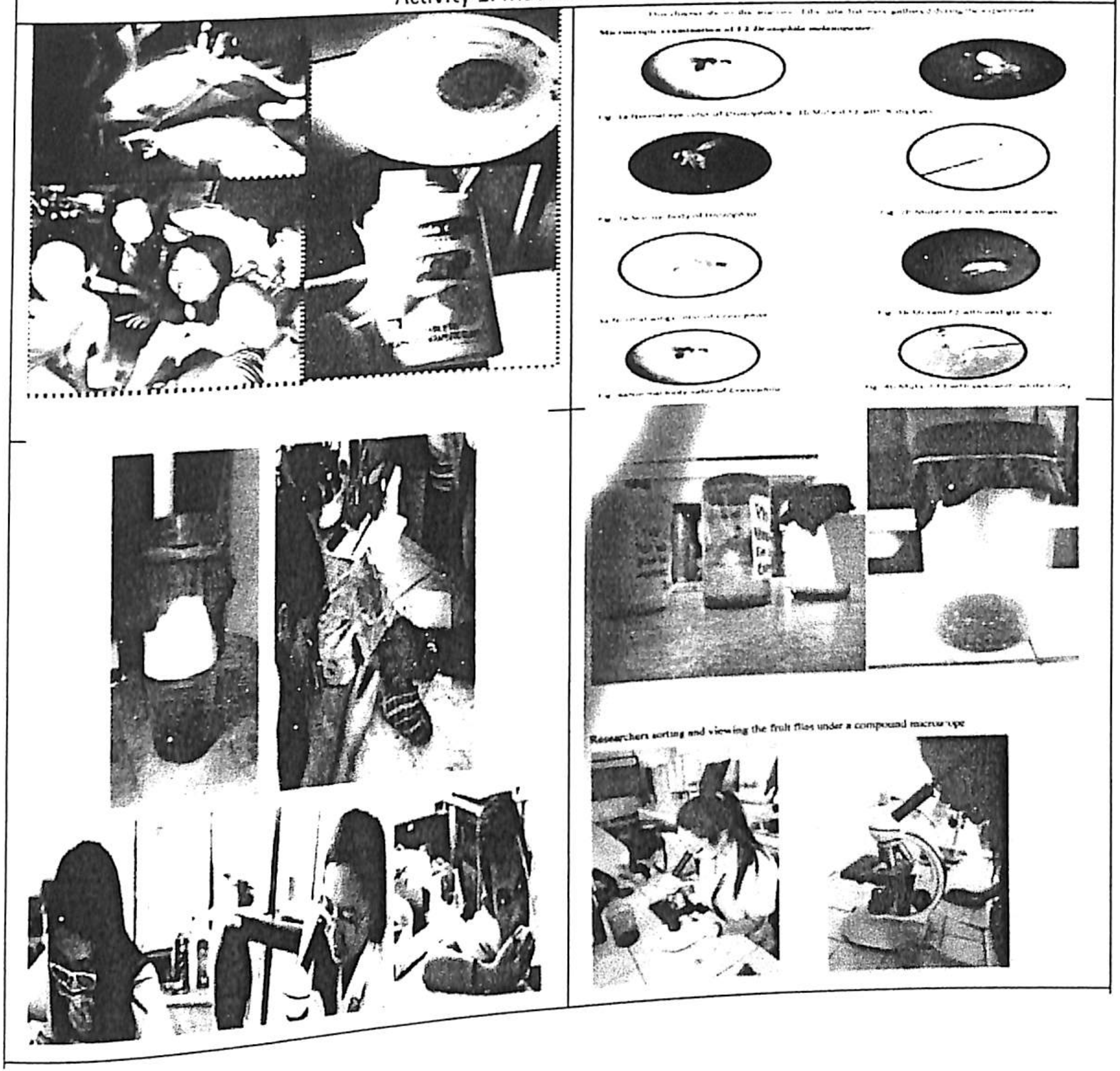
- List down the concepts (words/ phrases) you learned in this activity.
- Connect these ideas through concept mapping

Polygenic Inheritance
Genes
DNA
Genome-wide association Studies (GWAS)
SNPs (single nucleotide polymorphisms
Genotypes
Phenotypes
Trait
Mutation
Allelic heterogeneity
Locus heterogeneity



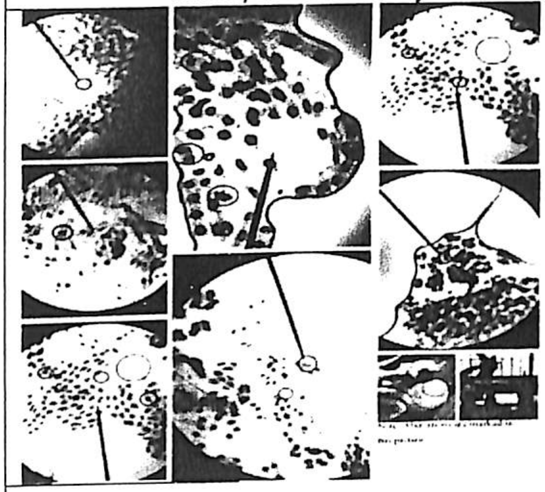
Appendix U
Photodocumentation

Activity 1: Mutations and Variations

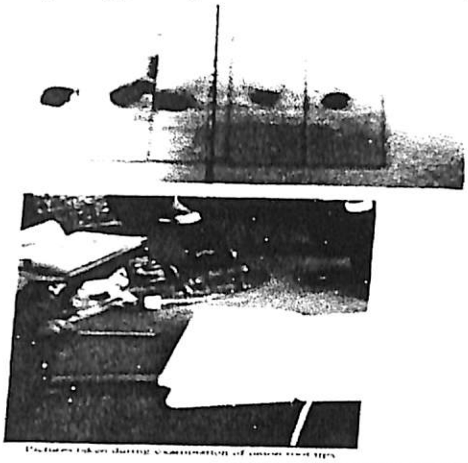


Researchers sorting and viewing the fruit flies under a compound microscope

Activity 4: Genotoxicity on Chromosome Morphology using *Allium* Test

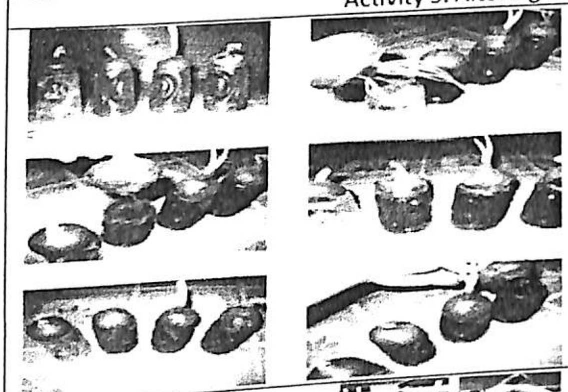


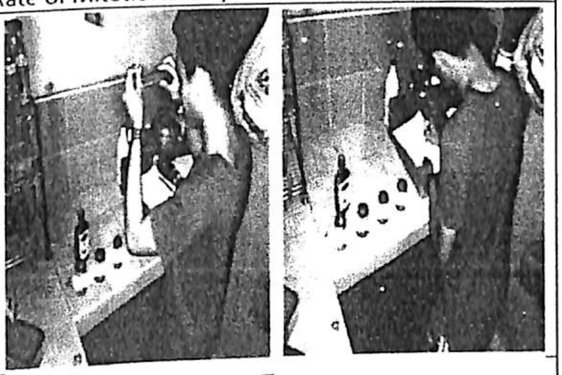
[illegible]

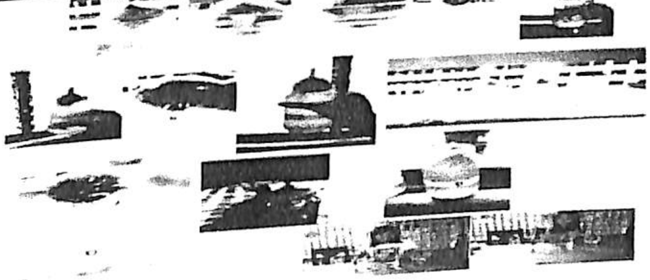


Pictures taken during examination of onion root tips

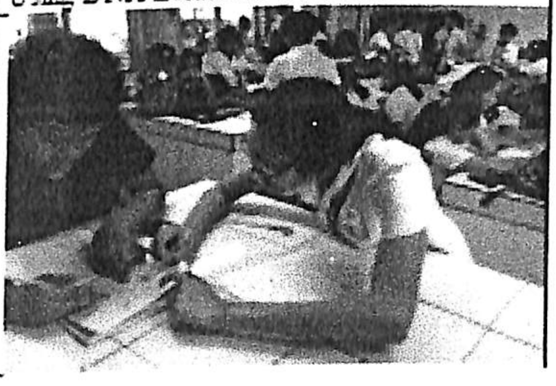
Activity 5: Altering the Rate of Mitotic Activity







Sample Photos of Control and Experimental Groups Laboratory Activities

<table>
<tr><td colspan="2">Activity No 1</td></tr>
<tr><td>Variations</td><td>Mutations on Fruit fly (*Drosophila melanogaster*) as Sources of Variations</td></tr>
<tr><td>Control Group</td><td>Experimental Group</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Activity No 2</td></tr>
<tr><td>Introduction to Some Genetic Concepts</td><td>Determination of Genotypes from Phenotypes in Humans</td></tr>
<tr><td>Control Group</td><td>Experimental Group</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Activity No 3</td></tr>
<tr><td>Control Group</td><td>Experimental Group</td></tr>
<tr><td>Ultrastructure of the Cell</td><td>Using DNA Evidence: Who did it?</td></tr>
<tr><td></td><td></td></tr>
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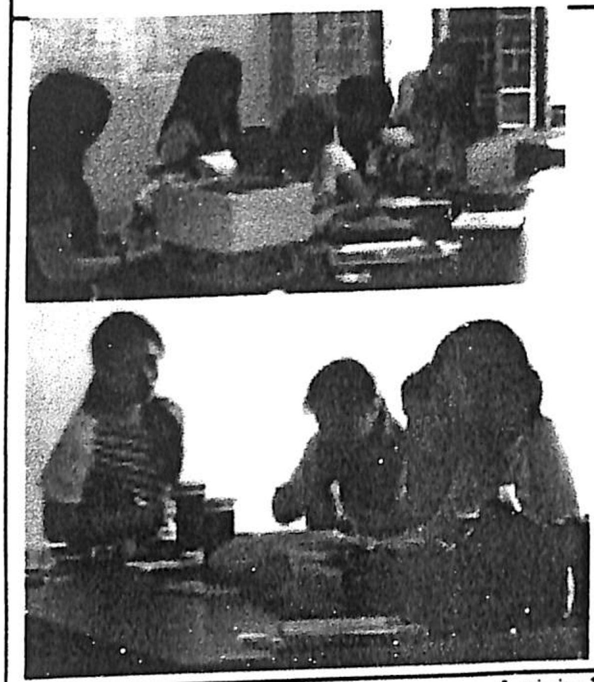
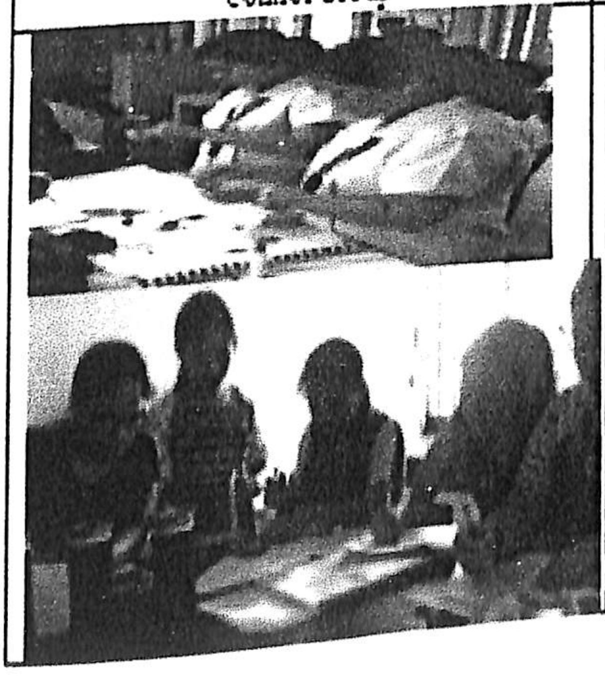
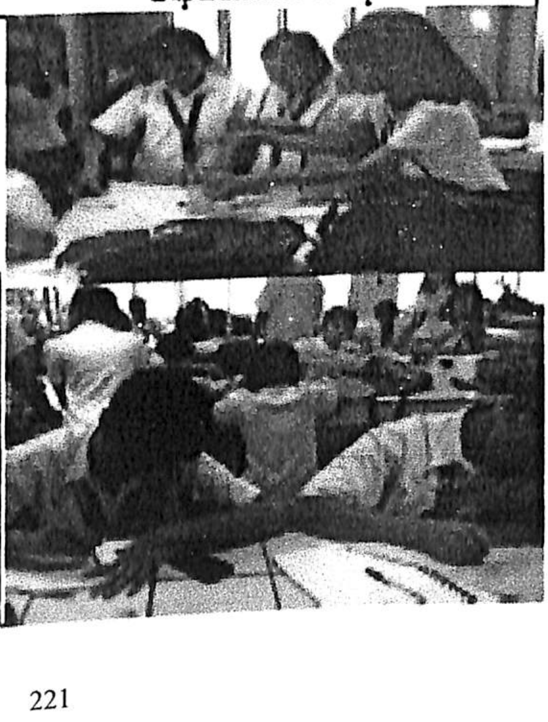
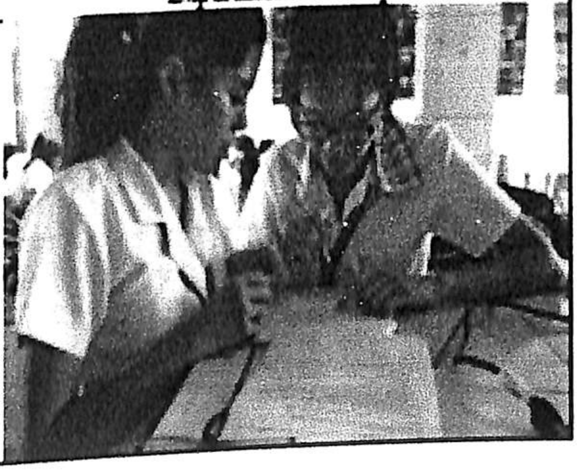
Activity No. 4	
Control Group	Experimental Group
Chromosome Morphology	Genotoxicity on Chromosome Morphology using *Allium* Test
	
Activity No. 5	
Mitosis	Altering the Rate of Mitosis
Control Group	Experimental Group
	

Activity No. 6	
Meiosis	Identifying the Stages of Meiosis in Different Specimen
Control Group	Experimental Group
	
Activity No. 7	
Chromosomal Aberrations	How Can Karyotype Analysis Explain Genetic Disorder?
Control Group	Experimental Group
	
Activity No. 8	
Mendelian Genetics	Mendelian Genetics: What are the chances?
Control Group	Experimental Group
	

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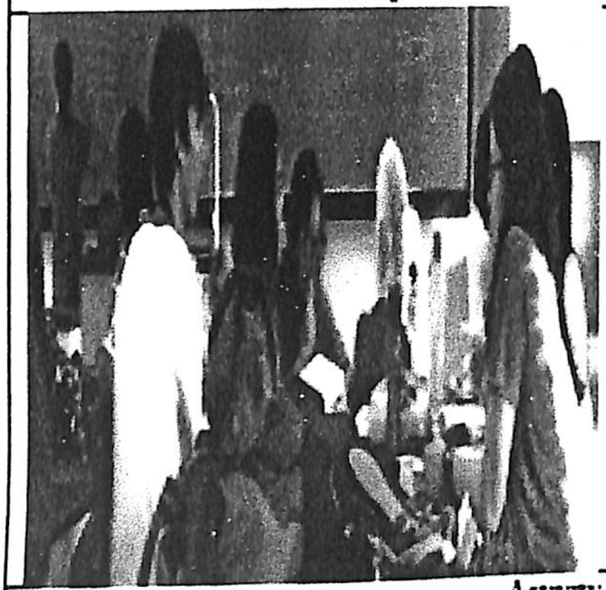
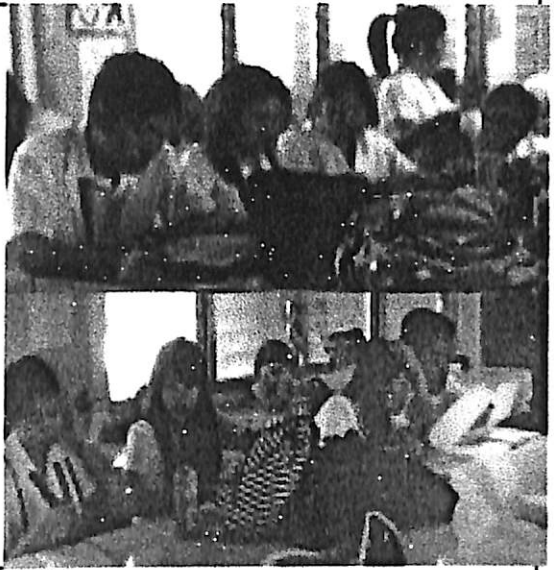
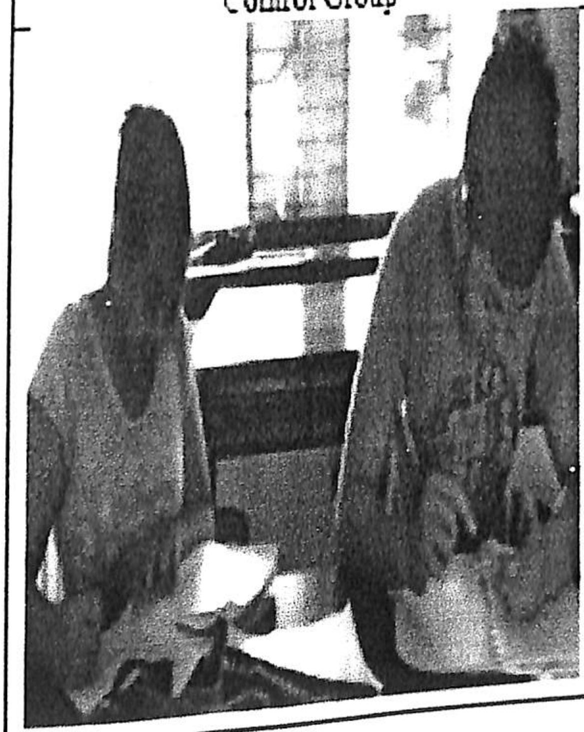
<tr><td colspan="2">Activity No. 9</td></tr>
<tr><td>Non-Mendelian Genetics: Multiple Alleles</td><td>Multiple Alleles: Solving a Blood Mystery</td></tr>
<tr><td>Control Group</td><td>Experimental Group</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Activity No. 10</td></tr>
<tr><td>Non-Mendelian Genetics: Polygenic Inheritance</td><td>Polygenic Inheritance: Tossing a Coin</td></tr>
<tr><td>Control Group</td><td>Experimental Group</td></tr>
<tr><td></td><td></td></tr>
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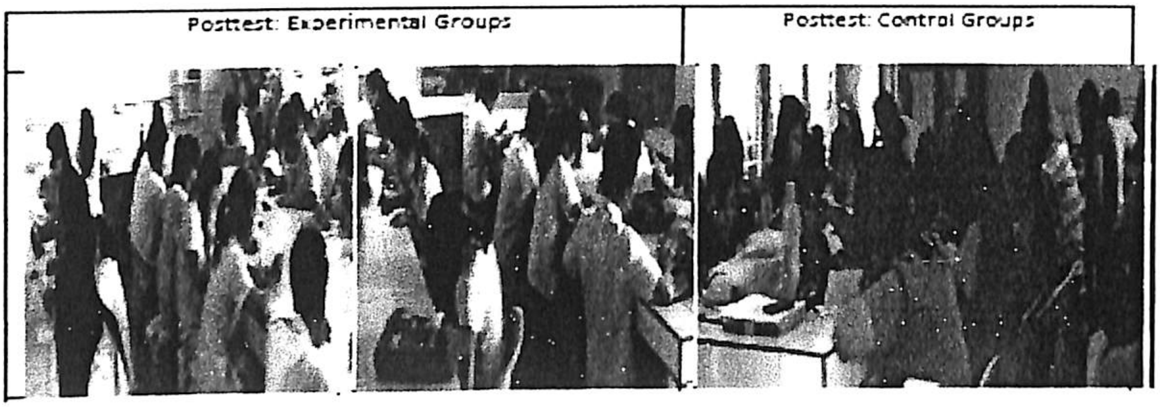
Sample Photos of Control and Experimental Groups Posttests



Posttest: Experimental Groups

Posttest: Control Groups

Sample Photos of Control and Experimental Groups Class Interview

Class Interview: Experimental Group

Class Interview: Control Group

Appendix V
Pretest-posttest Scores

Control Group

		Prescores	Prescores	Prescores	Postscores	Postscores	Postscores
Course	Student	Conceptual	Skills	Attitude	Conceptual	Skills	Attitude
Biotech	Binueza	7	7	2.15	15	19	2.35
Biotech	Casero	12	9	2.4	11	17	1.95
Biotech	Delariarte	11	14	2.4	20	21	2.25
Biotech	Diaz	11	11	2.4	21	19	2.55
Biotech	Enriquez	9	12	2.4	11	18	2.35
Biotech	Grino	7	16	2.65	11	22	2.65
Biotech	Mueda	15	10	2.55	28	27	2.5
Biotech	Sedotes	10	17	2.3	10	23	2.4
premed	Alag	7	4	2.2	22	32	2.35
premed	Alcudia	10	7	2.35	16	21	2.1
premed	Alderete	11	10	2.25	14	25	2.35
premed	Almosara	12	11	2.55	13	15	2.55
premed	Atienza	15	11	2.15	15	22	2.45
premed	Barrida	11	13	2.2	17	30	2.6
premed	Barruela	18	3	2.45	17	24	2.2
premed	Berebe	16	15	2.4	21	33	2.4
premed	Bernal	11	13	2.2	16	21	2.6
premed	Casuncad	12	12	2.6	7	21	2.2
premed	Dago	10	9	2.7	14	19	2.65
premed	Dela Cruz	7	15	2.05	16	21	2.5
premed	Delfin	12	11	2.7	23	23	2.5
premed	Galapin	12	14	2.4	19	26	2.45
premed	Gubaton	11	11	2.5	17	20	2.65
premed	Guinto	17	25	2.25	24	20	2.35
premed	Hecita	11	17	2.7	17	20	2.55
premed	Jabagat	7	8	2.4	13	22	2.4
premed	Legayada	8	16	2.75	16	14	2.35
premed	Libo-on	10	10	2.5	19	23	2.45
premed	Lo	13	15	2.2	22	27	2.45
premed	Navarra	16	16	2.6	26	33	2.3
premed	Nufuar	14	15	2.25	20	31	2.3
premed	Padilla	14	19	2.55	22	25	2.55
premed	Parcia	14	11	2.25	33	26	2.55
premed	Penaflorida	11	11	2.45	17	20	2.6
premed	Sala	10	10	2.6	29	26	2.45
premed	Segovia	14	9	2.2	21	31	2.4
premed	Servando	12	13	2.25	18	22	2.5
premed	Soriaso	14	9	2.55	15	16	2.4
premed	Tabilid	11	11	2.25	19	21	2.25
premed	Tabjan	13	12	2.3	20	22	2.65
premed	Tacurda	6	11	2.15	18	19	1.9
premed	Tirante	14	13	2.45	28	25	2.65
premed	Uygen	10	10	2.35	22	19	2.45
premed	Velasco	7	12	2.5	24	21	2.6
premed	Villanueva	18	21	2.35	29	22	2.85
	Total	521	549	107.8	846	1024	109.5
	Average	11.58	12.20	2.396	18.80	22.76	2.433
	Sample	45	45	45			
		Control					

Experimental Group

		Prescores	Prescores	Prescores	Postscores	Postscores	Postscores
Course	Course	Conceptual	Skills	Attitude	Conceptual	Skills	Attitude
Educ	Duran	11	9	2.5	17	23	2.4
Educ	Genciana	13	16	2.55	25	30	2.45
Educ	Frajillo	6	9	2.35	29	30	2.5
Educ	Loja	13	18	2.35	28	30	2.35
Educ	Pagdato	6	11	2.5	35	28	2.45
Educ	Palomaria	11	3	2.5	30	27	2.5
Educ	Rodriguez	8	8	2.1	33	25	2.35
Educ	Gumilor	10	9	2.35	20	29	2.3
Micro	Alminaza	11	15	2.45	28	25	2.7
Micro	Azcona	13	10	2.55	17	22	2.45
Micro	Babayen-on	5	7	2.45	29	26	2.45
Micro	Banabatac	15	14	2.6	20	17	2.65
Micro	Bartolome	8	18	2.4	25	24	2.25
Micro	Belario	10	13	2.4	22	25	2.6
Micro	Bermejo	9	20	2.6	22	27	2.65
Micro	Benal	11	10	2.35	13	22	2.45
Micro	Besares	19	12	2.35	16	25	2.55
Micro	Buday	17	4	2.4	30	29	2.3
Micro	Buena-oro	9	10	2.45	11	21	2.45
Micro	Cerilo	10	21	2.3	22	30	2.65
Micro	Corillo	7	11	2.7	11	23	2.4
Micro	Dayon	12	13	2.15	23	20	2.4
Micro	Durana	13	5	2.5	17	22	2.6
Micro	Ferrariz	14	20	2.4	20	28	2.3
Micro	Gito	15	8	2.45	21	19	2.55
Micro	Guay	8	12	2.5	29	26	2.3
Micro	Jardeleza	8	23	2.4	20	27	2.4
Micro	Legario	15	14	2.2	27	24	2.35
Micro	Lentija	12	15	2.35	19	29	2.15
Micro	Magallanes	8	12	2.15	18	19	2.25
Micro	Margate	8	15	2.15	22	19	2.5
Micro	Navallasca	12	16	2.15	22	23	2.1
Micro	Padasas	10	11	2.15	14	18	2
Micro	Panaguiton	12	6	2.25	24	27	2.35
Micro	Penaranda	14	21	2.3	24	23	2.5
Micro	Pintor	11	12	2.5	16	25	2.45
Micro	Raymundo	11	6	2.45	30	30	2.5
Micro	Sabido	11	16	2.3	25	19	2.5
Micro	Suladay	7	11	2.55	15	15	2.35
Micro	Sumbilla	10	11	2.3	26	30	2.2
Micro	Supetran	11	7	2.4	29	29	2.55
Micro	Tabaosares	15	13	2.25	23	27	2.4
Micro	Tampus	13	11	2.35	27	32	2.4
Micro	Tenebro	7	20	2.7	29	20	2.85
Micro	Velo	6	13	2.55	20	21	2.55
	Total	485	559	107.65	1023	1110	109.35
	Average	10.78	12.42	2.392	22.73	24.67	2.430
	Sample	45	45	45	45	45	
		Experimental					

Appendix W
Results of Independent Samples t-test on Inquiry Skills

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Skill Posttest Score	Control	45	22.7556	4.60314	.68620
	Experimental	45	24.6667	4.21577	.62845

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Skill Posttest Score	Equal variances assumed	.008	.930	-2.054	88	.043	-1.9111	.93049	-3.76027	-.06196
	Equal variances not assumed			-2.054	87.329	.043	-1.9111	.93049	-3.76046	-.06176

Appendix X
Results of Independent Samples t-test on Conceptual Understanding

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Postscore Conceptual	Control	45	18.8000	5.57429	.83097
	Experimental	45	22.7333	5.85196	.87236

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Postscore Conceptual	Equal variances assumed	.358	.551	-3.265	88	.002	-3.9333	1.20479	-6.32760	-1.53907
	Equal variances not assumed			-3.265	87.793	.002	-3.9333	1.20479	-6.32768	-1.53899

Appendix Y
Results of Independent Samples t-test on Attitude toward Genetics

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
POSTTATT	Control	45	2.4333	.18433	.02748
	Experimental	45	2.4300	.16075	.02396

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
POSTTATT	Equal variances assumed	.529	.469	.091	88	.927	.0033	.03646	-.06912	.07579
	Equal variances not assumed			.091	86.401	.927	.0033	.03646	-.06914	.07581

Appendix Z
Results of Pearson r Correlation on Inquiry Skills, Conceptual Understanding and Attitude

Control Group

		Postskills Control	Postconceptual Control	Post attitude Control
Postskills Control	Pearson Correlation	1	.451(**)	-.225
	Sig. (2-tailed)	.	.002	.137
	N	45	45	45
Postconceptual Control	Pearson Correlation	.451(**)	1	-.029
	Sig. (2-tailed)	.002	.	.852
	N	45	45	45
Post attitude Control	Pearson Correlation	-.225	-.029	1
	Sig. (2-tailed)	.137	.852	.
	N	45	45	45

** Correlation is significant at the 0.01 level (2-tailed).

Experimental Group

		Postskills Experimental	Postconceptual Experimental	Post attitude Experimental
Postskills Experimental	Pearson Correlation	1	.492(**)	-.019
	Sig. (2-tailed)	.	.001	.902
	N	45	45	45
Postconceptual Experimental	Pearson Correlation	.492(**)	1	-.109
	Sig. (2-tailed)	.001	.	.477
	N	45	45	45
Post attitude Experimental	Pearson Correlation	-.019	-.109	1
	Sig. (2-tailed)	.902	.477	.
	N	45	45	45

** Correlation is significant at the 0.01 level (2-tailed).